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Wastewater Treatment of Thai Dessert Production Enterprises by Anaerobic Process

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Abstract

This research aims to analyzed the removal efficiency of the Wastewater Treatment from Thai Dessert Production Enterprises by the Anaerobic Process by studying various parameters including BOD, COD, Total-N, TKN, Total-P, Ammonia, Nitrate, FOG, and Orthophosphate at different storage times ranging from 0 to 24 days. The study found that anaerobic treatment alone achieved removal rates of 38.10% for BOD, 40.91% for COD, 90.31% for FOG, and 25.75% for Total-P. Further improvement was observed with the addition of cow manure and pH adjustment during storage phases of 0, 3, 5, 7, and 9 days, incorporating one-day air exposure on days 5, 7, and 9. This enhanced treatment demonstrated superior removal efficiencies of 45%, 77%, 82%, and 45% for BOD, COD, FOG, and Total-P, respectively. These findings suggest that anaerobic treatment, when supplemented with external amendments like cow manure and pH control, exceeds the effectiveness of standalone anaerobic treatment. This method offers a feasible solution for managing wastewater from Thai dessert production and reducing pollution levels.

Keywords: Wastewater treatment; Thai Dessert Production Enterprises; Anaerobic wastewater treatment;

1. Introduction

Thai desserts are known for their rich, sweet, and creamy flavors, often made with coconut milk and sugar as key ingredients. Nearly every stage of Thai dessert production, including raw material preparation, production processes, product finishing, and equipment cleaning, involves the use of water. The wastewater generated from this process has several issues: it produces a strong unpleasant smell; it contains a high concentration of organic matter with an estimated BOD value of 20,000 mg/L (Zajda and Aleksander-Kwaterczak, 2019); discharge into public water sources leads to water pollution. Anaerobic wastewater treatment methods, like the Upflow Anaerobic Sludge Blanket (UASB) system, are often used in food industries that have a lot of organic pollution. However, these methods involve high installation costs, expensive maintenance, and chemical requirements. Small Thai dessert production enterprises, which are often budget-limited, face difficulties implementing appropriate wastewater treatment systems due to insufficient funding and inappropriate wastewater treatment before discharge.

There is a need for an alternative anaerobic wastewater treatment method that is cost-effective, easy to implement, and based on natural materials, making it accessible for small-scale enterprises to effectively treat wastewater. Nasir *et al.* (2012) discovered the application of 500 grams of fresh cow dung combined with 500 grams of fresh palm oil mill effluent achieves a total COD reduction of 33% under anaerobic circumstances. The pH was regulated automatically by the addition of 1 N HCl and 1 N NaOH as necessary, while stirring was sustained at around 150 rpm to achieve a neutral pH. Moreover, according to Güngör *et al.* (2004), the experiment showed that these manures can lower total COD (Chemical Oxygen Demand) and make biogas through anaerobic digestion. Specifically, at low COD (12,000 mg/l) and TS (1%) concentrations, total COD removal was 32.0-43.3%. At higher COD (53,500 mg/L) and TS (4.3%) concentrations, total COD removal efficiency was 37.9–50%.

Therefore, the objective is to evaluate the efficacy of anaerobic wastewater treatment when external variables, such as cow dung and pH adjustments, are incorporated to address the wastewater issues arising from Thai dessert production enterprises.

2. Methodology

2.1 Sample Collection and Preparation

Wastewater samples were collected from a Thai dessert manufacturing enterprise. The samples were filtered to remove large sediment particles, then poured into plastic buckets and mixed thoroughly. Wastewater samples were taken for component analysis in the laboratory. The remaining wastewater was stored in plastic tanks to allow fats to separate naturally over 72 hours.

2.2 Fat Removal and Analysis

After the 72-hour fat separation period, the layer of fat floating on the water surface was removed. The defatted wastewater was then analyzed for 15 parameters.

2.3 pH Neutralization

The wastewater pH was neutralized using 1 N NaOH. The pH-adjusted wastewater was analyzed for 15 parameters.

2.4 Experimental Setup

The wastewater was divided into experimental units, with 3 liters per unit. Each condition was tested in triplicate for hydraulic retention times (HRTs) of 3, 5, 7, and 9 days. The experimental groups were set up as follows: Control Group: Wastewater without pH adjustment, with HRTs of 3, 5, 7, and 9 days. pH-Adjusted Group: Wastewater neutralized to a pH of 7, with HRTs of 3, 5, 7, and 9 days. Cow Manure Addition Group: Wastewater mixed with wet cow manure at a ratio of 33.34 grams of cow manure to 200 milliliters of wastewater. The mixture was stirred until the manure dissolved. HRTs were set at 3, 5, 7, and 9 days. Aeration After Treatment: For samples with HRTs of 5, 7, and 9 days, lids were removed to allow air exposure for an additional day.

2.5 Anaerobic Condition Setup

The lids of the plastic jars were closed tightly, and the jars were covered with black bags to create anaerobic conditions (Figure 1).

Figure 1. Anaerobic Condition Setup

2.6 Sample Analysis

After the specified HRTs, wastewater samples were collected and analyzed for 15 parameters including Temperature, soluble solids, Suspended solids, Electrical conductivity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), total Nitrogen, TKN, Ammonia, nitrate, total phosphorus, orthophosphate and Fat, Oil and Grease to assess treatment efficiency.

3. Results and Discussion

The subsequent results pertain to a study examining the wastewater treatment practices of Thai dessert manufacturing enterprises utilizing the anaerobic treatment technology. The research assessed the water quality associated with the anaerobic digestion process.

3.1 Anaerobic Treatment

The study on anaerobic wastewater treatment found that the wastewater was contaminated with BOD, COD, Total-N, TKN, Total-P, Ammonia, Nitrate, FOG, and Orthophosphate, with initial values on day 0 being 15,750 mg/L, 35,200 mg/L, 456.87 mg/L, 436.80 mg/L, 39.049 mg/L, 16.559 mg/L, 20.078 mg/L, 21,837 mg/L, and 10.497 mg/L, respectively. After undergoing anaerobic wastewater treatment for 3, 5, 8, 10, and 24 days, it was observed that by the end of the 24-day experiment, the values of BOD, COD, Total-N, TKN, Total-P, Nitrate, and FOG showed a decreasing trend, with values of 9,750 mg/L, 20,800 mg/L, 203.46 mg/L, 203.46 mg/L, 28.993 mg/L, 0 mg/L, and 2,116 mg/L, respectively. This corresponds to treatment efficiencies of 38.10%, 40.91%, 55.47%, 53.42%, 25.75%, -44.06%, 100%, 90.31%, and -85.20%, respectively. However, the values of Ammonia and Orthophosphate increased to 23.855 mg/L and 19.440 mg/L, respectively, from the initial day, as shown in the table 1.

(1) Biochemical Oxygen Demand (BOD)

The BOD value on the first day was 15,750 mg/L, and after three days, it showed a decreasing trend and stabilized on the 10th day. By the end of the 24-day experiment, the BOD value had decreased to 9,750 mg/L, with a treatment efficiency of 38.10%. This is because over time, the microorganisms in the system break down the organic matter in the wastewater, resulting in a reduction in water pollution. Consequently, the BOD value or the amount of oxygen required by microorganisms during the decomposition process also decreased.

(2) Chemical Oxygen Demand (COD)

The initial COD value was 35,200 mg/L, which thereafter exhibited a declining trend over time. On the 24th day, the COD levels measured 20,800 mg/L. The declining trend of the COD value correlates with the BOD value, which represents the quantity of pollution that consumes oxygen to oxidize organic matter. The COD value consistently exceeds the BOD value, with a treatment efficiency of 40.91%.

Table 1. Water quality and treatment efficiency of BOD, COD, Total-N, TKN, Total-P, Ammonia, Nitrate, FOG, and Orthophosphate from the anaerobic treatment process at 0, 3, 5, 8, 10, and 24 days

Water quality parameters	Retention period						treatment efficiency (%)
	0 (day)	3 (day)	5 (day)	8 (day)	10 (day)	24 (day)	
BOD (mg/L)	15,750	14,200	13,600	12,616	11,950	9,750	38.10
COD (mg/L)	35,200	20,800	24,000	28,800	21,333	20,800	40.91
Total-N (mg/L)	456.87	254.97	306.93	240.80	214.66	203.46	55.47
TKN (mg/L)	436.80	253.86	291.2	240.80	214.66	203.46	53.42
Total-P (mg/L)	39.049	34.324	25.706	30.903	26.787	28.993	25.75
Ammonia (mg/L)	16.559	10.129	9.050	14.075	14.441	23.855	-44.06
Nitrate (mg/L)	20.078	1.665	15.803	0	0	0	100
FOG (mg/L)	21,837	5,241	4,816	2,675	3,525	2,116	90.31
Orthophosphate (mg/L)	10.497	21.657	21.824	21.228	19.165	19.440	-85.20

(3) Total Nitrogen (Total-N)

The initial Total-N value was 456.87 mg/L, and over time, the Total-N value showed a decreasing trend. On the 24th day, the Total-N value decreased to 203.46 mg/L, with a treatment efficiency of 55.47%. The Total-N value went down because microorganisms break down organic nitrogen compounds into inorganic substances. This is because organic nitrogen compounds contain protein groups that microorganisms use as food.

4) Total Kjedahl Nitrogen (TKN)

The initial TKN value was 436.80 mg/L, and over time, the TKN value showed a decreasing trend. On the 24th day, the TKN value decreased to 203.46 mg/L, with a treatment efficiency of 53.42%. The decreasing trend of TKN is consistent with the Total-N value, as microorganisms break down organic nitrogen into inorganic substances. Therefore, the TKN value decreased.

(5) Total Phosphorus (Total-P)

The initial Total-P value was 39.049 mg/L. Over time, the Total-P value tended to decrease and stabilized on the 10th day. By the end of the 24-day experiment, the Total-P value was found to have decreased to 28.993 mg/L, with a treatment efficiency of 55.47%. Since microorganisms break down organic matter into inorganic substances, the Total-P value tends to decrease.

(6) Orthophosphate (PO_4^{3-})

The PO_4^{3-} value increased over the storage period. On the first day, it was 10.497 mg/L. As time passed, the PO_4^{3-} value continued to rise, and by the end of the experiment on day 24, it reached 19.440 mg/L. The treatment worked only 85.20% of the time because PO_4^{3-} is an inorganic substance that is made when organic phosphorus breaks down, which makes it more valuable.

(7) Nitrate (NO_3^-)

The initial NO_3^- value was 20.078 mg/L. After 3 days, it showed a decreasing trend and stabilized on day 10. By the end of the 24-day experiment, the NO_3^- value was found to be reduced to 0 mg/L, as shown in Figure 19. The treatment efficiency was 100% due to the denitrification process, where microorganisms converted NO_3^- into N2 gas, leading to a decrease in NO_3^- levels.

(8) Ammonia (NH_3)

The NH_3 value increased over the storage period, from an initial value of 16.559 mg/L on the first day to 23.855 mg/L on the 24th day, resulting in a treatment efficiency of -44.06%. Since NH_3 is produced through the ammonification process, which transforms organic nitrogen compounds into ammonia compounds, this results in an increase in ammonia levels.

(9) Fat, Oil and Grease (FOG)

The initial FOG value was 21,837 mg/L. As the retention period increased, the FOG value tended to decrease. The 24th day revealed a FOG value of 2,116 mg/L, indicating a treatment efficiency of 90.31%. The system's microorganisms decompose fats, primarily composed of carbon, leading to a decrease in the FOG value.

3.2 Anaerobic wastewater treatment by adding cow manure as a catalyst

From the study of the anaerobic process over 24 days, it was found that the BOD value and other parameters remained above the industrial wastewater standards. Therefore, the experiment was modified and redesigned by adding external factors, specifically cow manure and adjusting the pH, to accelerate the degradation reaction. The experimental results are as follows:

The study on anaerobic wastewater treatment with the addition of external factors, specifically cow manure, found that the wastewater was polluted in terms of BOD, COD, SS, FOG, Total-P, TKN, Ammonia, Nitrate, and Orthophosphate, with initial values of 20,000 mg/L, 64,000 mg/L, 7,600 mg/L, 28,160 mg/L, 223 mg/L, 219 mg/L, 4 mg/L, ND, and 5 mg/L, respectively. The anaerobic wastewater treatment process with the addition of external factors, specifically cow manure, over 3, 5, 7, and 9 days, showed that the BOD, COD, SS, FOG, Total-P, TKN, Ammonia, Nitrate, and Orthophosphate values at the end of the 9-day experiment were 14,800 mg/L, 38,400 mg/L, 1,860 mg/L, 6,398 mg/L, 216 mg/L, 459 mg/L, 97 mg/L, 3 mg/L, and 80 mg/L, respectively. The treatment efficiencies for BOD, COD, SS, FOG, Total-P, TKN, Ammonia, Nitrate, and Orthophosphate of the anaerobic wastewater treatment process with the addition of external factors, specifically cow manure, were 26%, 40%, 76%, 77%, 3%, ND, ND, 0%, and ND, respectively, as shown in Table 2.

The study on anaerobic wastewater treatment with the addition of external factors, specifically cow manure and pH adjustment, found that the wastewater was polluted in terms of BOD, COD, SS, FOG, Total-P, TKN, Ammonia, Nitrate, and Orthophosphate, with initial values of 20,000 mg/L, 64,000 mg/L, 7,600 mg/L, 28,160 mg/L, 223 mg/L, 219 mg/L, 4 mg/L, ND, and 5 mg/L, respectively. The anaerobic wastewater treatment process with the addition of external factors, specifically cow manure, over 3, 5, 7, and 9 days, showed that the BOD, COD, SS, FOG, Total-P, TKN, Ammonia, Nitrate, and Orthophosphate levels decreased. By the end of the experiment on the 9th day, the residual values were 15,000 mg/L, 32,000 mg/L, 463 mg/L, 9,278 mg/L, 137 mg/L, 286 mg/L, 2 mg/L, ND, and 16 mg/L, respectively. The treatment efficiencies for BOD, COD, SS, FOG, Total-P, TKN, Ammonia, Nitrate, and Orthophosphate of the anaerobic wastewater treatment process with the addition of external factors, specifically cow manure and pH adjustment, were 25%, 50%, 94%, 67%, 39%, ND, 50%, ND, and ND, respectively, as shown in Table 2.

The study on anaerobic wastewater treatment with the addition of external factors, specifically cow manure and pH adjustment, exposed to air for 1 day over periods of 5, 7, and 9 days, found that the anaerobically treated wastewater with cow manure exposed to air for 1 day had BOD, COD, SS, FOG, Total-P, TKN, Ammonia, Nitrate, and Orthophosphate values at the end of the 9-day experiment of 13,000 mg/L, 14,900 mg/L, 1,760 mg/L, 7,015 mg/L, 218 mg/L, 448 mg/L, 68 mg/L, 2.5 mg/L, and 94 mg/L, respectively. The treatment efficiencies were 35%, 77%, 77%, 75%, 2.2%, ND, ND, 0%, and ND, respectively, as shown in Table 2.

The study results on anaerobic wastewater treatment with the addition of external factors, specifically cow manure and pH adjustment, exposed to air for 1 day with durations of 5, 7, and 9 days, found that the anaerobically treated wastewater with the addition of cow manure and pH adjustment exposed to air for 1 day had BOD, COD, SS, FOG, Total-P, TKN, Ammonia, Nitrate, and Orthophosphate values at the end of the 9-day experiment of 11,700 mg/L, 19,200 mg/L, 600 mg/L, 8,268 mg/L, 146 mg/L, 280 mg/L, 1 mg/L, ND, and ND, respectively. The treatment efficiencies were 42%, 70%, 93%, 71%, 35%, ND, 75%, ND, and ND, respectively, as shown in Table 2.

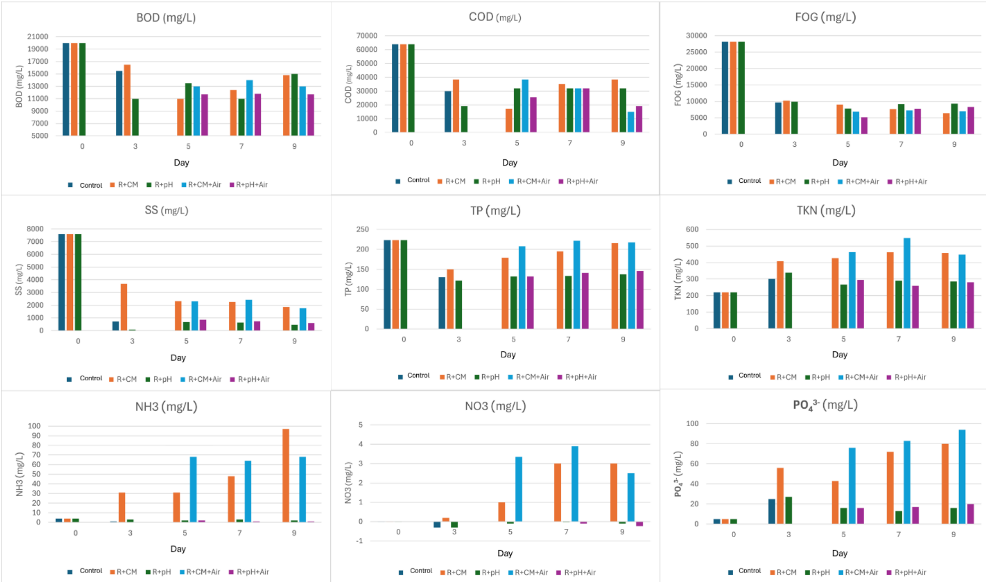
The impact of incorporating external elements, such as cow manure and pH adjustment, into anaerobic wastewater treatment over a retention time of 0–9 days, followed by one day of aeration, on the pollutant levels of the wastewater was examined. The preliminary concentrations of BOD, COD, SS, FOG, Total-P, TKN, Ammonia, Nitrate, and Orthophosphate were 20,000 mg/L, 64,000 mg/L, 7,600 mg/L, 28,160 mg/L, 223 mg/L, 219 mg/L, 4 mg/L, ND, and 5 mg/L, respectively, as reported in the study. In comparison, the BOD value decreased most significantly on the seventh day of anaerobic treatment with cow manure and pH adjustment, reaching 11,000 mg/L, reflecting a 45% treatment success rate, as illustrated in Figure 2. The COD level decreased most significantly on the ninth day of anaerobic treatment, following nine days of cow manure addition and one day of aeration. The concentration reached 14,933 mg/L, indicating that the treatment was effective 77% of the time. The SS value exhibited the most pronounced reduction on the third day of anaerobic treatment with the incorporation of cow manure and pH correction, decreasing the concentration to 85 mg/L with a treatment effectiveness of 99%. The FOG value decreased most significantly on the fifth day of anaerobic treatment with cow manure, followed by one day of aeration. The levels decreased to 5,173 mg/L, indicating that the treatment was effective 82% of the time. Furthermore, Figure 2. illustrates that the TP value had the most significant decline on the third day of anaerobic treatment, coinciding with the addition of cow manure and a shift in pH. This resulted in a concentration reduction to 122, indicating that the treatment was effective 45% of the time. The levels of TKN, ammonia, nitrate, and orthophosphate exhibit an upward trend, as illustrated in Table 2 and Figures 2.

When compared to anaerobic treatment, it is evident that anaerobic treatment with the addition of external factors such as cow manure and pH adjustment has a higher wastewater treatment efficiency than anaerobic treatment.

Table 2. Water quality results from the anaerobic treatment process with the addition of external factors, which are cow manure and pH adjustment on days 0, 3, 5, 7, and 9, with exposure to air on days 5, 7, and 9

Parameter	Sample	Duration (days)							
		0	3	5	7	9	Ana 5 Air 1	Ana 7 Air 1	Ana 9 Air 1
BOD (mg/L)	Control	20,000	15,500 (23%)	-	-	-	-	-	-
	cow manure	20,000	16,500 (18%)	11,000 (45%)	12,400 (38%)	14,800 (26%)	13,000 (35%)	14,000 (30%)	13,000 (35%)
	cow manure +pH	20,000	11,000 (45%)	13,500 (33%)	11,000 (45%)	15,000 (25%)	11,700 (42%)	11,800 (41%)	11,700 (42%)
COD (mg/L)	Control	64,000	29,867 (53%)	-	-	-	-	-	-
	cow manure	64,000	38,000 (41%)	17,067 (73%)	35,200 (45%)	38,400 (40%)	38,400 (45%)	32,000 (50%)	14,933 (77%)
	cow manure +pH	64,000	19,200 (70%)	32,000 (50%)	32,000 (50%)	32,000 (50%)	25,600 (60%)	32,000 (50%)	19,200 (70%)
SS (mg/L)	Control	7,600	720 (90.5%)	-	-	-	-	-	-
	cow manure	7,600	3,680 (52%)	2,320 (70%)	2,260 (70%)	1,860 (76%)	2,306 (70%)	2,420 (68%)	1,760 (77%)
	cow manure +pH	7,600	85 (99%)	675 (91%)	635 (92%)	463 (94%)	860 (89%)	740 (90%)	600 (93%)
FOG (mg/L)	Control	28,160	9,667.5 (66%)	-	-	-	-	-	-
	cow manure	28,160	10,218 (64%)	8,990 (68%)	7,625 (73%)	6,398 (77%)	6,890 (76%)	7,720 (73%)	7,015 (75%)
	cow manure +pH	28,160	9,908 (65%)	7,825 (72%)	9,188 (67%)	9,278 (67%)	5,173 (82%)	7,720 (73%)	8,268 (71%)
TP (mg/L)	Control	223	130 (42%)	-	-	-	-	-	-
	cow manure	223	150 (33%)	179 (20%)	195 (13%)	216 (3%)	208 (7%)	222 (0.4%)	218 (2.2%)
	cow manure +pH	223	122 (45%)	132 (41%)	133 (40%)	137 (39%)	132 (41%)	141 (37%)	146 (35%)
TKN (mg/L)	Control	219	301	-	-	-	-	-	-
	cow manure	219	407	427	462	459	463	549	448
	cow manure +pH	219	339	267	290	286	295	259	280
Ammonia (mg/L)	Control	4	0.7 (83%)	-	-	-	-	-	-
	cow manure	4	31	31	48	97	68	64	68
	cow manure +pH	4	3 (25%)	2 (50%)	3 (25%)	2 (50%)	2 (50%)	1 (75%)	1 (75%)
Nitrate (mg/L)	Control	ND	ND	-	-	-	-	-	-
	cow manure	ND	0.2 (0%)	1 (0%)	3 (0%)	3 (0%)	3.35 (0%)	3.9 (0%)	2.5 (0%)
	cow manure +pH	ND	ND	ND	ND	ND	0.01	ND	ND
Orthophosphate (mg/L)	Control	5	25	-	-	-	-	-	-
	cow manure	5	56	43	72	80	76	83	94
	cow manure +pH	5	27	16	13	16	16	17	20

Note: Ana 5 Air 1 means anaerobic treatment for 5 days and exposure to air for 1 day, Ana 7 Air 1 means anaerobic treatment for 7 days and exposure to air for 1 day, Ana 9 Air 1 means anaerobic treatment for 9 days and exposure to air for 1 day.



Note: R + CM means wastewater mixed with cow manure, R+pH means wastewater with adjusted pH, R + CM + Air means wastewater mixed with cow manure that has been exposed to air for 1 day. R + CM + Air means wastewater that has been adjusted for pH and exposed to air for 1 day.

Figure 3. Various parameter values after undergoing anaerobic treatment with cow dung addition and pH adjustment.

4. Conclusion

From the study of wastewater treatment from Thai dessert production enterprises using anaerobic treatment methods over storage periods of 0, 3, 5, 8, 10, and 24 days, it was found that various parameters remained above the industrial wastewater discharge standards. Therefore, a study was conducted on anaerobic wastewater treatment with the addition of external factors, namely cow manure and pH adjustment, to accelerate the reaction over storage periods of 0, 3, 5, 7, and 9 days, and exposure to air for 1 day on the 5th, 7th, and 9th days. Water samples were collected to analyze the parameters BOD, COD, SS, FOG, total-P, TKN, ammonia, nitrate, and orthophosphate. From the study, it was found that anaerobic wastewater treatment with the addition of external factors, namely cow manure and pH adjustment, achieved BOD, COD, SS, FOG, and Total-P treatment efficiencies of 45%, 77%, 99%, 82%, and 45%, respectively. This was observed during a 7-days retention period with cow manure addition and pH adjustment, a 9-day retention period with 1 day of aeration, a 3-days retention period with cow manure addition and pH adjustment, a 5-days retention period with 1 day of aeration, and a 3-days retention period with cow manure addition and pH adjustment, respectively. From the above information, it can be concluded that anaerobic wastewater treatment with the addition of external factors such as cow manure and pH adjustment can be a solution to the wastewater problem from Thai dessert production enterprises.

Since the wastewater from the Thai dessert production industry contains high concentrations of organic substances, the study results show that when the wastewater undergoes an anaerobic treatment process, it can reduce pollution levels. However, it still does not meet industrial wastewater discharge standards. Therefore, it is advisable to apply other treatment systems in conjunction, such as using plants that can absorb nutrients, which are inorganic substances, to treat the wastewater following the anaerobic treatment system, followed by an aerobic treatment system (anaerobic treatment -> aerobic treatment -> phytoremediation). This can serve as a guideline for further research.

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