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A Study on the Chemical Treatment Techniques of High Concentration Ammonia Nitrogen in Food Wastewater

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Abstract

Purpose: Since the food wastewater contains a high concentration of nitrogen, it is very important to find a way to efficiently remove it. **Research design, data and methodology:** A total of four experiments were conducted under different conditions to remove ammonia nitrogen present in the food wastewater. The experiment was designed by adding sodium hypochlorite to the raw food wastewater and varying conditions such as pH control, aeration/precipitation, and stirring. **Results:** The ammonia nitrogen removal rate in Experiment 1 was about 12% (sodium hypochlorite added), ammonia nitrogen increased about 4.7% in Experiment 2 (sodium hypochlorite added after aeration/precipitation in a bioreaction tank, stirring), and decreased about 52.5% (sodium hypochlorite added after controlling and stirring). **Conclusions:** When the concentration of sodium hypochlorite was high, ammonia nitrogen was best removed, and the pH was adjusted to 12, and sodium hypochlorite was added after stirring, and the removal was the second best. If the method of this study is further studied and developed, it can be basic data for ammonia nitrogen removal in the future.

Keywords : Food Wastewater, Ammonia Nitrogen, Sodium Hypochlorite, Chemical Treatment

JEL Classification Codes : I30, I31, I38

1. Introduction

The food wastewater from food waste is a mixture of moisture contained in food, feed for food waste, and washing water for salt removal for composting (Heo et al., 2008). Due to the recent increase in nutrient salts such as nitrogen and phosphorus, problems such as eutrophication of aquatic ecosystems have arisen (Jung & Hyun, 2020) and marine dumping has also been banned since 2013, making it important to apply appropriate organic matter removal measures (Kim & Jung, 2022).

In fact, the Water Environment Conservation Act regulates total nitrogen emission standards. Clean areas can be discharged at 30 mg/L or less, and Ga, Na, and special areas can be discharged at 60 mg/L or less (MOE, 2020). In particular, it is very important to remove and finally release nitrogen contained in the food wastewater because it contains high concentrations of organic matter and nitrogen

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(Heo et al., 2008).

Typical methods of removing ammonia nitrogen include prechlorination treatment, biological treatment, and deaeration (Kim et al., 2005). In particular, biological advanced treatment is applied a lot, and this method has the disadvantage of continuously supplying external carbon sources for microbial growth and can be changed by temperature and pH variation. (Kim et al., 2005; Lee et al., 2011)). This method makes it difficult to meet denitrification conditions because nitrification processes are difficult to occur if more amount is introduced than the treatment amount that microorganisms can handle. In addition, nitrogen is removed using natural or artificial wetlands in the United States and Australia, where the available sites are wide, but it is not easy to apply in Korea (Oh & Shin, 2018).

Therefore, this research studied chemical treatment methods using sodium hypochlorite to treat ammonia nitrogen present in food wastewater, and studied methods that require less cost and time than biological treatment techniques currently used.

2. Research Methods and Materials

2.1. Experimental Materials

In the experiment of this study, 1L beaker, jar test stirrer, sodium hypochlorite solution, sodium hydroxide solution, food desorption anaerobic digestion treatment solution, DR3900(ammonia nitrogen analyzer), and ORP meter (oxidation-reduction potential meter) were used.

1% sodium hypochlorite was prepared by dissolving 10 mL of sodium hypochlorite in 1000 mL of distilled water, and 5% sodium hypochlorite was prepared by dissolving 50 mL of sodium hypochlorite in 1000 mL of distilled water.

2.2. Experimental Methods

The experiment was conducted a total of four times with different conditions, and the experimental method of each experiment is as follows.

2.2.1. Experiment 1

1) Put raw sample in each beaker.
2) Add 1% sodium hypochlorite to the raw sample in 2mL increments.
3) The oxidation-reduction potential is measured with an ORP meter, and the amount of nitrogen is measured with a DR3900.

2.2.2. Experiment 2

1) Put raw sample in SBR bioreactor and aerate and precipitate for 6 hours.
2) Place aerated/precipitated samples in each beaker.
3) Add 1% sodium hypochlorite to the raw sample in 2mL increments.
4) Stir the sample of each beaker for 1 hour.
5) The oxidation-reduction potential is measured with an ORP meter, and the amount of nitrogen is measured with a DR3900.

2.2.3. Experiment 3

1) Add 1% sodium hypochlorite to the raw sample.
2) Adjust the pH of the sample to 12.0 with 10% sodium hydroxide.
3) Stir each sample at 200-250 RPM for 30 minutes.
4) Measure the amount of nitrogen with DR3900.

2.2.4. Experiment 4

1) Add 5% sodium hypochlorite until the ORP value of the raw sample becomes +980 mV.
2) Measure the amount of nitrogen with DR3900.

The table below compares a total of four experimental methods conducted in this study.

Table 1: Comparison of Experimental Methods

Exp NO	Method	Note
Exp 1	Add sodium hypochlorite solution	1% sodium hypochlorite
Exp 2	Raw water is introduced into the SBR bioreactor, sodium hypochlorite is added after 6 hours of aeration/precipitation, stirring for 1 hour each	1% sodium hypochlorite
Exp 3	Adjust the pH to 12 and stir at 200-250 rpm for 30 minutes before adding sodium hypochlorite	1% sodium hypochlorite
Exp 4	Add sodium hypochlorite until the ORP is +980 mV	5% sodium hypochlorite

In Experiment 3, the pH was adjusted, a stirrer was used in Experiments 2 and 3, and in Experiment 4, 5% sodium hypochlorite was used.

4. Results and Discussion

4.1. Results of Experiment 1

Table 2: Comparison of denitrification effects (Exp 1)

Contents	Amount of sodium hypochlorite (mL)						
	0	1	2	4	6	8	10
NH_4^+-N (mg/L)	2,709	2,501	2,494	2,488	2,428	2,394	2,371
T-N (mg/L)	2,849	2,987	2,940	2,907	2,914	2,928	2,855
ORP (mV)	-270				-11	+286	+390

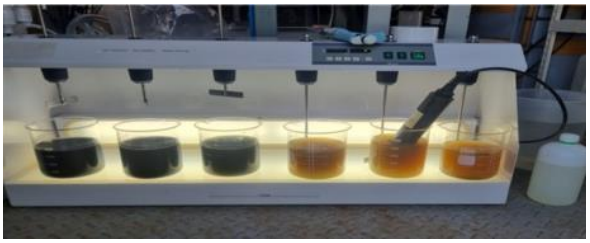

Figure 1: Comparison according to the amount of sodium hypochlorite injected (Exp 1)

When 10 mL of sodium hypochlorite was added to the raw sample without pH control, ammonia nitrogen decreased by 338 mg/L (about 12% decreased), but total nitrogen increased by 6 mg/L (about 0.2% increased). The target ORP value was set to +850mV and sodium hypochlorite was added, but the total nitrogen content increased together as the ORP value increased, so the method of Experiment 1 showed no significant effect.

4.2. Results of Experiment 2

Table 3: Comparison of denitrification effects (Exp 2)

Contents	Amount of sodium hypochlorite (mL)						
	0	1	2	4	6	8	10
NH4+-N (mg/L)	1,910	1,943	1,966	1,947	1,934	2,028	2,001
T-N (mg/L)	2,862	2,733	2,751	2,754	2,670	2,687	2,791
ORP (mV)	-0.3	+23.6	+72.4	+343.5	+440.0	+461.3	+468.7

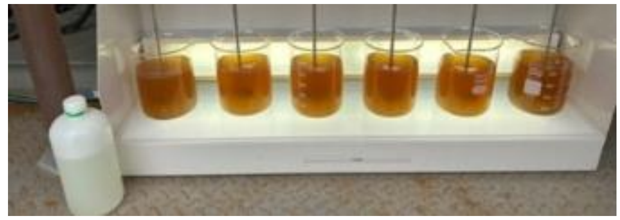

Figure 2: After adding sodium hypochlorite, before stirring

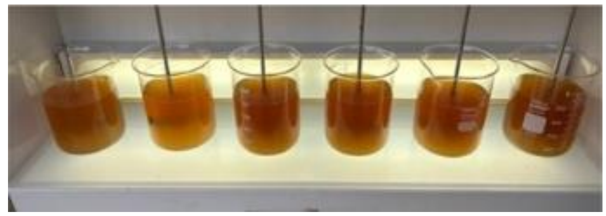

Figure 3: After adding sodium hypochlorite, after stirring

The raw sample was aerated in an SBR bioreactor for 6 hours without pH adjustment, sodium hypochlorite was injected with 1% sodium hypochlorite after precipitation, and then stirred for 1 hour. The ORP value increased as the amount of sodium hypochlorite injected increased, but the amount of ammonia nitrogen increased by 90 mg/L (about 4.7% increased) and the total amount of nitrogen decreased by 71 mg/L (about 2.5% decreased) and the method of Experiment 2 was ineffective in removing ammonia nitrogen.

4.3. Results of Experiment 3

Table 4: Comparison of denitrification effects (Exp 3)

Contents	pressurized floatation tank				pre-degradation tank			
	Before putting in		After putting in		Before putting in		After putting in	
	nitric acid nitrogen	ammonia nitrogen	nitric acid nitrogen	ammonia nitrogen	nitric acid nitrogen	ammonia nitrogen	nitric acid nitrogen	ammonia nitrogen
Analytical value (ppm)	42	1,125	29	620	10	159	8	64

As a result of adjusting the pH to 12 using 10% sodium hydroxide and stirring at 200~250 rpm for 30 minutes, 1% sodium hypochlorite was added. Nitric nitrogen was reduced by 13 mg/L (about 31% decreased) and ammonia nitrogen was reduced by 505 mg/L (about 45% decreased) in pre-dehydrogenation tank.

4.4. Results of Experiment 4

Table 5: Comparison of denitrification effects (Exp 4)

Contents	sodium hypochlorite	
	Before putting in	After putting in
NH4+-N(mg/L)	674	3.47
T-N(mg/L)	753	76.5
ORP(mV)	-300	+980
pH	8.6	7.2

When 5% sodium hypochlorite was added to raw samples with an ORP value of -300mV without pH adjustment until the ORP value reached +980mV, ammonia nitrogen decreased 670.53 mg/L (about 99% decreased) and total nitrogen decreased 676.5 mg/L (about 90% decreased).

5. Conclusions

This research studied chemical treatment techniques to remove ammonia nitrogen present in food wastewater. The following experimental results were derived by designing and performing an experiment on under which conditions the nitrogen removal rate was the highest using sodium hypochlorite.

In Experiment 1, which was injected with 1% sodium hypochlorite to raw samples, the amount of ammonia nitrogen tended to decrease slightly as the amount of sodium hypochlorite input increased, but the total amount of nitrogen did not decrease but rather increased.

The raw sample was injected in the SBR bioreactor by blowing for 6 hours, increasing 1% sodium hypochlorite after precipitation, and then stirring for 1 hour, the total amount of nitrogen tended to decrease slightly as the sodium hypochlorite input increased.

After adjusting the pH to 12 using sodium hydroxide, it was stirred at 200~250rpm for 30 minutes, and in Experiment 3 with 1% sodium hypochlorite, nitric acid nitrogen decreased by about 26%, and ammonia nitrogen decreased by about 53%.

In Experiment 4, in which 5% sodium hypochlorite was increased until the ORP value reached +980mV, the ammonia nitrogen decreased by about 99% and the total nitrogen decreased by about 90%.

Among the four experiments, Experiments 4 and 3 were able to remove ammonia nitrogen, and in particular, Experiment 4 had a high efficiency of about 99%. If this study is applied and demonstrated in the actual field, it is considered a good way to replace the existing biological treatment to remove ammonia nitrogen. However, since this is the result of a lab-scale experiment, the experiment will be conducted under more diverse conditions, and more accurate nitrogen removal rates and optimal techniques will be derived if applied in the actual field. In addition, in the case of Experiment 4 with a nitrogen removal rate of more than 90%, 5% of sodium hypochlorite must be used, so there is a possibility that there will be a burden on the purchase cost of the drug when using the method.

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