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Biological Nutrient Removal from Agroindustrial Wastewater Using a Two Reactor System

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Abstract – Agroindustrial wastewater is rich in organic material, especially organic carbon and nutrient. In this work a two reactors system consists of anoxic and aerobic reactor was operated with different recycle and C/N ratio. Experimentation using molasses-based artificial wastewater containing 114 mg/L of $\text{NH}_3\text{-N}$, 10 mg/L of $\text{NO}_3\text{-N}$, 25 mg/L of $\text{NO}_2\text{-N}$, and 1300 mg/L COD, which was fed directly into the anoxic reactor showed increasing of DO concentration in the anoxic reactor from 0,13 mg/L to 0,32 mg/L which increasing recycle ratios from 100% to 300%. Despite the anoxic reactor was capable to reach a nearly 94% denitrification efficiency, the overall system produced final effluent containing 98.31 mg/L of $\text{NO}_3\text{-N}$. yet, this system was capable to reduced COD concentration from 1,284 mg/L to 186 mg/L, reduced $\text{NO}_2\text{-N}$ concentration from 25.71 mg/L to 1.50 mg/L and $\text{NH}_3\text{-N}$ concentration from 114 mg/L to 0.91 mg/L with a 100% recycle ratio. Reducing the recycle ratio up to 50% still did not significantly improve the anoxic reactor for complete denitrification process. It produced a final nutrient containing 96.99 mg/L $\text{NO}_3\text{-N}$, 190 mg/L of COD, and 1.47 of $\text{NH}_3\text{-N}$ further experimentation using higher concentration of COD (2600 mg/L) with 100% recycle ratio resulted increasing denitrification efficiency from 94% to 97%. The overall system produced final effluent containing 94.48 mg/L of $\text{NO}_3\text{-N}$. this system was capable to reduced COD concentration from 2,644 mg/L to 232 mg/L

Keywords -

INTRODUCTION

Nitrogen compound in wastewater decreases water perimeter quality. It is because of nitrogen compound at certain concentration decrease oxygen concentration and cause eutrophication. That's why nitrogen compound in wastewater should be decreased as much as possible. A way to separate nitrogen compound is by applying waste treatment process biologically. General principal of biological treatment which is applied to separate nitrogen compound is nitrification and denitrification process.

Nitrification and denitrification are biological process in wastewater where nitrogen compound is changed into nitrogen gas. In nitrogen, ammonium oxidation becomes nitrite then nitrite is oxidized to be nitrate. Next step, nitrate is reduced to be nitrogen gas in denitrification process. Both processes change chemical compound which is harmful for environment to be the advantageous ones.

To make nitrification and denitrification perfect, we need to know the condition of environment and waste chemical compound. Worth-considering environment factors are dissolved oxygen and hydraulic retention time (HRT), for examples chemical compounds to be examined are organic deposit, ammonium, nitrite and nitrate. Dissolved oxygen is

needed while it is hardly needed in denitrification. This will also be influential in reduction oxidation process, which can be measured by ORP-meter. Hydraulic remain time will be represented by circulation debit. Circulation from aerobic reactor to anoxic reactor is believed to be very influential in nitrification and denitrification process perfection. Chemical compounds mentioned above are very influential in the process, as well. Organic deposit is needed for microorganism growth, so is ammonium nitride and nitrate.

MATERIAL AND METHOD

Material, which I used for this research, consists of two kinds, processing materials and analytical material. Material for processing is molasses based artificial waste. Materials for analytical purpose are chemical materials for analysis of COD, $\text{NH}_3\text{-N}$, $\text{NO}_3\text{-N}$, $\text{NO}_2\text{-N}$, DO, pH and ORP analysis.

Tools used for research are two-steps reactors, anoxic and aerobic reactor, with capacity of 5,000 ml respectively. Tool for analysis is analytical tool for COD, $\text{NH}_3\text{-N}$, $\text{NO}_3\text{-N}$, $\text{NO}_2\text{-N}$, DO meter, pH meter and ORP meter. Analytical methods used are COD with oxidarion calcium dichromate methods, BOD with Winkler methods, $\text{NH}_3\text{-N}$ with Nessler method, $\text{NO}_3\text{-N}$ with brusin-sulfanilat methods, and $\text{NO}_2\text{-N}$ with naftilamin method.

This research examines optimum condition in nitrification and denitrification process.

Optimizing is observed by circulating process from aerobic reactor to anoxic reactor.

Besides, optimum ratio of COD and nitrogen compound in wastewater in nitrification and denitrification process is measured

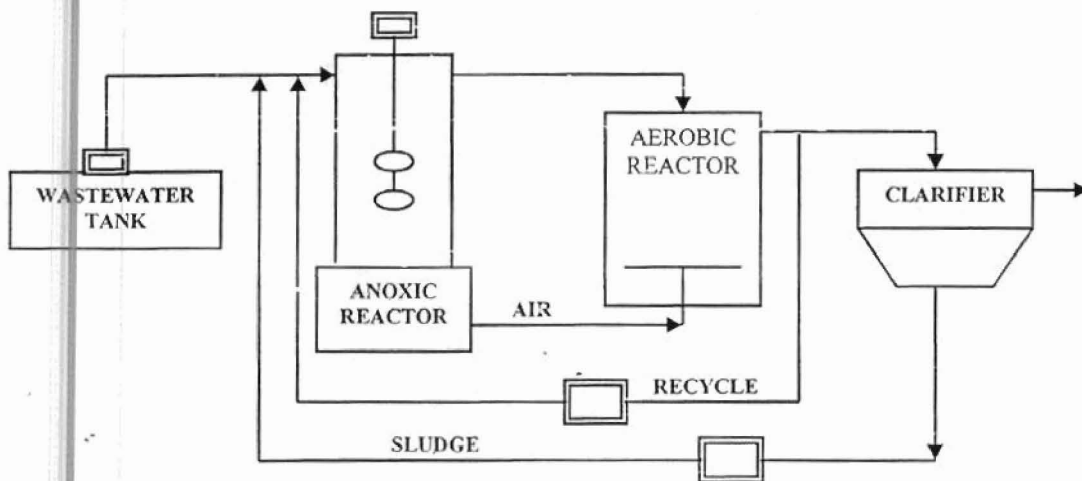


Figure 1. Reactor Configuration

Figure 1 shows reactor configuration used in this research. Various circulations from aerobic reactor to anoxic reactor are done in the research. Various circulation's are 0%, 50%, 100%, 200% and 300% to influent.

On a research, which is done to examine the influence of burdened waste against nitrification and denitrification process, it is made various waste with various ratio of COD and nitrogen compound. The ratio will be made to 10/1 and 20/1

RESULT AND DISCUSSION

1. Circulation Speed Influence to $\text{NH}_3\text{-N}$ decrease (Nitrification)

$\text{NH}_3\text{-N}$ change obviously takes place either at anoxic reactor or at aerobic reactor at anoxic reactor the more circulation speed the more $\text{NH}_3\text{-N}$ decrease. This can happen because more oxygen concentration dissolve when circulation speed is higher. When dissolved oxygen concentration at anoxic reactor reaches higher, nitrification process will work at anoxic reactor

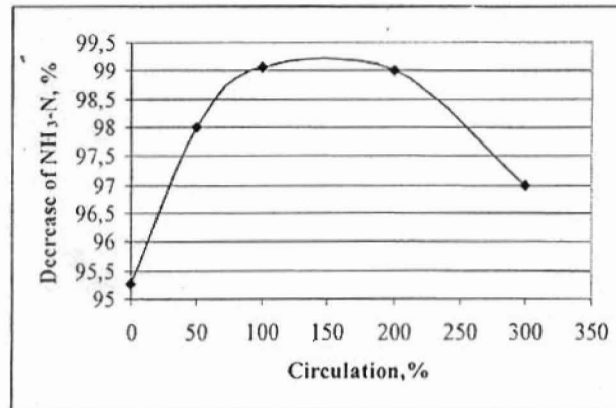


Figure 2. Circulation Speed Influence to Total Percentage of $\text{NH}_3\text{-N}$ Decrease

As a whole $\text{NH}_3\text{-N}$ can be decreased particularly at aerobic reactor where nitrification process occur. Total percentage of $\text{NH}_3\text{-N}$ decrease at every circulation speed level is seen at figure 2. Figure 2 shows that most optimum decrease of 99.07% takes place at 100% circulation speed level.

Nitrification process occurs at aerobic reactor where ammoniac is changed to be nitride and then nitride is oxidized to be nitrate. Thus decreasing ammoniac at aerobic reactor shows nitrification amount. Figure 3 shows that circulation significant for decreasing $\text{NH}_3\text{-N}$. At ratio of COD/N 20/1 with 100% circulation, total decrease of $\text{NH}_3\text{-N}$ is smaller compared with COD/N 10/1 ratio i.e. from 99.7% to be 93.68%.

Figure 2 shows that optimum percentage to decrease ammoniac is 100% circulation toward influent i.e. 99.07%. In this case, it is said that optimum nitrification at COD/N 10/1 occur at 100% circulation. By increasing COD/N ratio to 20/1 so that nitrification decrease to 93.68%. It shows that COD/N ratio increase has enough influence to decrease nitrification.

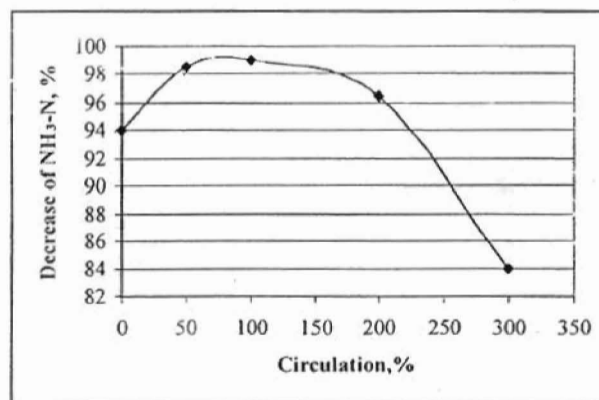


Figure 3. Circulation Speed Influence to Percentage $\text{NH}_3\text{-N}$ Decrease at Aerobic Reactor

2. Circulation Speed Influence to $\text{NO}_3\text{-N}$ decrease (Denitrification)

Beside of waste contains $\text{NO}_3\text{-N}$. $\text{NO}_3\text{-N}$ itself is made at aerobic reactor. Further change of ammoniac to be nitride is becoming nitrate. Nitrate resulted at aerobic reactor is circulated to anoxic reactor to be changed to be nitrogen gas. This denitrification process is done by bacteria *Pseudomonas*, *Alkaligenes*, *Acinetobacter*, *Hyphomicrobium*, and *Thiobacillus* (Fochit and Verstrate, 1977). These bacteria live in limited oxygen content. In this research, optimum oxygen content denitrification decrease again.

Denitrification is stated as decrease of $\text{NO}_3\text{-N}$ at anoxic reactor. There are two sources of nitrate which go into anoxic reactor namely influent and circulation of aerobic reactor. Circulation of aerobic reactor bears dissolved oxygen so that the faster circulation speed the bigger dissolved oxygen at anoxic reactor. Level of circulation influences decrease percentage of nitrate at anoxic reactor as shown by Figure 4.

Figure 4 shows that increase of circulation speed influence decrease percentage of nitrate. It means the faster circulation speed the higher concentration of nitrate goes into anoxic reactor.

It is clear if it's compared to control (0% circulation speed). From exposed circulation, 200% circulation speed reaches the highest decrease percentage of nitrate i.e. 94.97%. At higher exposed circulation i.e. 300%, decrease speed of nitrate goes down again. It means the most optimum of circulation speed is 200%.

When ratio increase of COD/N becomes 20/1 denitrification is almost unchanged i.e. 94.78%.

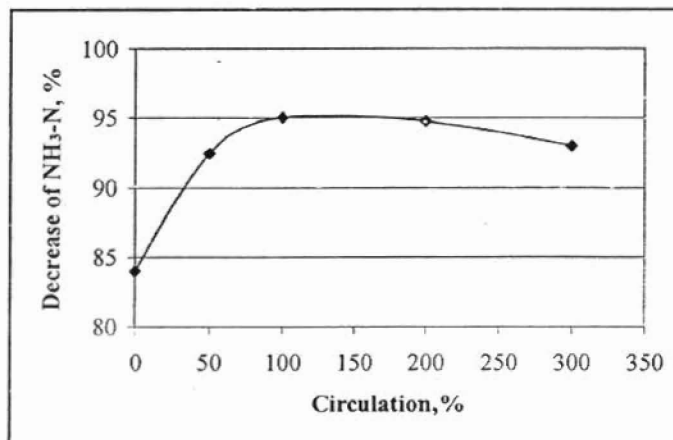


Figure 4. Circulation Speed Influence to Total Percentage of $\text{NO}_3\text{-N}$ Decrease

3. COD Decrease in Nitrification and Denitrification

Decrease percentage of COD is almost not influenced by circulation speed level. At 0% circulation COD decrease 85.24%, at 50% circulation COD decrease 85.23%, at 100% circulation COD decrease 85.94%, at 200% circulation COD decreases 85.0% and 300% circulation cause COD to decrease 85.38%. While COD/N 20/1 ratio which done at 100% circulation, COD decrease from 85.94% to 91.70%.

4. Total Nitrogen Compound Decrease

Total nitrogen is sum of $\text{NH}_3\text{-N}$, $\text{NO}_3\text{-N}$, and $\text{NO}_2\text{-N}$ concentration. At COD/N 10/1 ratio average efficient decrease of nitrogen compound at 100% circulation is 60.13%, while COD/N 20/1 ratio is 59.46%. The highest compound if effluent is $\text{NO}_3\text{-N}$. This compound becomes high because of there is a change of nitride to be nitride to be nitrate as a result of ammoniac change.

CONCLUSION

Optimum nitrification of COD/N 10/1 ratio can be reached at 100% circulation and 99.07% efficiency while COD/N 20/1 is at the same circulation and 93.68% efficiency. Optimum denitrification of COD/N 10/1 can be reached at 200% circulation and 94.97% efficiency while COD/N 20/1 is at 100% circulation and 94.78% efficiency. Total efficient decrease of nitrogen compound at COD/N 10/1 ratio is 60.13% while COD/N 20/1 is 59.46%.

RECOMENDATION

In order to raise efficient decrease of nitrogen compound, it should be added an anoxic reactor after aerobic to make nitrate concentration down.

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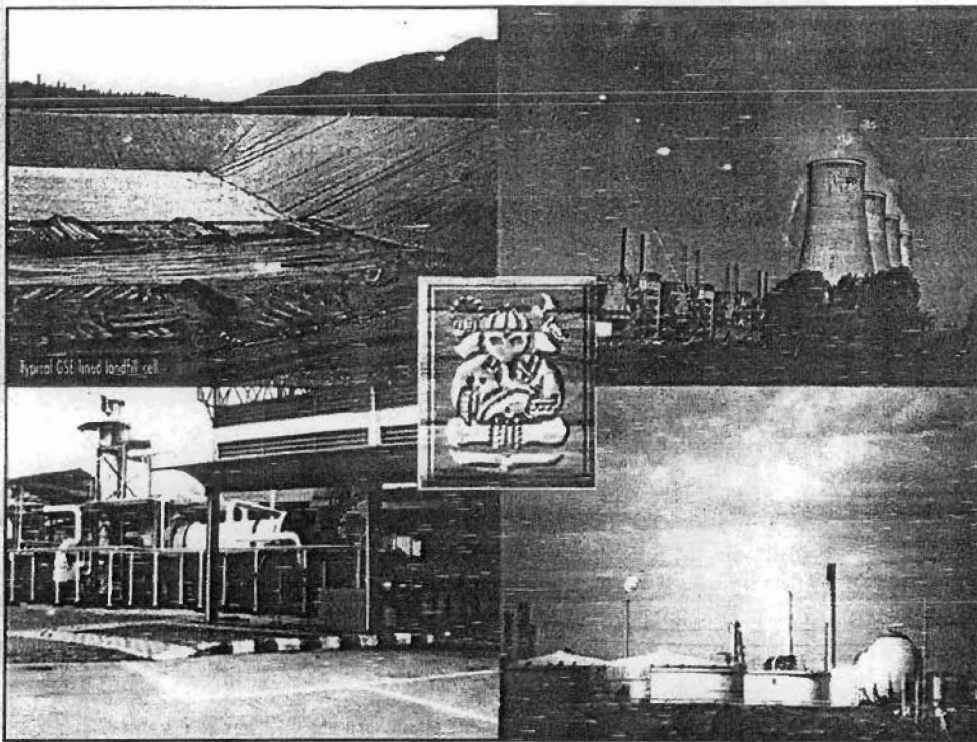
PROCEEDINGS

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