# Effect of a rapid repair mechanism for nitrification capacity in the load impact wastewater treatment

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**Abstract**. The nitrification capacity in the wastewater treatment is very important, and is particularly vulnerable to impacts. In this study, a rapid repair mechanism for nitrification was built and the result showing that, with the addition of exogenous nitrifying bacteria and organic nutrient, the nitrification capacity in the pilot scale equipment was restored in 20h, the concentration of $NH_3$-N in discharge conforms to the one-class A permitted criterion (GB 18918-2002) and remain stable for long time, while the nitrification capacity in control group would not be fixed by itself in 196h. The repaired experimental group has the advantage of strong shock resistance and stable operation, and under the second high impact load, the concentration of $NH_3$-N in effluent remain stable.

## 1. Introduction

With the rapid development of world economy, the demand for water in industrial production is increasing, as well as the discharge of wastewater. Excess ammonia nitrogen in wastewater has caused wide attention of researchers and environmentalists advocates. High $NH_3$-N concentration is known to heavy algal growth thus promoting the eutrophication in water bodies. Elevated $NH_3$-N concentration also causes certain effect for water treatment equipment and reuse engineering plant [1]. As one of the wastewater treatment processes, microorganism treatment is a method of low cost, high efficiency and pollution free. Nitrification is the predominant removal process of ammonia in the microorganism treatment. While nitrifying bacteria have a low growth rate, and are sensitive to the external stimulus such as temperature, pH, dissolved oxygen and toxic substances, nitrification is also the limiting step of biological denitrogenation, and vulnerable to load shocks[2].

When the nitrification system been impaired and the $NH_3$-N concentration of discharge water continue to be high, traditional restored approaches, such as stop intake, replace the activated sludge and increase of HRT and aeration, require long stretches of time. Chemistry methods which control the $NH_3$-N concentration at least temporarily are usually high-cost and generate secondary pollution [3]. It is critical to establish an efficient and effective method to repair the nitrification capacity for the load shocked wastewater treatment. In this study, a rapid repair mechanism is built to restore the nitrification capacity of a load shocked industrial park treatment plant. The park treatment plant was shocked by the upstream factory accident drainage, and the nitrification system of it was nearly destroyed. Pilot scale equipment was built and debug for the reference about the park treatment system, and exogenous nitrifying bacteria and organic nutrient were added to facilitate the reparation of nitrification system. Data and conclusions of this study will provide technical support and theoretical guidance for the treatment plants with the same problem.

## 2. Materials and methods

### *2.1. The wastewater treatment plant in the industrial park*

The design treatment capacity for the wastewater treatment plant in an industrial park of Suzhou is 8000 $m^3$/d, and the upstream wastewater was mainly domestic wastewater, printing and dyeing wastewater, tannery wastewater, pesticide wastewater and metal processing wastewater, in which the domestic wastewater accounts for about 40%. The treatment processes in the plant are "Collection-well, Anoxic-tank, Anaerobic-tank, Clarifier, and Effluent". The pollutant concentrations in the inflow and effluent under normal operating conditions are showing in table 1. After been shocked by the accident drainage, the $NH_3$-N concentration in effluent had increased to 26-31 mg/L and remained high in a long time.

**Table 1.** Pollutant concentrations in the inflow and effluent under normal operating conditions.

| Sample | $COD_{Cr}$ (mg/L) | $NH_3$-N (mg/L) | TN (mg/L) | pH |
|---|---|---|---|---|
| Inflow | 290-370 | 23-30 | 35-43 | 7.5-8 |
| Effluent | 38-46 | 0.2-0.8 | 22-32 | 6.8-7.3 |

### *2.2. Equipments and materials for the pilot scale experiment*

In this study, two same systems of pilot scale experiment were set up, one was experiment group and other was control group. The treatment processes for the two systems were designed for the reference about the treatment system in the industrial park treatment plant. Experimental studies and debug had been conducted, simulating operating conductions of the park treatment plant. The flow diagram for the pilot scale equipment is showing in Fig. 1. The effective volume of the tank is 0.5 $m^3$, in which the wastewater from regulation pool in the park treatment plant was pumped as incoming water every 12h. The design treatment capacity for each device is 100L/h. The effective volume of Anoxic-tank is 0.8 $m^3$ and Anaerobic-tank is 2.4 $m^3$. The activated sludge of every tank was inoculated from the corresponding treatment tank of plant.

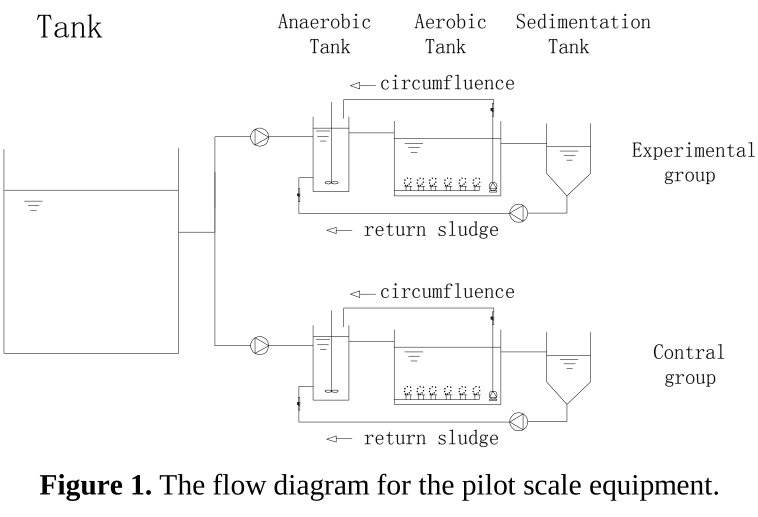


**Figure 1.** The flow diagram for the pilot scale equipment.

The exogenous nitrifying bacteria added in the experimental group are Novozymes BioRemove™ 5805, and the organic nutrient, which is patented product, was produced by SAES Environmental Science and Technology CO. Ltd. The organic nutrient is to improve the structure of zoogloea granules in activated sludge, and to enhance the attachment and proliferation for the exogenous nitrifying bacteria [4].

*2.3. Methods*

The rapid repair mechanism was composed of the addition of exogenous nitrifying bacteria and organic nutrient. The dosage of exogenous nitrifying bacteria added into the experimental group's Anaerobic-tank is 100 mg/L, and was provided by twice. At the start of experiment, take time as 0 h and added 60% of nitrifying bacteria. When the experiment time is 6 h provided the other 40% of nitrifying bacteria. The dosage of organic nutrient is 300mg/L and was provided by fifth times. Added 20% of organic nutrient at 0.5h and provided 20% of organic nutrient every 12 h. The control group was added no agents as contrast.

The concentration of $NH_3$-N in incoming water and effluent from experimental and control group was detected every 4 h according to the Nessler's reagent spectrophotometry [5]. The structure of zoogloea granules in activated sludge from two groups was detected by Olympus BX41 - DP25 microscope.

## 3. Result and discussion

*3.1. Removal of $NH_3$-N in experiment and control group*

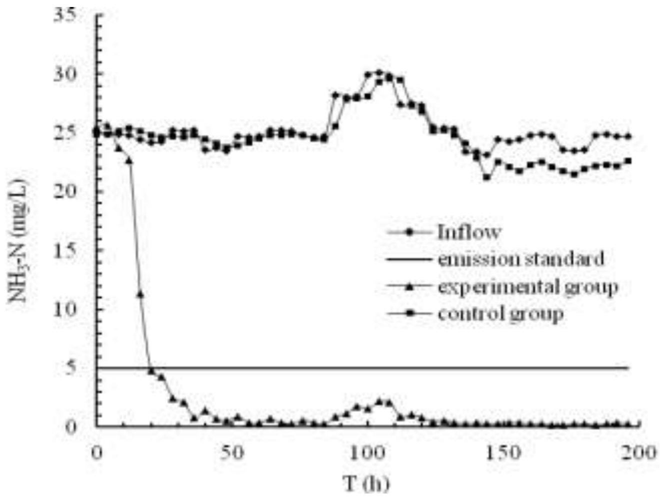


**Figure 2.** Removal of $NH_3$-N in experimental and control group.

The $NH_3$-N concentration in incoming water and effluent from experimental and control group during experiment was shown in Fig 2. As shown in Fig 2, the concentration of $NH_3$-N in effluent from experimental group increased in 8h after the addition of nitrifying bacteria. Main causes of the fluctuation is that in the medium of nitrifying bacteria, there was a suitable amount of $NH_3$-N, and the nitrifying bacteria need to take a certain time to attach and grow. After 12h the concentration of $NH_3$-N in effluent from experimental group decreased with immersing time, and 16h reduced significantly, 24h reduced to standard value (5 mg/L) [6]. As time went on, the concentration of $NH_3$-N in effluent from experimental group reduced to 1mg/L, and the removal rate was up to 95%. This result suggest that with the assistance of organic nutrients, the nitrifying bacteria were allowed to stay with the zoogloea granules in activated sludge, rapidly multiplying and spreading out to remove $NH_3$-N, and the repair mechanism for nitrification did work rapidly and effectively in 24h. As a control, the $NH_3$-N in effluent from control group was almost the same value with that of income water, and the removal rate of control group was still below 5% after 150 h. This results shown that the nitrifying system could not be restored by generation's update during a short time.

At 88 h of experiment time, the concentration of $NH_3$-N in income water increased to 29 mg/L, which brought second impact load. The concentration of $NH_3$-N in experiment group had a little volatility and was still below 2 mg/L, conformed to the discharge stand, while that in control group increased rapidly to 28 mg/L during the second impact load. After 24h the concentration of $NH_3$-N in experiment group revert back to 1 mg/L and 36h to below 0.5mg/L. This result suggest that with the assistance of exogenous nitrifying bacteria and organic nutrient, the nitrifying system in experiment group built stronger stability and shock resistance ability. Similar results have been reported in other studies [7].

### *3.2. The effect of organic nutrients*

With the addition of exogenous nitrifying bacteria and organic nutrient, the nitrification capacity of load shocked treatment system was restored, the structure of zoogloea granules had been changed and activated sludge settleability been strengthened. Fig 3 shows the effect of organic nutrients on the structure of zoogloea granules in activated sludge.

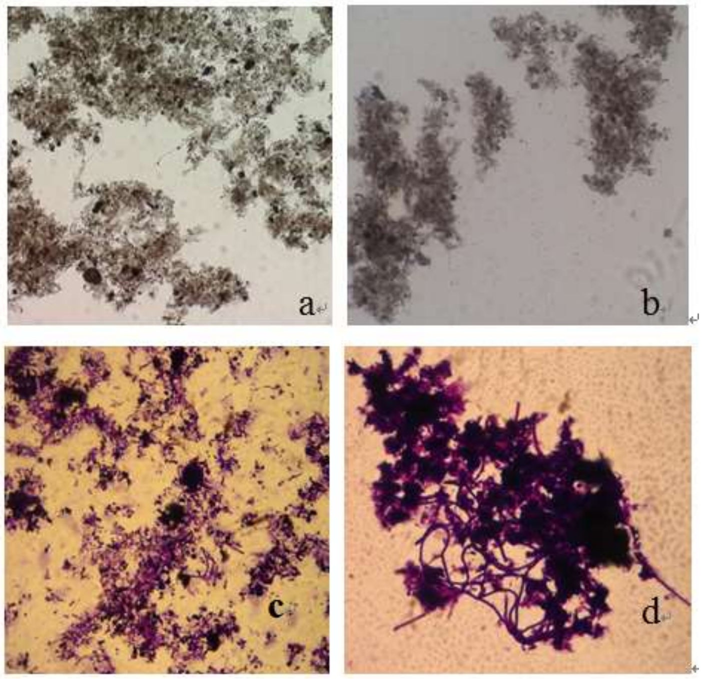


**Figure 3.** The effect of organic nutrient on the structure of zoogloea granules in activated sludge.

As shown in Fig 3, the microscopy images of 100 times for experimental group is (a) and control group is (b), and 1000 times for experimental group is (c) and control group is (d). Contrast image (a) and (b), with the assistance of organic nutrient, the structure of zoogloea granules in activated sludge from experimental group had been improved and were more compact, which has the advantage of attachment and proliferation for the exogenous nitrifying bacteria. And compare image (c) and (d), the zoogloea granules in experimental group had more filamentous fungi structure, which help to compact the structure of zoogloea granules. These results suggest that the addition of organic nutrient stimulate the proliferation of bacteria in activated sludge. Previous research has proved that the organic nutrient is advantageous to the total number of bacterial species, and the community structure of bacteria [8].

## 4. Conclusion

The rapid repair mechanism for nitrification, with the addition of exogenous nitrifying bacteria and organic nutrient, restored the nitrification capacity in the pilot scale equipment in 20h, the concentration of $NH_3$-N in discharge conforms to the one-class A permitted criterion (GB 18918-2002), and after been repaired for 24h, the nitrification capacity could remain stable for a long time. While only relay on the self-healing capabilities, the nitrification capacity in the control group would not be fixed in 196h.

The structure of zoogloea granules in activated sludge had been improved in the repaired experimental group, which has the advantage of attachment and proliferation for the exogenous nitrifying bacteria. Thus the experimental group had strong shock resistance and stable operation, and under the second high load impact, the nitrification capacity self-restored in 24h and the concentration of $NH_3$-N in discharge remain stable.

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