Experimental Research on Enhanced Denitrification by Biological Agents

Xiaoyu Liu^{1,2*}, Ruozheng Li^{1,2}, Zhengkun Li^{1,2}, Can Wang^{1,2}

¹ Nari Group Corporation/State Grid Electric Power Research Institute, Nanjing 210000, Jiangsu Province, China

² Beijing Guodian Futong Science and Technology Development Co., Ltd., Beijing 100070, China

Abstract. Biological agents play a significant role in sewage treatment, with good removal effect, low sludge yield, good performance, and shorten the system start-up time, impact load resistance and stability enhancement. This paper describes the characteristics of biological agents and the effect of biological agents on wastewater denitrification was investigated through experiments, so as to provide effective basis support for the wide application of biological agents in the field of urban sewage treatment. The experiment showed that through reasonable addition of biological agents, the removal rates of COD, NH₃-N and TN in low pollutant sewage treatment were increased by 41%, 15% and 62% respectively.

1 Biological agents and biofortification techniques

In recent years, with the increase of environmental protection requirements and the continuous development of environmental biotechnology, bioremediation, as a water pollution treatment technology with low investment, high efficiency, convenient operation and flexibility, has been gradually developed and applied in projects, and is gradually being widely valued and applied worldwide. Bioaugmentation presents a quick and cost effective way to solve wastewater treatment problems that would traditionally be solved with expensive capital enhancements[1-2].

This study adopts BiOWiSH[™] technology which creates a composite biocatalyst from a unique blend of microorganisms, enzymes, and co-factors. This composite biocatalyst enhances biochemical reactions in wastewater treatment plants, enabling the process to work faster and more efficiently than native biological organisms alone. BiOWiSH[™] biocatalysts coexist with existing wastewater biology to enhance their rate of reaction, resulting in a more efficient biological treatment process[3].

2 Advantages of biological agents in the application of municipal sewage

Biological agents are bacterial liquid agents selected from the nature with specific degradation functions. The application of biological agents can effectively shorten the time of microbial culture and domestication, improve the concentration of microorganisms in the biological treatment system, and thus improve the work efficiency. In addition, biofortified agents are easy to operate, safe to use and can save energy. For example, in the sewage

treatment of urban sewage, bacteria can be activated and added to the sewage, which can erode the organic particles of grease in the sewage, and has an obvious effect on the treatment of grease blockage in the sewage. In addition, the carbohydrates, nitrogen and phosphorus and other nutrients in urban sewage provide sufficient nutrients for the growth and reproduction of microorganisms. The use of special microbial agents to enhance the treatment of urban sewage can significantly improve the removal efficiency of organic matter in sewage, reduce the generation of solid substances, enhance nitrification, enhance the effect of denitrification and phosphorus removal, and thereby improve the water purification efficiency of urban sewage[4-6].

3 The experiment part

3.1 The experiment purpose

This experiment is expected to study the application effect of biological reagent in the process of urban sewage treatment by using BiOWiSH[™] technology company's biological agents. Under aerobic conditions, the effects of adding biological reagents on organic pollutant in the treated water and the changes of TN indicators were investigated to study BiOWiSH[™] preparation's bioremediation effect on urban sewage.

3.2 The water sample

The drainage of the company apartment was chosen as the water sample of this study. The water quality is shown in the table 1.

*Corresponding author's e-mail: liuxiaoyu1@sgepri.sgcc.com.cn

Table 1. The water quality situation.

COD (mg/L)	NH ₃ -N (mg/L)	pH	NO ₃ -N (mg/L)	TN (mg/L)
79	29.6	7.28	1.03	31.1

3.3 Experimental materials and methods

3.3.1 Experimental materials

The experiment was carried out with the biological agents which belongs to BiOWiSH™ in the United States and the AMBR device for the study of denitrification. By investigating the removal rates of COD, NH₃-N and TN, this paper studies whether biological agents have positive effects on sewage treatment, especially on denitrification.

(1) Chemicals and agents

BiOWiSH™ biological agents, glucose, KMnO₄, C₂Na₂O₄, K₂S₂O₈, C₇H₆O₃, C₄O₆H₄KNa, Na₂Fe(CN)₅NO₂·H₂O, NaClO, NaOH, HCl, H₂SO₄.

(2) Devices

AO plus MBR, pumps, air compressor, oxygen analyzer.

(3) Detection methods

GB/T 15456-2008 Industrial circulating cooling water - Determination of the chemical oxygen demand - Potassium permanganate method.

HJ 536-2009 Water quality-Determination of ammonia nitrogen-Salicylic acid spectrophotometry.

HJ 636-2012 Water quality-Determination of total nitrogen UV spectrophotometric method-Alkaline potassium persulfate digestion method.

3.3.2 Experimental methods

The device parameters were set according to these parameters:

(1) flow rate: 6L/h;

(2) HRT: A=7.31h, O=18h ;

(3) mixture reflux ratio: 200%-400%;

(4) dosage of biological preparation: 5ppm;

(5) dosage of glucose demand: C/N=4.

After adding activated sludge, sewage and nutrients, aerate for one day, the experiment was carried out according to the experimental methods in table 2.

Table 2. Experimental methods.

The serial number	Conditions	Reflux ratio
1	nothing added	200%
2	only biological agents	200%
3	only biological agents	400%
4	only glucose	400%
5	biological agents and glucose	400%

3.4 Conclusion and discussion

(1) Conduct experiments according to serial numbers 1 and 2 in table 2. The indexes changes of COD, NH₃-N and TN are shown in figure 1-3.

In experiment 1, the removal rates of COD, NH₃-N and TN were 35%, 82% and 22% respectively. In experiment 2, the removal rates of COD, NH₃-N and TN were 76%, 97% and 23% respectively.

Through comparison of experiments 1 and 2, it was found that the removal rate of COD and NH₃-N respectively increased by 41% and 15% by adding biological agents, it can be seen from the COD change curve in figure 1 that it takes about 8 days for COD to be

reduced to 50mg/L in experiment 1, and only 4 days for COD to be reduced to 20mg/L after adding biological agents. This shows that biological agents can not only improve the removal rate of COD, but also improve the removal speed, which is also applied to the NH₃-N change curve in figure 2.

The removal rate of TN in both experiments was very low, and the removal rate did not increase after adding biological agents.

It can be concluded that the reflux ratio of 200% and only adding biological agents can significantly improve the removal rate of COD and NH₃-N, but it has no effect on the removal rate of TN.

Figure 1. The trend of COD in two experiments.

Figure 2. The trend of NH₃-N in two experiments.

Figure 3. The trend of TN in two experiments.

(2) Continue the experiment according to the numbers 3-5 in table 2. Only the index change of TN was investigated, as shown in figure 4.

Figure 4. The trend of TN in five experiments.

It can be clearly seen from table 3 that on the condition of adding biological agents only, the reflux ratio increased from 200% to 400%, the denitrification rate decreased, which is contrary to the theoretical value. Considering the reasons, probably because a large amount of dissolved oxygen in the aerobic zone enters the anoxic zone and damages the denitrification environment. And by increasing the reflux ratio, the denitrification bacteria could not utilize enough organic matter during denitrification, which affected the

denitrification reaction and reduced the denitrification rate.

It can be seen from experiment 3-5, under the condition of reflux ratio of 400%, adding glucose can effectively improve the denitrification rate, and adding glucose and biological agents together can improve the denitrification rate to 84%.

Therefore, it can be concluded that the addition of nutrients should be taken into account in the enhanced denitrification by biological agents, so that the denitrification rate can be effectively improved.

Table 3. Denitrification rate under different conditions.

The serial number	Conditions	Reflux ratio	Denitrification rate
1	nothing added	200%	22%
2	only biological agents	200%	23%
3	only biological agents	400%	21%
4	only glucose	400%	54%
5	biological agents and glucose	400%	84%

4 The experimental conclusion

(1) Only adding biological agents can remove COD and $\text{NH}_3\text{-N}$ effectively, but not TN.

(2) Adding carbon source can increase the denitrification rate to 54%, and adding carbon source and biological agent together can increase the denitrification rate to 84%.

References

1. Liu, Z., Huang, R.M., He, J.C.. (2014) Bio-augmentation of SBR with Microbial Agent. Chinese Journal of Environmental Engineering, 8: 1988-1991.
2. Li, Y., Chen, J. etc. (2014) Study on Application of Decontamination Biologics in Water Quality Improvement of Urban Watercourses. The Water Environment, 4: 30-32.
3. BioWiSH™ Industrial Wastewater Brochure Ir.
4. Chen, L.C.. (2017) Research and application of microorganism preparation in water treatment. Applied Chemical Industry, 46: 986-987.
5. Yuan, D.Y.. (2015) Effect evaluation and influence factor analysis of biofortification technology in wastewater pretreatment. Resource Conservation and Environmental Protection, 3: 175-176.
6. Wang, P.. (2017) Study on The Mechanism and Application of Biofortification Technology in Wastewater Treatment. Resource Conservation and Environmental Protection, 3: 175-176.