Research on Efficiency of Improved IFAS Process in Treating Rural Sewage

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Abstract. Based on researches of a wastewater treatment plant for rural sewage treatment in Tongzhou District, Beijing city, efficiency of IFAS process was studied to support its broad-wide use in rural area. The results showed that, for the influents with COD, ammonia, TN and TP levels of 60-203mg/L, 9.5-40mg/L, 16-45mg/L and 1.2-4.7mg/L, highest removals of 91%, 98%, 78% and 93% can be obtained with levels of effluents below than 40mg/L, 1.5mg/L, 15mg/L and 1.0mg/L. Removals of the contaminants were low under low temperatures in winters.

1. Introduction
Activated sludge process is the most widely used sewage treatment technology in the world. With the improvement of wastewater treatment requirements, a variety of new and improved activated sludge processes have been extended. In 1980s, an integrated fixed-film activated sludge (IFAS) technology was developed on the basis of traditional activated sludge process [1]. In this technology, different types of fillers are added to the suspended sludge to strengthen the reactor, so as to obtain higher sludge quantity. At the same time, the generation cycle of microorganisms is longer, which is beneficial to the survival and enrichment of microorganisms related to nitrogen and phosphorus removal and can improve the efficiency of nitrogen and phosphorus removal. By coupling the advantages of activated sludge and biofilm, the improved IFAS process has the advantages of stronger adaptability, shock load resistance, prevention of sludge bulking, good mass transfer effect and enhanced denitrification function [2-4].

The treatment efficiency of improved IFAS process is affected by many factors such as temperature, influent water quality and biofilm thickness. Based on a sewage treatment project in Tongzhou District of Beijing, this paper studies the impact of improved IFAS process on the actual rural domestic sewage treatment efficiency, so as to provide support for the promotion of the process in rural areas.

2. Methods and materials
2.1. Reactor description
The improved IFAS process equipment is shown in Figure 1, which is composed of anaerobic unit, anoxic unit, aerobic unit and secondary sedimentation tank. The designed treatment scale is 100 m³/d,
and the hydraulic retention time is 9.8h. Fixed composite fiber packing is adopted, and the filling ratio is 35% of the aerobic unit tank capacity.

The specific process flow is as follows: sewage is lifted to anaerobic tank, and then flows into anoxic tank, aerobic tank and secondary sedimentation tank by gravity flow. Firstly, the sludge is returned to anoxic tank, and nitrate nitrogen is degraded by denitrification, and then the mixed liquor of anoxic tank is returned to anaerobic tank for phosphorus release.

![Figure 1. Improved IFAS process equipment](image)

### 2.2. Test water and analysis method

The test water is the actual domestic sewage of a rural area in Tongzhou District of Beijing. The main pollutants inflow water quality index is shown in Table 1.

| Water quality index | COD (mg/L) | TN (mg/L) | NH₃-N (mg/L) | TP (mg/L) | pH  |
|---------------------|------------|-----------|--------------|-----------|-----|
| Concentration       | 60-203     | 16-45     | 9.5-40       | 1.6-5     | 6.7-7.5 |

### 2.3. Water quality analysis method

The main water quality indexes and analysis methods determined in the test are shown in Table 2.

| Items     | Analytical method                                      | Standard number |
|-----------|--------------------------------------------------------|-----------------|
| CODcr     | Rapid digestion spectrophotometry                      | HJ/T399-2007    |
| NH₃-N     | Nessler's reagent Spectrophotometry                     | HJ535-2009      |
| TN        | Potassium persulfate oxidation ultraviolet spectrophotometry | HJ635-2012 |
| TP        | Molybdenum antimony spectrophotometry                   | GB11893-89      |
3. Results and discussion

3.1. Analysis of COD removal efficiency
From January 8, 2019 to August 29, 2019, the influent COD concentration fluctuates within 60-203 mg/L, and the corresponding COD removal rate fluctuates in the range of 25% - 91%. Under the influence of low temperature in cold season, the removal rate is low, about 25% - 60%. In warm season, the removal rate is higher than 70%, and the highest removal rate is more than 90%. The effluent concentration is kept below 40 mg/L.

![COD treatment efficiency of improved IFAS process](image)

Figure 2. COD treatment efficiency of improved IFAS process

3.2. Analysis of ammonia nitrogen treatment efficiency
During the trial operation period from January 8, 2019 to August 29, 2019, the ammonia nitrogen concentration in the influent water fluctuated within 9.5-40 mg/L. The corresponding ammonia nitrogen removal rate fluctuates in the range of 5%-98%, and the removal rate is low due to low temperature in the cold season. Studies have shown that the biological nitrification reaction can be carried out in the temperature range of 4-45°C. The optimal growth temperature of nitrifying bacteria is 25-30°C. Studies have shown that when the temperature is less than 15 °C, the nitrification rate is significantly reduced, and the activity of nitrifying bacteria is greatly reduced. When the temperature is lower than 5°C, the life activities of nitrifying bacteria are almost stopped, and it is more common that the stable operation of the nitrification process cannot be realized due to the lower temperature in winter [5]. When the temperature is higher than 15°C, the removal rate can reach more than 90%, and the effluent concentration is mostly kept below 1.5mg/L.
3.3. Analysis of total nitrogen treatment efficiency
The data show that during the operation period from January 8, 2019 to August 29, 2019, the total nitrogen influent concentration was in the range of 16-45mg/L, and the corresponding total nitrogen removal rate fluctuated in the range of -15%-78%, and the total nitrogen concentration even showed an upward trend during the low temperature period. According to the analysis, this phenomenon is related not only to the sharp decrease of the activities of nitrifying bacteria and denitrifying bacteria at low temperature [6, 7], but also to the deterioration of sludge settling performance and the loss of fine sludge particles into the effluent at low temperature [8-10]. In warm season, the total nitrogen removal rate is higher than 50%, and the effluent concentration is mostly kept below 15mg/L.

3.4. Analysis of total phosphorus treatment efficiency
During the operation period from January 8, 2019 to August 29, 2019, the total nitrogen influent concentration fluctuated in the range of 1.2-4.7 mg/L, and the corresponding total phosphorus removal rate fluctuated in the range of -33%-93%. Similar to the degradation of total nitrogen, the concentration...
of total phosphorus in the effluent has an upward trend during the low temperature period, which is mainly due to the decrease of sludge settling performance under low temperature conditions, which leads to the loss of fine sludge particles [11, 12]. In the sewage treatment system, activated sludge enriches phosphorus in sewage through microbial life activities. At low temperature, due to the low secretion ability of microbial community, the adhesion between microorganisms becomes weak, resulting in fine particles of activated sludge, which is not suitable for sedimentation, and the concentration of total phosphorus in effluent does not decrease but rises when it enters the effluent. Moreover, the rising trend of TP at low temperature is consistent with that of TN, which proves this inference. Under the condition of increasing temperature, the total phosphorus removal rate is higher than 60%, and the effluent concentration is mostly kept below 1.0 mg / L.

![Figure 5. TP treatment efficiency of improved IFAS process](image)

To sum up, the improved IFAS process can achieve good treatment effect for rural domestic sewage with low concentration. However, at low temperature, like other biochemical treatment processes, the treatment efficiency is low due to the low microbial activity in activated sludge at low temperature. It is expected that the low temperature efficiency can be improved by further advanced treatment, reducing pollution load and further prolonging sludge age.

4. Conclusion
The effect of improved IFAS process on rural domestic sewage treatment was studied. When the concentration of COD, ammonia nitrogen, total nitrogen and total phosphorus were 60-203 mg / L, 9.5-40 mg / L, 16-45 mg / L, 1.2-4.7 mg / L, respectively, the removal rates were 91%, 98%, 78% and 93%, and the corresponding effluent concentrations were below 40 mg / L, 1.5 mg / L, 15 mg / L and 1.0 mg / L, respectively. The auxiliary chemical phosphorus removal measures can meet the requirements of class a emission standard of pollutants for municipal wastewater treatment plant (GB 18918-2002).

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