Study on Application of Multifunctional Compound Microorganism Product in the Sewage Plant Treatment for Sludge Reduction

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Abstract: Reducing the quantity of excess sludge has become a popular research subject in wastewater treatment. Therefore, based on the current sludge reduction theory, some special microbial strains were selected, and through certain cultivation process, a multiifunctional compound microorganism product was developed to reduce the sludge quantity. The microorganism product was used in sewage wastewater treatment plant for pilot test. Five sets of identical equipment with the A^2/O process and the same operating method were adopted, and the effect of SV and MLSS were analysed. The effects on sludge reduction were compared.The results show that the sludge reduction reaches 57.3%. The multifunctional compound microorganism product improved the effluent quality and the COD, NH_3-N and TN in the effluent are 37.85mg/L, 0.30mg/L and 12.37mg/L respectively. The microorganism does not require any special treatment unit, and does not change the original treatment process also. Therefore, the microorganism product will effectively improve the sludge reduction effect, and reduce the pressure of the sludge disposal for the wastewater treatment plants.

1 INTRODUCTION

Sludge reduction refers to the physical, chemical and biochemical means to minimize the amount of biosolids discharged from the entire wastewater treatment system. At present, more attention has been paid to sludge reduction technology. At the same time, the research of sludge reduction technology is also the necessary way to make sludge harmless and resourceful (Li et al., 2007; He and Zhou, 2004). In the past ten years, sludge reduction technology has been focused on improving sludge containing organic degradation methods such as: 1) sewage treatment process variant; 2) the biodegradation of sludge was enhanced by mechanical, biological, thermal or enzymatic treatment; 3) sludge stabilization process modification (Zhang and Hong, 2005; Lin and Guan, 2005). At present, sludge reduction technology based on uncoupling metabolism, maintaining metabolism, bioaugmentation and biological predation are gradually being applied for the biological treatment of wastewater (Wang and Song, 2003; Rensink and Ruckens, 1998). However, there are still many researchers have done much work on sludge reduction technology.So far, a feasible treatment method towards sludge reduction , which can integrate validuty and environmental security perfectly, has not been developed yet.

In the process of sludge reduction, bioaugmentation is the means of reducing sludge by adding microorganisms with specific functions in the biological treatment system of sludge (Liang et al., 2004; Li, 2008). Bioaugmentation technology has been widely used in many aspects of environmental protection, such as livestock and poultry manure deodorization, sewage treatment, water eutrophication treatment, domestic waste treatment and so on, with good results achieved (Zhang et al., 2008; Yuan et al.. 2007; Neyens et al., 2004). In this study, a sewage treatment plant with a treatment capacity of 30000 m^3/d was used for the sludge reduction by adding a compound microbial preparation. The objective are to investigate the effect of biological agents on improving effluent quality of existing treatment systems, and the effect of sludge reduction.

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2 EXPERIMENTAL AND METHODS

2.1 Raw Water and the Quality

The water quality is shown in Table 1 and 2 as follows:

Table 1: The quality of Influent.

	COD	BOD	SS	TN	TP
	mg/L	mg/L	mg/L	mg/L	mg/L
Index	500	170	160	50	6.0

Table 2: The quality of effluent.

	COD	BOD	SS	TN	TP
	mg/L	mg/L	mg/L	mg/L	mg/L
Index	≤50	≤10	≤10	15	0.5

2.2 The Technological Progress

The municipal wastewater treatment plant adopts the A^2/O ordinary activated sludge process which has biological function of biological phosphorus and nitrogen removal with pre anaerobic and anoxic stages. Sludge treatment was carried out by gravity concentration and dewatering with belt dewatering machine.The process flow is shown in Figure 1.

2.3 Experimental Device and Method

2.3.1 Experimental Equipment

Each point dosing equipment adopts the mixing barrel and metering pump integrated dosing device, as shown in Figure 2. The agitator is used when dispensing, and the dosing solution is added to the target pool at a certain flow rate by a metering pump. The total amount of aeration was controlled, and the amount of aeration grit chamber accounted for 50%, in addition the other four points accounted for 50%.

2.3.2 Experimental Method

Through the actual influent flow (36000 m^3/d) and the target concentration (2 ppm) of the sewage treatment plant, the total dosage of multifunctional compound microorganism product was determined. The multifunctional compound microorganism product were a mixture of Bacillus,Pediococcus, Lactobacillus plantarum and some nutrient.

The total amount to be treated is controlled during the dosing process, the distribution of each point is added to ensure the total dosage unchanged. At the same time, according to the operation and processing of the reasonable adjustment, the dose distribution at the beginning of the start-up is shown in Table 3 as follows:

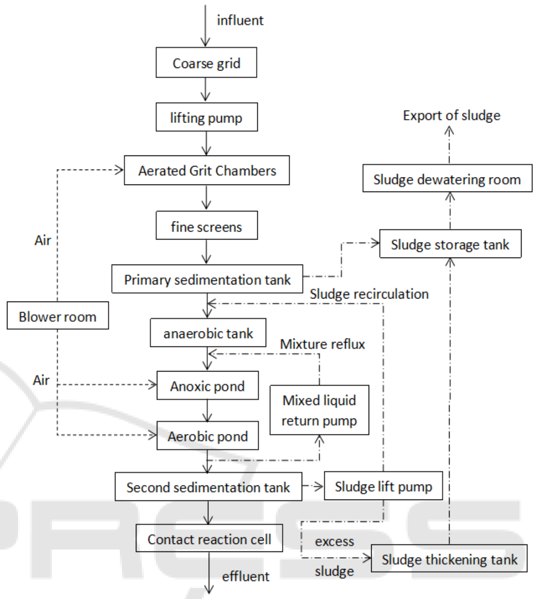


Figure 1: The technological process route.

Figure 2: The picture of the dosing equipment.

Table 3: The dosage of product at the beginning.

	Grit Removel	Anaerobic tank-South	Anaerobic tank-North	Anoxic tank-South	Anoxic tank-North
Dosage proportion	50%	15%	15%	10%	10%

The test started on the eighth day, the target concentration was adjusted to 1ppm, the total dosage of the reagent was determined, and the dosage was reduced at the same point with each other in the dosing process. Dosing at this stage was shown in Table 4 as follows:

Table 4: The dosage of product at the stable period.

	Grit Removel	Anaerobic tank-South	Anaerobic tank-North	Anoxic tank-South	Anoxic tank-North
Dosage proportion	50%	15%	15%	10%	10%

Continuously adding the compound microorganism agent, the change of effluent water quality in each section of sewage treatment process were analyzed, and the quality of raw water, primary sedimentation tank effluent, the two series of anaerobic tank effluent, biochemical pool water, the final effluent were detected.

2.4 Test Method

Routine test data for water and various units COD, NH_3-N, TN, MLSS, SV30, nitrification liquid reflux ratio, sludge reflux ratio and regular biological microscopy etc..

The common indexes such as COD, NH_3-N, TN were detected by the national methods. The sludge concentration (MLSS) were monitored by gravimetric method. The by national standard method. Microscopic examination were measured by optical microscope (XSZ-G, Chongqing optical instrument factory).

3 RESULTS AND DISCUSSION

3.1 The Effect about COD

The difference between two series biochemical process unit is not much, the quality indices are shown in Figure 3.

Figure 3 indicates that in despite of the raw water quality fluctuate, the effluent COD can be kept below 50 mg/L, which can fully meet the demand of first-degree A standards of GB18918-2002. The research that using MEMA(multi-environmental microbial agent) in Carrousel oxidation ditch have the consistent conclusion (Yang et al., 2016).As the influent contains a large number of organic suspended substances, the COD concentration of influent is very high, and generally fluctuates between 800~2000 mg/L. After the treatment of aerated grit tank, large particles suspended solids were removed, the COD of the effluent decreased significantly, could generally reach as low as 200~250 mg/L. The effluent COD of primary sedimentation tank was relatively stable, which reduces the load impact on the subsequent biochemical treatment. The COD was reduced gradually after biochemical treatment, the effluent was below 50 mg/L.The average concentrations of COD in effluent were 37.85 mg/L. The two series of North and South were stable. In addition, the COD of effluent was stable within two weeks after adding compound microbial preparation, and all of them could reach the first level A emission standard.

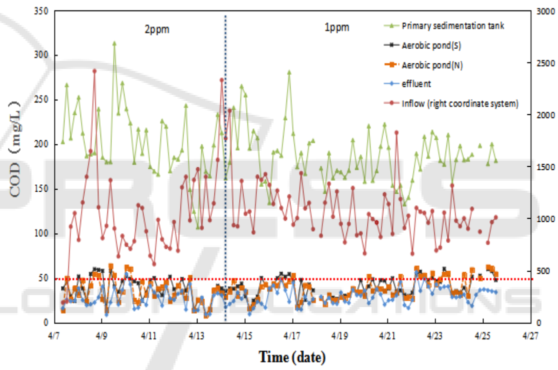


Figure 3: The removal of the COD.

3.2 The Effect about TN

Generally, the influent TN is between 60~90 mg/L, and the removal rate of TN is about 50% by the removal of suspended particulate matter in the aeration grit chamber. As shown in Figure 4, the effluent TN of primary sedimentation tank is between 30~45mg/L, and it is relatively stable before entering biochemical pool, the TN in biochemical reaction area is greatly reduced, and nitrification denitrification occurs at this stage, it can be concerned that there exists SND in A^2/O system (Fang-Ying et al., 2006). At the same time, the compound microbial preparation products were added in the anaerobic zone and anoxic zone, and the TN of the South and North aerobic section had little difference, all of which were between 11-15mg/L. After second sedimentation tank treatment, TN removal little. Within 8 days of treatment, the effluent fluctuated but remained stable.After 13 days (about a sludge age cycle), the concentration of TN was reduced to 9~10 mg/L when adding the target concentration of 1 ppm. The average concentrations of TN in effluent were 12.37 mg/L and which could reach the first class A standard (<15mg/L). However, dosing the compound microorganism product 13 days later (about a sludge age period), the TN decreased to 9~10 mg/L.

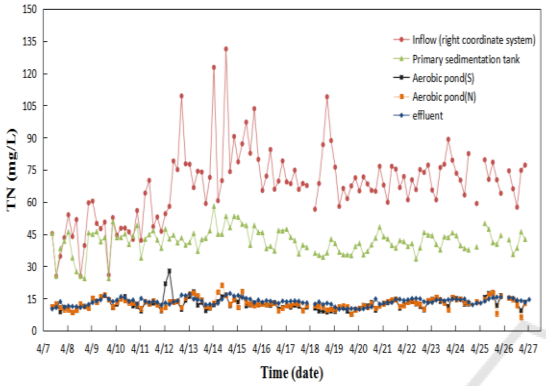


Figure 4: The removal of the TN.

3.3 The Effect about NH_3-N

After adding multifunctional compound microorganism product, sludge age is prolonged, which is conducive to the growth of nitrifying bacteria, and increased nitrification in the same conditions. It is conducive to nitrification of ammonia nitrogen. As shown in Figure 5, the NH_3-N removal efficiency is stable after adding the compound microbial agent, and kept the good treatment effect.The average concentrations of NH_3-N in effluent was 0.3 mg/L, the removal rate was more than 99%.

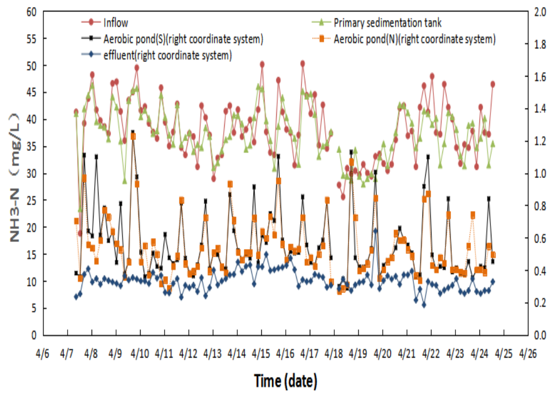


Figure 5: The removal of the NH_3-N.

3.4 Sludge Sedimentation Performance Change Analysis

The structure of microbial floc also directly affected the proportion of aerobic zone and anoxic zone in sludge floc and mass transfer effect in the floc, it also affects the degree of difficulty in microbial acquisition of DO and substrate. The larger sludge particles increased the proportion of anoxic microenvironment, and the mass transfer resistance of sludge particles with compact structure was large (Guo et al., 2007). The organic carbon source in water is difficult to penetrate into the sludge floc, and the results is that it is difficult for the internal microorganism to contact with carbon source, which affects the removal efficiency of carbon and nitrogen.

The changes of SV30 and MLSS were observed after adding compound microbial preparation, as shown in the Figure 6. During the whole experiment, the MLSS in the biochemical pool of the North Series decreased from 5300 mg/L to 4700 mg/L after the addition of microorganism, and the MLSS in the South series also decreased. From the change curve of SV30, the SV30 gradually decreased, and the sludge settling performance was in good condition.SV30 has a gradual downward trend, and the observation of settlement process shows that sludge settling speed is significantly accelerated, sludge settlement performance becomes better.After adding microbial preparation, the sludge settlement performance was improved, the sludge volume was reduced by 57.3%, the microbial preparation could improve the effluent quality.

3.5 Microscopic Examination of Microbial Biochemical Pool

Routine microscopic examination of activated sludge in the biochemical tank, microscopically observed case worms, roaming insect, vorticella, epistylis, rotifers, dun pellionella, a little whipworms, as shown in the Figure 7. The dominant species are Vorticella and rotifer. After adding multifunctional compound microorganism product, the microbial phase changed a little, and the microbial species were abundant. The growth condition is stable, the floc structure was fluffy, the color was yellow brown, and the sludge activity strong.

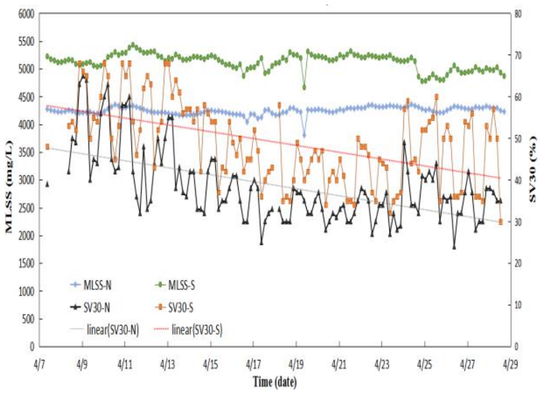
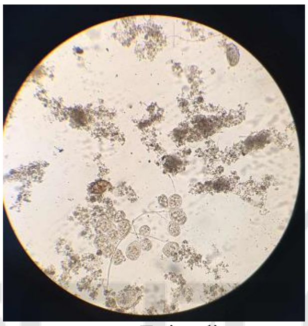
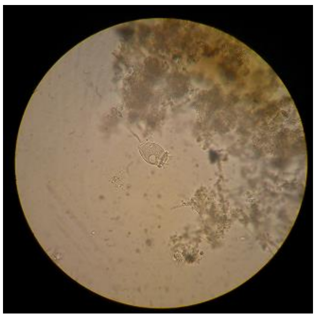


Figure 6: The sludge performance.



a. Epistylis

b. Rotifers



c. Vorticella

Figure 7: The microscopic examination.

4 CONCLUSIONS

The study highlights the effectiveness of multifunctional compound microorganism product in increasing efficiency and reducing consumption of infrastructure. There is no effect on the stability of existing system in WWTP. Moreover, the removal rate of COD, NH_3-N and TN can be improved by the biochemical system when the influent water quality fluctuates greatly. The results suggest that adding compound microorganism product target concentration was 2 ppm, the A^2/O system was very stable. After adding multifunctional compound microorganism product, the sludge settlement performance was improved, the sludge volume was reduced by 57.3%, the average concentrations of COD, NH_3-N and TN in effluent were 37.85 mg/L, 0.3 mg/L, 12.37 mg/L, respectively.The compound microbial preparation has good sludge reduction effect. At the same time, reduce the burden of sludge treatment and disposal of sewage treatment plant, reduce the degree of organic sludge. It does not change the original treatment facilities and operation mode, and the power consumption of the whole system will not increase.

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