

Influence of reaction period on a new packing SBBR process treating high-salt and phosphorus deficiency

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Abstract. In order to solve the problem of high-salt ballast wastewater treatment, Sequencing Biofilm Batch Reactor of new packing activated sludge process used to simulate an experimental study. When Chloride ion concentration is $20\pm 2\text{g/L}$, the impacts of reaction period and anoxic time (T_a) / aerobic time (T_o) on the effect of the treatment process and sludge activity were investigated. The results show the salt acclimation SBBR process can effectively remove organic contaminants; when the reaction period was 49h, the removal rates of Chemical Oxygen Demand (COD) reached more than 91.0%, and the removal rate of $\text{NH}_4^+ - \text{N}$ was 83.3%, the removal rate of Total Nitrogen (TN) was 67.7%, and the effluent concentration of COD, $\text{NH}_4^+ - \text{N}$ and TN were respectively 45.7mg/L, 7.8mg/L and 18.6mg/L. At this time, TF reached 43.6 $\mu\text{g/ml}$. With the T_a / T_o increase, the degree of denitrification increased and the nitrification rate reduced. When T_a/T_o 1:3, the optimal nitrogen removal appeared, ammonia removal efficiency was 83.8%, the effluent concentration was 7.8mg / L, TN removal rate was 67.7%, and the effluent concentration was 18.6mg / L, to reach effluent standards. Technical support was also provided to solve the problem of coastal salt waste low phosphorus wastewater.

1. Introduction

Sequencing batch biofilm reactor (SBBR), completely mixed in the space, with the time to completely push on streaming, has a high response speed. Under the same processing efficiency, SBBR pool body is less than the volume of a continuous flow process, saving floor space, and the same reactor by changing the operation parameters can perform different functions of wastewater treatment, with flexible operation mode[1]. Chlorine (water) for high concentrations of chlorine ions in waste water raw water fluctuation, the characteristics of the strong role of microbe poisoning[2-5], was combined with the advantage of SBBR craft, in order to obtain a stable biological treatment effect[6-9]. Pans wadden et al.[10] found that the treatment of wastewater with high salinity by salinity-domesticated activated sludge can improve the removal efficiency of organic matter and ammonia nitrogen. When SBBR crafts a period after the end of the water, raw water from the reactor, the change of quantity of inlet water quality within the reactor on biological treatment system no longer has any effect, which gives it high resistance to impact load capacity[11]. Therefore, this research through the study of a new type of packing SBBR craft obtained correct and reasonable experimental data, so as to find out feasible process design parameters and operation parameters for actual high chloride wastewater treatment engineering design, debugging, operation and management. This data will provide a strong technical basis.



2. Materials and methods

2.1. Test device

The test apparatus is shown in figure 1: SBBR reactor made of organic glass 200 mm in diameter, 1 m high, effective volume 14 L, water from the bottom in, and drainage in the middle. The bottom of the device is equipped with an aeration disc, and the internal temperature is kept constant with heating instrument control. Internally, add polyester filter material, cylindrical, size of $\phi \times h = 5 \text{ mm} \times 10 \text{ mm}$, nonpoisonous and harmless, with good chemical stability. Fill more than 50% with polyester fiber filter material with a porosity of 95%. The reactor temperature should be controlled at 25 °C. Dissolve oxygen at 3 to 5 mg/L, pH of 7-8. After a period of time, the cultivation of the activated sludge is domesticated, make advantageous salt resistant bacteria strains, and adjust the parameters to achieve smoothness.

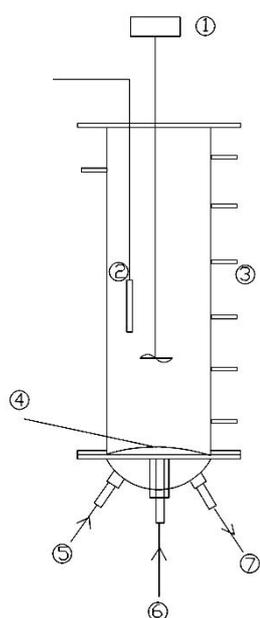


Figure 1. SBBR test apparatus.

Note: ① Agitator ; ② Temperature controller ; ③ Water intake; ④ Aeration disc; ⑤ Water inlet; ⑥ Air inlet; ⑦ All landowners mud mouth

2.2. Test raw water

This test was of Dalian new port sewage treatment plant water quality for the study of reference. This paper studies conditions after dealing with the oil removal of separation tank water. Based on a test, the water COD concentration is 450-550 mg/L, ammonia nitrogen, 35 to 45 mg/L, TN50-60 mg/L, pH at 7.5-8.5, aerobic phase DO for 3 to 5 mg/L, the phosphate content is 0.05, the C/P for 10000:1, and the phosphorus source has an extreme lack of water.

2.3. Test methods

In the test for early domestication salt-tolerance of aerobic sludge, sludge concentration of 5 g/L [12]: The SBBR reaction period consists of five stages, namely the water phase, oxygen mixing stage, aerobic aeration stage, sedimentation stage, and drainage stage. Initial conditions: SBBR operation periods are selected for 13 h, 25 h, 37 h, 49 h, 61 h and 73 h, in which the phases are: water phase 5 min, anoxic and aerobic time ratio of 1:3, sludge sedimentation 50 min, drainage 5 min, and decantation pen 1:1. The temperature should be in the 20 ~ 24 °C range. Investigate the treatment effect of the SBBR reactor in different reaction periods, and measure the different sludge dehydrogenase activity, and the optimization of process conditions. Adjust the SBBR run aerobic and anaerobic period. It will conclude the best Ta/To.

2.4. Analytical methods

In this study, all methods are in accordance with the method of determination of "Water and Wastewater Monitoring Analysis Method" (Fourth Edition) (National Environmental Protection Agency 2002) stipulations. The specific indicators and test methods are shown in table 1.

Table 1. Analytical methods.

Test items	Analytical methods	Use of instruments
NH ₄ ⁺ -N	Nessler reagent spectrophotometric	WFJ2100 type visible spectrophotometer
NO ₃ ⁻ -N	UV spectrophotometry	UV-Vis spectrophotometer
TN	Persulfate oxidation - UV spectrophotometry	UV-Vis spectrophotometer
COD	Fast hermetic digestion method (photometric)	WFJ2100 type visible spectrophotometer Electric oven thermostat blast
TTC	Detection of enzyme activity spectrophotometric [13]	WFJ2100 type visible spectrophotometer

Note: COD (sealed digestion using nitric acid, due to high chlorine ions, is contained in water samples, so the appropriate dilution water samples, and according to Hg: Cl = 10:1 join HgSO₄ masking).

3. Results

In high salinity (Cl - concentration of 20000 mg/L) conditions, through the successful domestication of activated sludge, the reactor treatment effect stabilized, DO for 5 ~ 6 mg/L, temperature of 12 °C, PH 7.5 ~ 8.5, water filling ratio of 0.5, change reaction period.

3.1. The influence of the reaction period on COD removal

During the test, the influent water COD concentration control was between 450-550 mg/L, the reaction period was selected from 13h, 25h, 37h, 49h, 61h and 73h. In turn, run 3 cycles per phase, monitoring data of three times the average of the analysis results, comparing the different reaction periods on the degradation of organic matter.

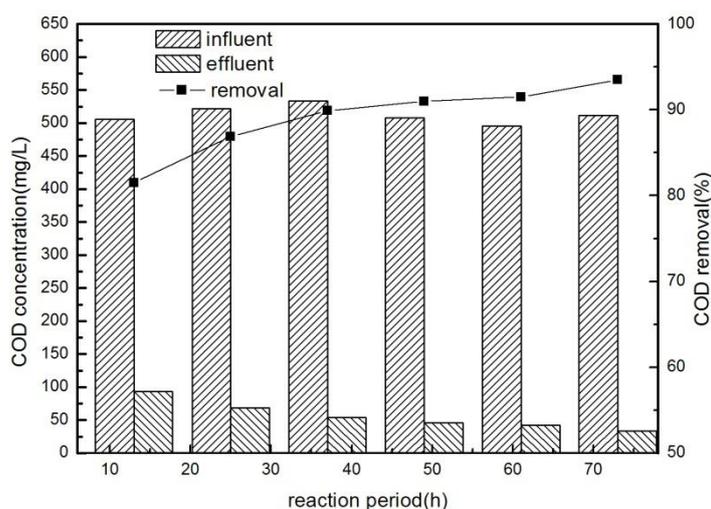


Figure 2. The efficiency of different reaction periods on COD removal.

As can be seen from figure 2, the longer reaction period, the better COD removal efficiency. The salinity influences the COD degradation. The activated sludge salt-tolerant bacteria in the high salt environment of the SBBR reactor, has the ability of degradating organic matter less than ordinary microbial slightly in the sludge, but has a strong effect on the degradation of organic matter. When the reaction cycle was 13 h, 25 h and 24 h, the effluent COD concentrations of 93.6 mg/L, 68.4 mg/L and 53.7 mg/L, did not meet the level of the A discharge standards. When the reaction period was 49 h, 61 h and 73 h, the effluent COD concentration was less than 50 mg/L, and the COD removal rate was over 90%, which meets the national and local regulations of COD emission levels of A standard. Therefore, the best operation period is 49h.

3.2. The influence of reaction period on ammonia nitrogen removal

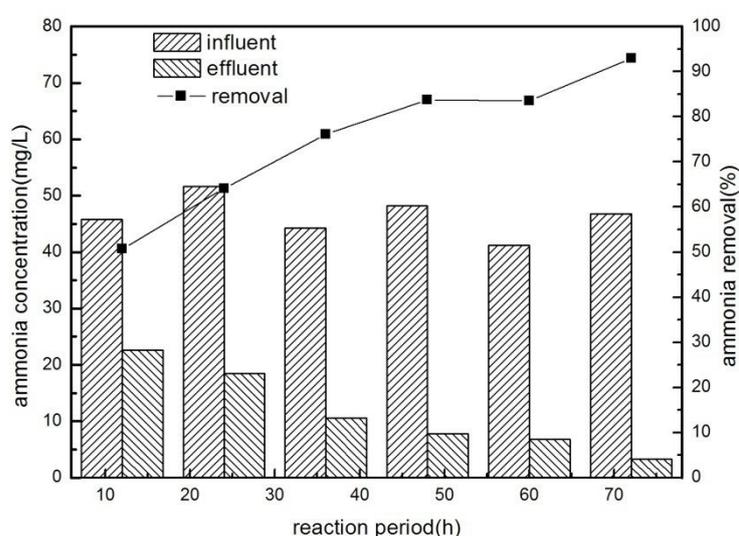


Figure 3. The efficiency of different reaction periods on ammonia nitrogen removal.

The ammonia nitrogen concentration of effluent water is 41.2 ~ 51.6 mg/L. Ammonia nitrogen effluent water concentration is significantly affected by reaction period changes. When the reaction period was 49h, 61h and 73h, the average water ammonia nitrogen concentration was 7.8 mg/L, 6.8 mg/L and 3.3 mg/L, the average removal rate of ammonia nitrogen was 83.8%, 83.5% and 92.9%, respectively. Therefore, under the condition of high salinity, ammonia nitrogen was still able to achieve better removal, and nitrosation bacteria can still work effectively. The longer the reaction period, the better treatment effect of the system. When the reaction period exceeded 37h, the effluent water concentration of ammonia nitrogen was under 8 mg/L, which can meet the national and local regulations for ammonia nitrogen emission levels of A standard.

3.3. The influence of reaction period of TN removal

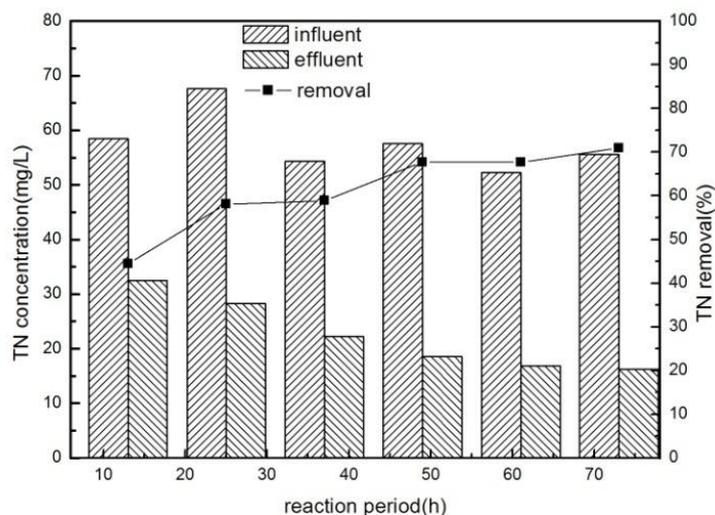


Figure 4. The efficiency of different reaction periods on total nitrogen removal.

As can be seen from figure 4, with an influent water total nitrogen concentration of 52.3 ~ 67.69 mg/L, the total nitrogen was affected by the reaction period significantly. When the reaction period was 49h, the average discharge total nitrogen concentration was 18.6 mg/L, and the total nitrogen removal rate was 67.7%. Visibly, under high salinity conditions, as the reaction period increased, the total nitrogen removal can get a better treatment effect, significantly. Biological denitrification needs two processes, include nitrification and denitrification, but the total nitrogen removal was affected by those two processes. First ammonia nitrogen nitration was under aerobic conditions, then the aerobic phase generated nitrate as an electron acceptor in the anoxic environment, and the organic carbon source as an electron donor for the denitrification reaction, so as to realize the removal of nitrogen. Therefore, the denitrification stage really removes nitrogen, and nitrification is the necessary condition to realize nitrogen nitration^[14]. Figure 3 and figure 4 show that with a less than 25h reaction period, owing to the bad effect on nitrification, it was unable to provide a sufficient electron acceptor for the denitrification reaction, which causes the system total nitrogen removal rate to be low. The reaction period, by contrast, over 37h is good for removal of total nitrogen, and effluent water was less than 20 mg/L, which reaches level 1 B emission standards.

3.4. The influence of reaction period on microbial activity

Sludge dehydrogenase activity is the core factor affecting the system organic matter degradation. Microbial growth and metabolism requires energy, and as the key step in the biological oxidative decomposition of organic matter dehydrogenation in cells, molecular oxygen is the ultimate hydrogen donor, and the more hydrogen comes through the oxidative respiratory chain, the higher the dehydrogenase activity. The level of dehydrogenase directly reflects the activity of the microbial metabolism. Sludge samples are taken at the end of each reaction period; an elevated TF value of the sludge indicates that the more hydrogen oxygen in the process of oxidation respiratory chain is transferred to the oxygen in the process of microbial metabolism, as growth and metabolism of microorganisms is fast, so the biochemical effect of sludge utilization is good. Different reaction periods of dehydrogenase activity of activated sludge were compared to instruct the sludge biochemical ability of the SBBR system.

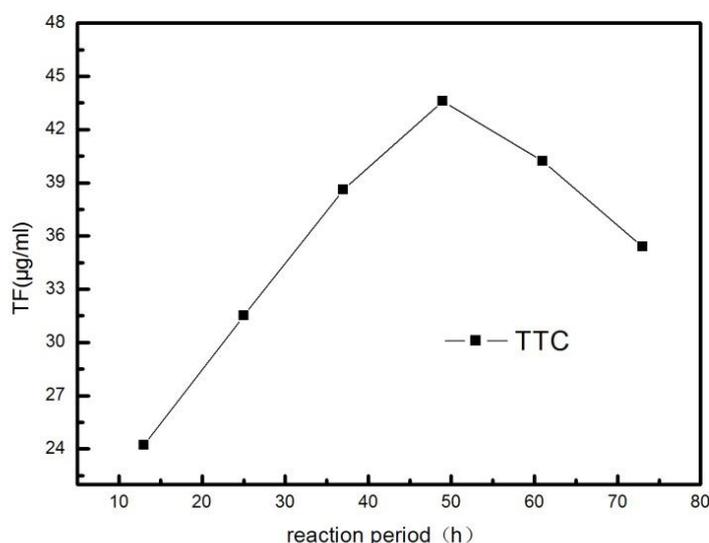


Figure 5. The influence of reaction period on microbial activity.

As can be seen from figure 5, when the reaction period was less than 49h, the dehydrogenase activity of microorganisms in the SBBR reactor increases with the extension of the reaction period. When the reaction period was 13 h, TF was 24.2 $\mu\text{g/ml}$; when the reaction period increased to 49h, the maximum TF was 43.6 $\mu\text{g/ml}$. Then, as the reaction period continued to extend, the microbial activity began to fall; when the reaction period was 73h, TF dropped to 35.4 $\mu\text{g/ml}$. The results show that when the reaction period was short, the microorganism in the reactor had just recovered from the last period. The microorganism was in a slow growth phase, and metabolic system needed to adapt to a new environment at the same time as synthetase, coenzyme, and other metabolic intermediate metabolites, so that the metabolic activity in this period is not strong. As the shorter reaction period did not reach the vigorous stage of microbial growth, so the dehydrogenase activity was relatively low; when the reaction cycle was longer, the microorganism in the reactor had been prepared for the period of adjustment, which had reached the exponential phase of growth strength, and the period of the microbial growth had enough material base. At the same time, the external environment was also best, along with the microbial metabolism and enzyme activity. Thus, the dehydrogenase activity is higher. When the reaction period continued to increase and reached a certain length, microorganisms in the reactor necessary to maintain the survival of the material basis were exhausted, nutrient ratios imbalanced, microbial growth entered the decline phase, and the external environment continued to grow worse. As harmful metabolites increased, cellular catabolism is greater than synthetic metabolism, which led millions of bacteria to death, and dehydrogenase activity dropped with a long reaction period.

3.5. The influence of reaction period on operation time A and O paragraphs

On the basis of the experimental study above, select the best reaction cycle as 49 h, control temperature 12 °C, pH 7.5 ~ 8.5, water filling ratio 0.5, fixed water, precipitation and drainage length of time constant, adjust single cycle of oxygen session with the aerobic session run length, and set Ta (A period of time) and To the period of time (O) ratio on the SBBR reactor effluent indicators. Specifically of oxygen in the test of time and operation of aerobic sessions as table 2:

Table 2. Single cycle anoxic and aerobic running time.

	Anaerobic time T_A	Aerobic time T_O	T_A/T_O
Plan A	24	24	1:1
Plan B	16	32	1:2
Plan C	12	36	1:3
Plan D	8	40	1:5
Plan E	6	42	1:9

The SBBR reactor anoxic and aerobic section running time of ammonia nitrogen and total nitrogen removal had some influence, as figure 6 shows, so that the T_a/T_o decreased, and the ammonia effluent water concentration decreased. When the T_a/T_o was 1:3, the ammonia effluent water concentration was 7.8 mg/L and the removal rate was 83.8%, which reaches the level of A effluent water standard. The greater the T_a/T_o , the smaller the effluent water concentration of TN. When T_a/T_o was 1:3, the TN effluent concentration was 18.6 mg/L, with a removal rate of 67.7%. In terms of the reason for this, when T_a/T_o is greater, the aerobic period is relatively shorter, causing incompleteness of nitrification, and the ammonia nitrogen removal rate is low, resulting in a smaller aerobic phase of nitrate and less nitrite[15]. When the lack of oxygen time is relatively longer, the anoxic period has enough time for denitrification. In addition, due to the short aerobic period, the removal rate of carbonaceous organic is reduced, which makes the anoxic period of the carbon source sufficient. Therefore, as the T_a/T_o becomes higher, the SBBR has higher denitrification, and the denitrification effect is better. Also, when T_a/T_o is reduced, the aerobic period is prolonged, and the ammonia nitrogen removal rate increases, but the lack of oxygen time is short and the carbon reduces, causing the denitrifying effect become poor and the TN removal rate to reduce. Based on comprehensive consideration, the best T_a/T_o is 1:3.

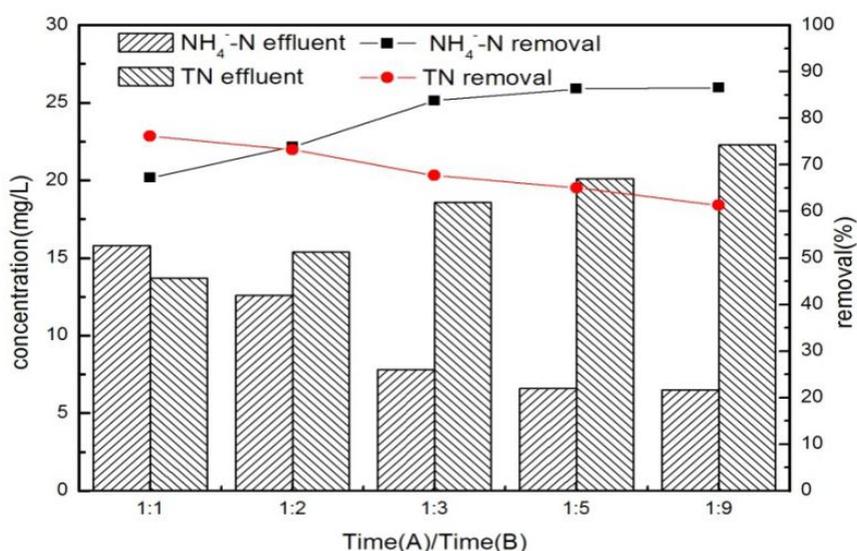


Figure 6. $T_A:T_O$ effect on denitrification SBBR reactor.

4. Conclusion

Under the condition of high salinity, new type packing SBBR craft adopted through domestication of the success of the activated sludge can effectively remove organic pollutants. When the reaction period was more than 36 h, the removal rate of COD was over 90%, and the effluent COD concentration was less than 50 mg/L; the ammonia nitrogen removal rate was over 80%, and the ammonia water concentration was under 8 mg/L, which meets the national and local regulations of the COD emission level of A standard. Therefore, the best operation period was 48 h. The total nitrogen

also had a better removal rate. With the extension of the reaction period, the treatment effect was obviously better. When the reaction period was more than 37h, the reactor for removal of total nitrogen was better, and the total nitrogen was less than 20 mg/L, which reaches level 1 B emission standards. In high salt sludge in new packing SBBR system activity, the microbial growth rule is closely related with the reaction cycle. When the reaction cycle was 49 h, microbes reached the exponential phase of growth strength, microbial metabolism, and enzyme activity, so the dehydrogenase activity reached maximum, TF is 43.6 $\mu\text{g/ml}$. At the same time, the sludge dehydrogenase activity was high in salt SBBR system, which is one of the core factors of organic matter degradation ability. For a 49 h reaction period, the system of COD, ammonia nitrogen and total nitrogen removal efficiency to achieve optimization, an additional reaction cycle treatment effect is not obvious. The Ta/To (the ratio of anoxic and aerobic time) influenced the denitrification effects obviously; with an increase of Ta/To, the denitrification rates increased, and the nitrification rates decreased. When the Ta/To was 1:3, the denitrification effect achieve optimization, the ammonia nitrogen removal rate was 83.8%, the water concentration was 7.8 mg/L, the TN removal rate was 67.7%, the effluent concentration was 18.6 mg/L, and the primary standard level of the water was reached.

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