Research on Purification of Domestic Sewage by Artificially Strengthened Ecological Filter Bed in North China

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Abstract Artificially strengthened filter bed is an innovative wastewater treatment technology based on the coupling of eco-contact oxidation filters and artificial wetlands purification mechanism. By small scale laboratory equipment, the effects of cascade aeration, filter type, filter clogging and other ecological factors on the operation effect of artificial filter bed were studied. As indicated by the results, the pretreatment of cascade aeration had obvious effect and could satisfy the oxygen requirements of artificially strengthened ecological filter bed. Through the analysis on the purification results of volcanic and gravel filter, the effluent quality of volcanic filter was better than that of gravel filter. With the advantages of low operations costs and good effluent quality, the artificially strengthened ecological filter bed has great value to be popularized in North China.

Key words Artificially strengthened ecological filter bed, Sewage purification, Research, China

Along with the rapid economic development in China, the urban population is getting worse and worse, which results in mounting domestic sewage in cities and deterioration of water quality[1]. The artificial strengthened ecological filter bed is an innovative sewage treatment technology which is founded based on the coupling of eco-contact oxidation filters and artificial wetlands purification mechanism[1]. The effects of cascade aeration satisfied the growth of ecological filter bed, economized the aeration and power equipment, and reduced the operation fees, which provided a new technology for the purification of domestic sewage in North China. The function of artificial strengthened ecological filter bed in the purification of sewage in north China is studied so as to provide reference for the purification of domestic sewage in North China.

1 Materials and methods

1.1 Water quality The original water for this experiment came from the sewage well of certain neighborhood in Shenyang. The water quality was shown in Table 1.

Table 1 Indicators of water quality during the experiment period

Monitored indicators	Changes	Mean value
Temperature//℃	7.0 -22.0	14.6
pH	7.1 -7.7	7.3
DO//mg/L	0.2 -4.3	1.6
COD//mg/L	309.0 -464.0	398.0
TN//mg/L	33.3 -95.0	44.1
TP//mg/L	4.0 -7.5	5.0
NH_4^+//mg/L	5.0 -35.0	14.9

1.2 Experiment setup The cascade aeration reactor was shown in Fig. 1. Such kind of aeration equipment is of innovative design and all equipments are is organic glass. The size of second grade aeration reactor was 0.35 m × 0.35 m × 0.90 m and the cascade gradient was 0.30, 0.45, 0.60, 0.75 and 0.90 m. What is in the re-aeration reactor was the string oxidized stuff, about a size of 0.80 m × 0.35 m × 0.35 m. This design theory of aeration equipment was that the bypass of water in the original buffer manger realized the exchange of solution and air through the fall of second grade board to increase the dissolution of oxygen in the water.

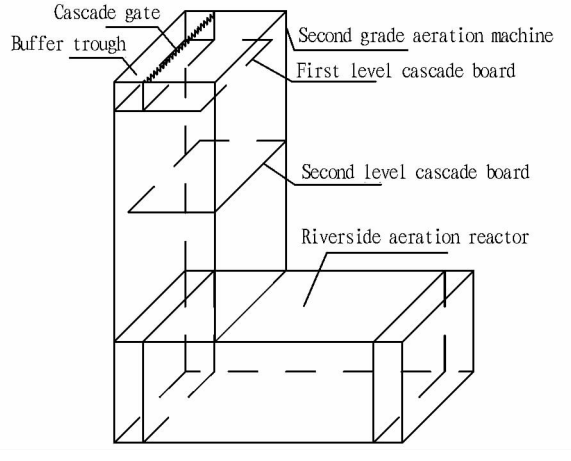

Fig. 1 Cascade aeration reactor

The small artificial strengthened ecological filter bed was shown in Fig. 2. The equipment used rotating meter to measure the influent in the reactor, and used gas meter to determine the technological aeration and counter-aeration amount. The size of the equipment was 2 000 m × 350 mm × 700 mm and the stuffing was volcano filtering at a rate of 85%. The diameter of the particle was 50 mm. The material of the equipment was PE. There were two machines like this.

1.3 Projects and methods to monitor water quality COD

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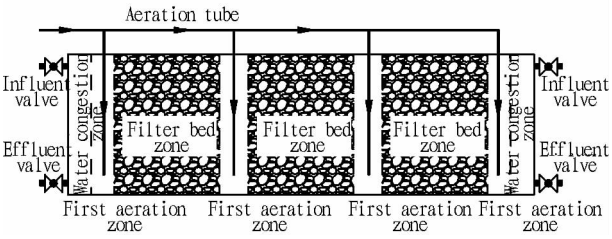

Fig. 2 Equipment of artificially strengthened ecological filtering bed

was measured through standard Potassiumdichromate method. TN was observed by ultraviolet spectrometry. DO was measured by resolved oxygen meter. NH_4^+-N was measured by sodium detergent. TP was observed by molybdenum antimony resistance spectrometer. PH was measured by online acidity meter.

1.4 Technological process The technological process was shown in Fig. 3.

2 Results and analyses

2.1 Analysis of the effect of cascade aeration During the different stages of the growth of organisms, the resolution of oxygen directly influenced the organisms and NH_4^+-N in the biological degradation water and the membrane activity of microorganism[2]. So far, according to the data, the minimum DO that can meet the demand of microorganism was 2.0 mg/L in the sewage treatment technology by biological process. Based on DO amount, the resolution rate of reactor on organism, N and P was consistent[2]. Table 2 indicated that the cascade aeration reactor had good re-oxygen effect, which can meet the minimum requirement of the growth of microorganism. Data indicated that DO in the water rose with the increasing cascade height before decreased again, which was similar to the study result[4]. The added value of DO reached the maximum when the cascade gradient was 0.6 m. If the cascade height increased, the added value of DO even would reduce. The added value of DO did not increase with the cascade height, which suggested that the high cascade height didn't mean to be good in the aeration of cascade. In the experiment, when the cascade height was 0.6 m, the addition of DO was close to peak value and the 0.6 m cascade gradient was the optimal cascade height.

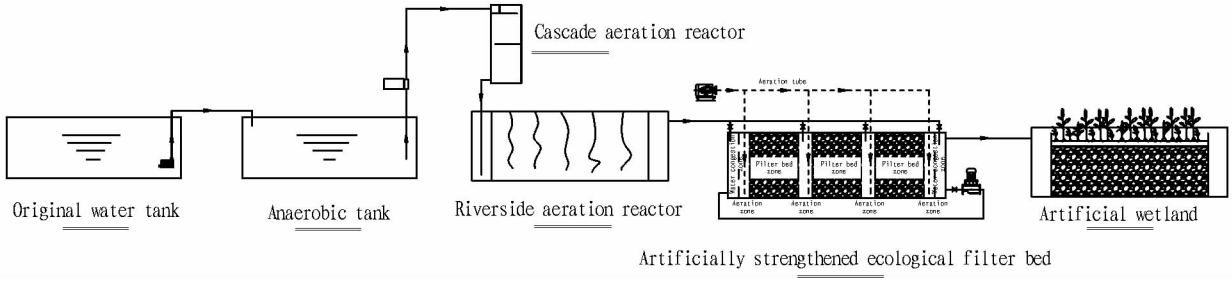

Fig. 3 Technological process

Table 2 Cascade aeration oxygen effect

Cascade height // m	DO in the influent // mg/L	Cascade region DO // mg/L	Mean added value of DO // mg/L
0.30	3.1	4.9	1.8
	1.9	4.1	2.2
0.45	2.3	4.9	2.4
	0.2	2.6	2.4
0.60	0.6	3.3	2.7
	0.5	3.3	2.8
0.75	1.2	3.8	2.6
	2.8	5.5	2.7
0.90	0.2	3.3	3.1
	0.2	3.0	2.8

2.2 Comparison of DO changes on different filter beds Because the artificial strengthened ecological filter bed is a kind of advection contact oxidation reactor based on biological membrane treatment, and such kind of reactor hasn't been widely applied in the water treatment technology, the technological details of DO expansion needs further study. During the experiment, portable dissolved oxygen determiner is applied to measure the DO in the water. The filter area 200 – 650 (front part), 775 – 1 225 (middle part), 1 350 – 1 800 mm (later part), and DO in the effluent. By applying the two artificial strengthened ecological filter beds of volcano rock and gravel at routine COD content and moderate aeration zone (DO concentration > 7.00 mg/L), the distribution of DO mean values in two consecutive periods were shown in Fig. 4.

As shown in Fig. 4, the consumption of DO by volcano filter material was quite different from that by gravel filter material. The consumption of DO by volcano filter material was steady. When the almost saturate DO water went into the filter bed after the preaeration, the entire DO was in a high level. The gravel filter material moved fast and the DO level decreased dramatically after the water with saturated DO entered the filter bed. Though the implanted aeration in the center increased oxygen supply in the filter bed, there might be distinct anti-oxygen area from 450 mm to 650 mm, and from 1 350 mm and 1 800 mm. The COD concentrations in the effluent of reactor of two kinds of filter materials were different. Such curve about the DO changes indicated that the consumption of microorganism in the reactor of gravel filter material was much more than that in the volcano filter material. Meanwhile, the small gravel went against the diffusion of DO and intensified the waste of DO in the water, which led to lower utilization efficiency. Obviously, if the moderate and large scale of production experiment used gravel as filter material, its aeration intensity and scale was higher than using volcano filter material, which would guaran-

tee the effective length of aerobic treatment.

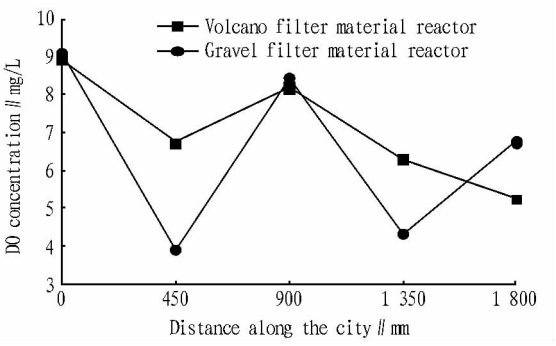

Fig. 4 DO concentration of filter bed in the first and third aeration filter bed

2.3 Study on the congestion of stuff in the filter bed The stuff congestion in the artificial strengthened ecological filter bed is a hard core to crack in the operation[5]. The way to solve the stuff of traditional biological filter bed should be to take out the stuff automatically or mechanically and then to clean the filter bed. During the operation, proper measures should be applied to ease or avoid congestion. First of all, the pre-treatment of influent was the key to solve the congestion in the filter bed. There was sediment zone in this experiment so as to get clean water, and then put the clean water into the cascade aeration machine. Through twice precipitation, the suspended substances and particles can be reduced by 50% and 70%. The effect of such kind of technology was distinct. Secondly, while the artificial strengthened ecological filter bed was designed, the space between the filter bed and the aeration zone changed the way traditional biological filter tube was deployed. The design of aeration not only solved the congestion of tube in the operation, but also enhanced the efficiency to use DO. Besides, the equipment can put off the congestion caused by falling biological membrane through the control of operation form. There was a discharge in the equipment. After certain time, when the entire biological filter bed was empty and the falling biological membrane became dry, large amount of water was put in to cleanse the filter bed so as to prolong the period of using filter bed. In the actual operation, the proper congestion had positive influence on the degradation of organisms and the removal of N and P. The congestion of stuff was a sign of appropriate ecological filter bed.

3 Conclusion

Firstly, the distinct pretreatment of cascade aeration can satisfy the requirement of artificial strengthened ecological filter bed. When the height of cascade aeration was within 0.6 m, the DO of cascade aeration was stable, and both had positive relation. The data suggested that the optimal cascade height should be 0.6 m. Secondly, through the study of the property of the artificial strengthened ecological filter bed, the dissolution and use efficiency of volcano rock and gravel were quite different. In order to enhance the degradation of filter bed on the organism, the volcano filter material greatly improved the efficiency to process water quality. Thirdly, the study on the technology to filter materials relieved the congestion of traditional biological filter bed, and promised a broad future for the application of artificial strengthened ecological filter bed in the purification of living sewage in the north China.

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