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Assessment and Remediation of Landscape Water Quality in the Central Area of Zibo City

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Abstract. In this study, eight water-quality indices, such as temperature, pH, colority, DO, BOD_5, COD_{Mn}, NH_3-N and TP, were monitored based on the water environment of Yulong River- the only landscape river in the central area of Zibo city. The water quality assessments of each individual parameter were performed. Results showed that Yulong River had already been eutrophicated. According to the current water qualities and environmental characteristics of Yulong River, an ecological complex filter plan was proposed to remedy Yulong River.

Introduction

With the fast development of social economy and acceleration of urbanization, the landscape river, an important part of the urban ecosystem and the primary producer and regulator of ecological balance, has increasingly shown its irreplaceable functions in the urban ecological construction. Therefore, it is of great importance to investigate the natural regularity of landscape water so as to maintain the water quality and to coordinate the relationship between urban construction and landscape water body.

Generally, the landscape water is of relatively small area and water capacity with low self-cleaning ability. Some scenery water lacks a complete ecological chain because the tap water or groundwater were used as the water source, which contributes to the low self-cleaning ability [1]. At present, the urban water sources are polluted seriously with high levels of nitrogen and phosphorus contents. In addition, plant nutrients such as nitrogen, phosphorus, carbon, potassium and fertilizer, agricultural chemicals will be carried massively into the low-lying landscape river by the scour of rainwater and infiltration of irrigation water. Furthermore, the poor management of environment also makes the waterbody the receptor of sanitary sewage and waste. Sometimes, serious pollution causes the eutrophication of waterbody. Then, algas bloom in the water and the water becomes black and maladorous, which severely affects the natural and residential environment and jeopardize the human health.

Investigation and analysis of the Yulong Landscape River

Survey of the water environment of Yulong River. As the only landscape river in urban centre district of Zibo City, the Yulong River is connected with the Man Si River in the upstream, and converges with the main branch Beida River in the middle stream. Its main stream flows along the west side of Shiji Road to the north to Nanying Road in the High-Tech Zone and folds again to the east, passes through the Shiji Road and Xiliu Road, and finally joins the Dongzhulong River. The length of the river is approximately 17km and the average width and depth are 15m and 2m, respectively.

After the site investigation of Yulong River, the water qualities were obtained as follows：(1) In the reach from source to the north of 309 State Road, there were floating matters on the water surface,

such as leaves, plastic bags, and so on. In this region, the river was shallow with thick sediments, and there were signs of death such as small fish. The dark green water was of poor quality with fewer aquatics and algaes; (2) In the reach near Jiaozhou-Jinan Railway, The floating objects on the water surface were fewer, the water color was light-green. The water was of better quality with some fish survivals and fewer algaes; (3) In the reach near the Xincun West Road, The water color was yellow-green. The small dead fish were floating on the water surface. The water quality became worse. The floating objects in the water were fewer, but the algaes were prosperous and there were a number of daphnia and other aquatic organisms, which revealed obvious eutrophication in the river; (4) In the reach near the Huaguang Road, the water color was dark. Most of algaes died and drifted on the water. The aquatic animals were fewer and the water was micro-smelly. The water appeared to be in the worse eutrophication; (5) In the downstream, there were many floating objects, and the water color was yellow-green. There were fewer algaes in the water, and the water quality was better, which was suitable for fish reproduction.

Monitoring of water quality of the Yulong River.

Selection of the sampling point. The representative sampling point was chosen at the intersection of Yulong River and the Renmin West Road, in the middle of the river, which was situated at the downstream of the Yulong River and could reflect the water pollution level comprehensively.

Monitoring items. According to the requests of "Surface Water Environment Quality Standards" (GB3838-2002), and the actual situation of the Yulong River, eight indices were selected to assess the water pollution: temperature, pH, colority, DO, COD_{Mn}, BOD_5, NH_3-N and TP.

Methods of analysis and detection. These methods were in accordance with standard analytical methods stipulated by GB3838-2002 [2].

Monitoring results.

Monitoring results of water quality of Yulong River were shown in table 1.

Table 1 Monitoring results of water quality of Yulong River

Item	Temperature ℃	pH	colority	DO mg/L	COD_{Mn} mg/L	BOD_5 mg/L	NH_3-Nm g/L	TP mg/L
Result	21.7	7.43	65	5.43	18.2	8.42	5.0	0.227

Waterbody evaluation

Water quality assessment of the Yulong River. In order to fully reflect the pollution of the Yulong River and to improve the water quality, Class Ⅳ Standards in "Surface Water Environment quality Standards" (GB3838-2002) were applied in the assessment. Because of no specific requirements on colority in GB3838-2002, the original scenery water standards were still adopted. The Yulong River was comparted by six rubber dams. The river flowed extremely slowly, and the ratio of breadth-depth was so large that it was taken as lake or reservoir.

The single factor evaluation was performed for the water quality assessment. Eight water indices of the Yulong River were tested, of which only three items came up to the National Standards. The assessment results were shown in table 2.

Table2 Water quality assessment results

Item	Temperature	pH	Colority	DO	COD_{Mn}	BOD_5	NH_3-N	TP
Result	＜1	0.215	2.6	4.43	1.82	1.403	3.33	2.27

Analysis of assessment results. Five of the eight water indices exceeded the standard values. The colority was 65, which was 2.6 times higher than the standard value. Since the color of water darkened, its light-transmittance decreased, which inhibited the growth and reproduction of the aquatic organisms due to the poor photosynthesis. The actual testing value of permanganate index was 18.2mg/L, which exceeded 0.82 times over the standard. Further, it reduced the concentration of dissolved oxygen in the water at night. The tested BOD_5 was 8.42mg/L, 1.403 folds of the standard value. And this index reflected that organic compounds exceeded the allowed capacity in the water. The waterbody of Yulong River downstream near the Liantong Road had become dark and smelly. It

indicates that the water was under the anoxic condition because the organic content was higher and the oxygen consumption rate was greater than the reoxygenation rate. As a result of the anaerobic microorganism's function, the organic compounds decomposed into CH_4, CO_2, NH_3 and little amount of H_2S. The measured value of ammonia nitrogen was 5.0mg/L, which far exceeded 2.33 times over the standard. The measured value of the total phosphorus was 0.227mg/L, which exceeded 1.27 times over the standard. Generally, the waterbody in which the total phosphorus and the inorganic nitrogen concentration respectively reached 0.02mg/L and the 0.3mg/L, symbolizes that it had already been in eutrophication. Because the total phosphorus and ammonia nitrogen of the Yulong River exceeded the above value, it is determined that the Yulong River had been in eutrophication. The wide growth of algaes corroborated this conclusion.

Analysis of pollution sources. The landscape water of the Yulong River was mainly affected by the human activities. The pollution sources could be divided into the point sources and nonpoint sources according to their characteristics.

Point pollution sources mainly include ① Industrial wastewater. Some chemical plants were situated in the upstream of the Yulong River, and the effluent sewage from these plants polluted the Yulong River. ② Domestic sewage. The massive domestic sewage from the hotels and residential areas along the Yulong River also polluted the river, as well as the rinsed wastewater from people living along the river. ③ Wastewater from urban sewage plants. The Nanding Sewage Plant was located at the upstream of Yulong River. Once it supplied water for the Yulong River, the quality of the treated water would become the key factor to determine the water quality of the Yulong River. If the quality of the treated water did not meet the standards, it would pollute the Yulong River. ④ Leachate of the municipal wastes. There were piles of rubbish along some reaches of the Yulong River. The leachate, which contained organic compounds and poison, flowed into the river with the storm water runoff, which resulted in the serious pollution of the river and severely endangered the aquatic organism’s survival.

Yulong River was built along the Xiliu Road, which was mainly agricultural area. Therefore the nonpoint source pollution of the river was serious. Especially when it rained, the rain runoff brought the used oil, gravel, scrap paper on the road into the Yulong River. Because of the excessive application of chemical fertilizers in the agricultural region of the upstream, the nutrients, such as nitrogen and phosphorus and pesticide were brought into the river by the runoff which polluted the river.

Remediation plans of landscape water quality

Remediation process of the Yulong River. Based on the assessment of the Yulong River, the organic pollution and the nitrogen, phosphorus contents which exceeded the allowed value were the primary causes of water pollution, therefore the treating emphasis was to reduce the nitrogen and phosphorus concentration, to eliminate the organic matter and to prevent the eutrophication [3]. Ecological composite filter bed technique which combined the sand filter with the wetland pond bed was applied to treat the river water. With low energy consumption and small footprint, the ecological composite filter bed was a new kind of process to treat the polluted urban landscape river water. It conformed to the requests of urban ecology, and could remove COD, SS, turbidity, nitrogen, phosphorus, and so on.

The technical process was shown as follows:

Influent→Rubber dam→Simple grid→Ecological composite filter bed→Rinsing tank→Effluent

The feed water (the polluted water of the Yulong River) was oxygenated when it flowed past the rubber dam, then flowed into the simple grids where large floatings were removed, further entered the ecological composite filter bed where the pollutant was removed through the filtration of pebbles, adsorption of carbon residues and biofilms. After that, the treated water flowed into the plant bed for further degradation, and the effluent flowed into the rinsing area, finally into the Yulong River.

Considering the characteristics of water treatment process and environmental characteristics of the Yulong River, the initial setting points of the process are shown in figure 1.

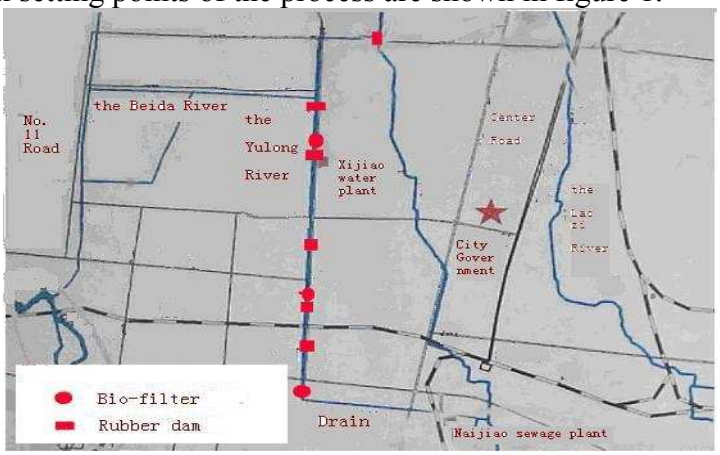

Fig.1 Schematic of arrangement plan of improvement for Yulong River

Feasibility analysis of the remediation plan. Due to the natural purification, small footprint, simple process without complex structures, cheap filter media and ease of administration, ease to access survival plants, the ecological composite bed was of less investments and operation costs.

It could not only achieve the treatment purpose, but also can unify the ecological sceneries around the city to apply the ecological composite filtering bed to treat the polluted urban landscape river. This treatment system was constructed in the river channel. Kinds of possibilities were considered involving planting ornamental plants and breeding the aquarium fish. The terrain was fully used for aeration, such as using the natural fall, the artificial fountain, and so on, which can also bring great ecological benefits to the urban environment.

After a period of operation, the filter media would be filled and blocked to a certain degree as a result of suspended solids and the biofilms in the river. Draining off the water, taking manual clean-up and changing filter material partly could restore the functions of filter media.

Conclusions and Suggestions

The detection and assessment results indicated that the Yulong River had already been in serious eutrophication, and the water quality could not meet the class Ⅳ standards of GB3838-2002.

According to the current situation of the Yulong River, the ecological filtering bed was proposed, and the feasibility of the process was also analyzed. Then the treatment setting points were initially determined.

Suggestions were proposed to control the point pollution sources of the Yulong River, to treat the sewage from the hotels and residential quarters along the river before it flowed into the Yulong River. Moreover, it is necessary to control the non-point pollution sources of the Yulong River, for example, to reduce the application of chemical fertilizers and pesticides, to reform agricultural irrigation, and to replace the flooding irrigation by the drip irrigation and spray irrigation. This can reduce the losses of nitrogen and phosphorus effectively.

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