Experiments of Water Quality Monitoring and Sediment Pollution Release in Shamao River

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Abstract. The Shamao River is an urban river in Wuhan Economic Development District, which water body is under heavy polluted. A whole year water quality monitoring was carried out in 2019, and the corresponding results showed that the water quality of Shamao river was lower than class V bad water quality. The sediment and overlying water samples were collected. Qualified and analyzed pollution indicators, including COD, ammonia nitrogen (NH$_3$-N) and total phosphorus (TP). The influence of pollutant in water released from sediment was analyzed through laboratory water column simulation experiment. It was found that there was no correlation between concentrations of COD, NH$_3$-N in sediment and corresponding concentrations in overlying water samples. The amount of total phosphorus (TP) in water samples are related to the amount of sediments. Simulated sediment pollution releasing experiments showed that the COD in sediment had weak effect on water quality. The releasing of nitrogen and phosphorus from the sediment increased with time, caused the secondary pollution of the water body.

Keywords: Shamao River, Sediment; Release, COD, Ammonia nitrogen (NH$_3$-N), Total phosphorus (TP)

1. Introduction

As the city grows and the population increases, more pollution discharged into inland river. Therefore, the concentrations of some pollutant in water body including COD, N, P, etc. have exceeded limits, which led to the water body turned into black-odorous water seasonally or even permanently [1,2]. The black-odorous water not only harmed the living environment in city, but also has negative impact on humans’ health. Nowadays, people started to strongly reflect this water problem [3].

Sediment pollutants become the focus of water body restoration. Research shows that the high concentration of S and N in sediment is due to the large amount of pollutant will precipitate and accumulate in the sediment after the water body keeps black and odorous for a period of long time. Vice, this is one of the main reasons of black-odorous river. So, during the black-odorous water treatment process, the sediment will play an important role in the corresponding overlaying water quality, which will become a new polluted internal source and cause the secondary pollution of the water body [4,5].

The Shamao River is an artificial river that connects the Maying River and the Yangtze River in Shamao City, Hannan District, Wuhan, with a total length of 1.55km. Its main function is to divert and reduce pressure during floods. However, for a long time, this water ditch has served as an urban sewer. Industrial sewage along the bank and all kinds of urban sewage are discharged into it, which seriously pollutes the water body of the river and led residents reflect strongly its black color and stink odor. As
a volunteer for the past two years, we have conducted publicity and water quality monitoring of the Maying River Basin in Hannan District. Collected water samples and sediments of Shamao River, analyzed the pollutant indicators COD, ammonia nitrogen, total phosphorus, etc., and then discussed the effects of sediments on river water quality. Besides, a simulation experiment on the release of sediments pollutants was carried out, in order to provide some reference for solving the black and odor problem of Shamao River.

2. Materials and Methods

2.1. Materials and Instruments
Nessler's reagent, potassium sodium tartrate, ammonium molybdate, potassium peroxodisulfate, ascorbic acid, vitriol, sodium hydroxide, ammonium chloride, Monopotassium phosphate, etc are all analytical purity, and were purchased through Sinopharm Chemical Reagent Co., Ltd. Experimental water is ultrapure water.

COD rapid digestive device (Beijing Lianhua Yongxing Technology Development Company), multi-parameter water quality analyser (American YSI Company), V-5100 type VIS Spectrophotometer (Shanghai Yuanxi Instrument Co., Ltd.).

2.2. Collection and Analysis of Water Samples and Sediments of Shamao River
According to the Surface Water and Sewage Monitoring Technical Specifications (HJ/T 91-2002), sampling points were set in the upper, middle and lower reaches of Shamao River separately. Sampling was monitored once a month from January to December 2019, and shallow sediments samples were collected in May. Dissolved oxygen (DO) in water samples was measured on-site with a multi-parameter water quality analyzer; the concentration of ammonia nitrogen and total phosphorus were measured in laboratory, using Nessler's colorimetry and ammonium molybdate spectrophotometry respectively [6]. Sediment was quickly collected and stored in a sealed plastic bucket, then transferred to the laboratory within 2 hours for cold storage. The ammonia nitrogen and total phosphorus in sediments were measured by the persulfate method [7].

2.3. Simulated Sediment Pollution Releasing Experiments
The sediment pollutant simulation experiment device adopted a self-made organic glass reactor with a diameter of 15 cm and a height of 120 cm, and the temperature was kept constant with the circulating water. The sediment was added slowly from the top of the container, and then about 2L of tap water sample, with a height of about 15cm was added slowly by using a siphon method. Combined a syringe and silicone tube sampler for regular samples, and tried not to disturb the sediment. After those, the concentrations of COD and ammonia nitrogen and total phosphorus were analyzed.

3. Results and Discussions

3.1. Shamao River Water Quality Analysis
From January to December 2019, the Shamao River water quality was monitored and investigated continuously, measured the indicators including dissolved oxygen (DO), chemical oxygen demand (COD), ammonia nitrogen (NH$_3$-N) and total phosphorus (TP) were measured. The results are shown in figure 1. In accordance with the Surface Water Environmental Quality Assessment Methods (Trial), Surface Water Environmental Quality Standard (GB 3838-2002) and some relevant standers. Reference the V category water quality from the Surface Water Environmental Quality Standard (GB 3838-2002), the DO only has exceeded standard in January and June, the COD exceeded the standard only in April, however, the ammonia nitrogen and the total phosphorus exceeded the corresponding standards in most months. Therefore, the overall water body was inferior to Category V. Moreover, the water body was dark and brown with a fishy smell, which belonged to the urban black-odorous water body.
3.2. Correlation Analysis of Sediment and River Water Quality

The sediments samples and their corresponding overlying water samples of the Shamao River were collected in May 2019. The monitoring results of those sediment samples and water samples are shown in Table 1. The correlations between pollution indicators in sediments samples and the pollution indicators in the water samples were discussed, and the results were shown in figure 2.

From figure 3, the concentrations of COD (which represents the organic pollutants in sediments) and NH$_3$-N in sediments samples have poor correlation with the concentration of corresponding overlying water samples. The reason might be the water quality changed quickly when the sewage discharged into the river, while the sediment changed relatively slowly. And there is a certain correlation between the TP in sediment samples and corresponding overlaying water samples, which might be related to the adsorption of phosphorus in the sediment.

Table 1. The monitoring results of water quality and sediment in Shamao River.

| Sampling sites | COD overlying water (mg/L) | COD sediment (g/Kg) | NH$_3$-N overlying water (mg/L) | NH$_3$-N sediment (g/Kg) | TP overlying water (mg/L) | TP sediment (g/Kg) |
|----------------|---------------------------|---------------------|-------------------------------|-------------------------|--------------------------|--------------------|
| Upstream       | 45.7                      | 126.3               | 6.1                           | 1.23                    | 0.57                     | 0.856              |
| Midstream      | 43.9                      | 78.9                | 7.77                          | 1.05                    | 0.40                     | 1.13               |
| Downstream     | 40.2                      | 67.8                | 5.31                          | 0.92                    | 0.42                     | 0.66               |
3.3. Influence of Sediment Release on Overlying Water the Nutrient Release from Sediments

Generally, the river has been under black and smelly for a long period of time, and the pollutants in the water body will diffuse and concentrate in the sediment, so the organic matter and inorganic salt in the sediment will transfer and transform into the corresponding overlying water through physical, chemical, and microbial reactions. Additionally, its concentrations in the sediment and river water are different, the redistribution of chemical pollutants between these two phases will lead the pollutants in the sediment releases into the corresponding overlying water, which will cause secondary pollution and affect the water quality [8].

According to the laboratory simulation release experiment, the results are shown in figure 3, figure 4, and figure 5. From figure 4, the release of COD in the sediment increased with time, and the release of COD was stable after 10 days, but the overall release of sediment had little effect on the water quality.

From figure 4 and figure 5, the concentrations of the ammonia nitrogen and the total phosphorus in the overlying water gradually increased over time. That is because the dissolved oxygen (DO) in the reaction water column was decreasing with time, and the DO in the water used up slowly about 10 days. Phosphorus accumulating bacteria in the sediment released phosphorus under anaerobic conditions, and so did the organic nitrogen in the sediment was in the microorganisms released ammonium nitrogen. So, under the experimental conditions, the sediment seemed as a "source", the nitrogen and phosphorus in the sediment were diffused and released from sediment to the corresponding overlying water body, caused secondary pollution to the corresponding overlying water body [9].

Figure 2. Relationship between pollutant concentrations of sediments samples and overlying water samples.
4. Conclusions
The DO, COD, the ammonia nitrogen and the total phosphorus in the Shamao River were monthly monitored from January to December in 2019. And the ammonia nitrogen and the total phosphorus exceeded the standard every month, which were the main pollutants. The concentrations of the COD and NH$_3$-N in the sediment had poor correlation with the concentrations in the corresponding overlying water samples, and there was a certain correlation about TP between in sediments the corresponding water samples.

The sediment release simulation experiments in 31-day showed that the COD concentration in the sediment had a small change and stabilized at 10 days, which had little effect on the water quality.

Both the concentrations of NH$_3$-N and the TP in the overlying water increased with time increasing, and the released of sediment had a certain effect on the corresponding overlying water quality, which could be seemed as a "source" of secondary pollution.

In nature environment, the relationship between the sediment and water pollution is very complex, because there are many factors and mechanisms will affect the sediment releasing pollutants, however, there are still many uncertain factors in the characteristics and impact of the sediment in the for black-odorous water bodies, which require further and deeper study to provide favorable technical support for solving the black-odorous water quality problem ultimately.
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