Study on Water Quality Characteristics and Production Coefficients of Urban Domestic Sewage in Shanghai

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Abstract. The existing coefficient of urban domestic sewage production cannot reflect the differences among regions. It is difficult to meet the needs of environmental protection work in Shanghai. This study divided Shanghai into three tiers. According to the 2017 on-line monitoring data of urban sewage treatment plants in main urban areas, Xincheng district and Xinshi town, the concentration of pollutants of each tier was calculated. And the production coefficients of urban domestic source pollutants at all tiers in Shanghai was obtained by combining with the urban per capita comprehensive domestic water consumption. The results showed that the COD_{cr} concentration changes in Xincheng district were relatively large, and that changes in the main urban area and Xinshi town were relatively small. The pollutant production coefficients of the main urban area, Xincheng district and Xinshi town were COD_{cr}: 75.6 g/d.cap, 66.95 g/d.cap, 28.02 g/d.cap, NH_3-N: 7.76 g/d.cap, 5.32 g/d.cap, 2.04 g/d.cap.

1. Introduction

With the rapid growth of population and social economy, the discharge of wastewater from domestic sources in Shanghai accounted for 85% of the total amount of wastewater in 2017[1], the proportion of living source pollutants in the total urban pollutants was increased, which has became one of the main reasons affecting the quality of urban water environment. Therefore, ascertaining the situation of urban living source pollution is very important for water pollution reduction and environmental management decisions.

The existing domestic sewage production coefficient research in China was mainly divided into three tiers, individual [2-3], residential quarters [4-7], sewage treatment plants [8-9], in addition, there are scholars on campus [10] as a study area. Individuals and residential communities lack research on wastewater from service industries such as catering and accommodation. The campus environment was relatively closed, the staff was fixed, and it was not representative because it was special. The resulting per capita pollutant production coefficient may differ from the actual pollution situation.

The object of this study was wastewater from urban living sources, which mainly includes wastewater from residents' household life and tertiary industry, schools, and office activities. By collected Shanghai different development tiers of sewage treatment plant influent water quality monitoring data, combined with the urban water supply, formulate pollutant production coefficients for urban living sources in Shanghai.

2. Research Methods

2.1. Statement of Problem

Considering the city's districts economic, social and industrial development level and the status quo, the "Shanghai Urban Master Plan" (2017-2035) and "Shanghai Water Supply Plan" (2017-2035 years) as the basis, the city divided into major urban areas, Xincheng district, and Xinshi town, and determine the production coefficients of COD_{cr} and NH_3-N at different tiers.

The urban domestic sewage is collect by the sewage pipe network and then discharged to the sewage treatment plant, when the rainwater and industrial wastewater mixed in the sewage pipe network are relatively small, it can be considered that the influent concentration of the sewage treatment plant is equivalent to the urban sewage produced concentration [8]. Collecting different tiers of 2017 sewage treatment plant influent water quality on-line monitoring data, analysis of water quality characteristics of urban life source. In order to reduce the impact of rainfall on the concentration of urban sewage, through screening of meteorological factors (the rainfall 3 consecutive days did not exceed 1 mm), obtaining the import concentration of urban sewage treatment plants at different tiers, and calculating the production coefficient of urban living source water pollutants in combination with per capita comprehensive domestic water consumption at different tiers.

2.2. Methods

The estimation of pollutant generation per capita per day (GCPD) values was conducted according to the following equations (1) [11]:

$$F=Q\cdot k\cdot C/1000 \quad (1)$$

In the formula:

F——Single factor production coefficient of comprehensive domestic sewage in a certain level of town, g/d.cap;

Q——Urban per capita comprehensive domestic water consumption, L/d·cap;

k——Comprehensive urban drainage coefficient, dimensionless;

C——Average concentration of urban comprehensive domestic sewage, *mg/L*.

The value of *k* is select as follows: when $Q \leq 150$ L//d·cap, *k* is 0.8; when $Q \geq 300$ L/d·cap, *k* is 0.9; when 150 L/d·cap $< Q <$ 300 L/d·cap, *k* is determined by interpolation.

2.3. Key Parameter

Comprehensive urban water consumption is includes domestic water consumption and public service water consumption. According to the "Shanghai System Plan" (2017-2035), the per capita residential water consumption index in the main urban area is generally 120-160 L/d·cap, and Xincheng district is generally 120-150 L/d·cap, Xinshi town is generally 80-100 L/d·cap. Water indicators for public services can be characterized by tertiary industry coefficients [12]. According to the residents' water consumption and tertiary industry coefficients the average value of urban comprehensive living water consumption in the main urban area is 310 L/d·cap, in Xincheng district is 240 L/d·cap, in Xinshi town is 117 L/d·cap.

2.4. Data Processing and Quality Control

Sewage treatment plant data uses SPSS 25 software, using descriptive statistics in statistical analysis to check whether the data conform to the normal distribution. According to the Dixon test, the data of the main pollutant concentration values outside the standard deviation of ± 3 times are outliers, and the outliers are excluded. Using ORIGIN 2017 for data analysis and graphing.

3. Results and Discussion

3.1. Concentration of Domestic Sewage

In order to avoid the influx of river water and groundwater and the leakage of drainage network, using the ratio of the dry season to the annual average (that is, the correction coefficient) is shown in Table 1, the contaminant concentration was corrected to achieve the closest to the actual concentration of the

object, the corrected concentration of domestic sewage is shown in Table 2.

Table 1. Calculation results of pollutant the correction coefficient

Paramater	Main urban area	Xincheng district	Xinshi town
COD_{cr}	1.06	0.96	1.07
NH_3-N	1.11	0.92	1.03

Table 2. Concentration of domestic sewage at different tiers (mg/L)

Paramater	Main urban area	Xincheng district	Xinshi town
COD_{cr}	270.98	324.39	299.40
NH_3-N	27.80	25.79	21.76

It can be seen from Table 2 that the comparison of COD_{cr} concentration was Xincheng district > Xincheng district > main urban area, and the comparison of NH_3-N concentration was main urban area > Xincheng district > Xinshi town.

3.2. Analysis of the Distribution Characteristics of Sewage Water Quality

3.2.1. Variation of pollutant concentration. As shown in Figure 1(a), the COD_{cr} concentration tiers of three tiers variation having certain similarity, in 2017 the overall upward trend of January to March, April to August decreased, the concentration of October to December increased, small peak in September, and the main urban area of the highest values of the year in September. The minimum COD_{cr} concentration in all three tiers was appeared in August. The COD_{cr} concentration changes in Xincheng district were relatively large, and the COD_{cr} concentration changes in the main urban area and Xinshi town were relatively small.

As shown in Figure 1(b), the three tiers of NH_3-N concentration in whole was January 2017 to March rise, from April to September decreased, and fluctuations occur. The main urban and Xinshi town concentrations were rised of October to December, Xincheng district concentration was increased in November, but decreased in December concentration. Three tiers of NH_3-N concentration of relatively stable changes.

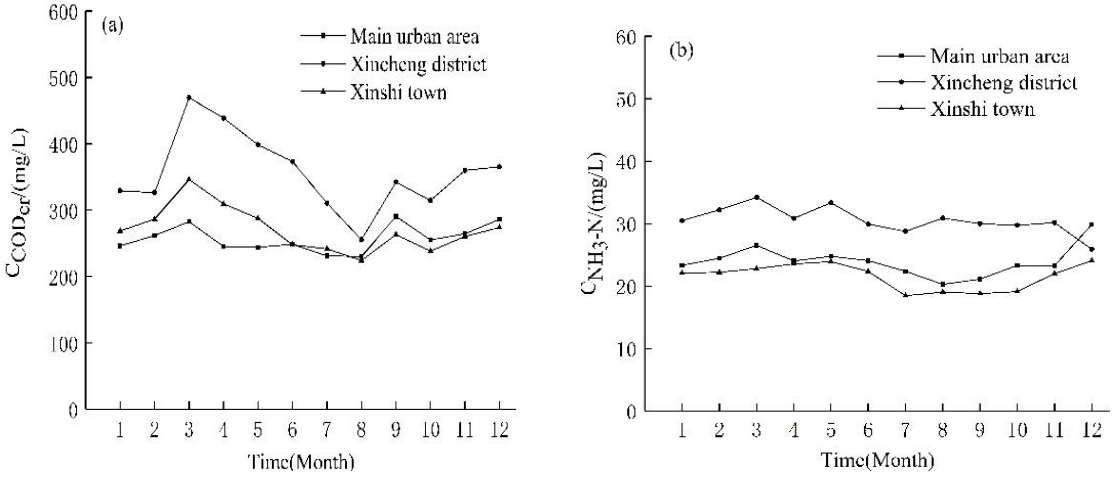

Figure 1. Annual variation curve of pollutant concentration

3.2.2. Accumulation probability analysis of sewage water quality. As shown in Figure 2(a), the concentration range of the higher probability distribution of COD_{cr} in the main urban area was 150-350 mg/L, and its cumulative probability was 86.2%. As shown in Figure 2(b), the concentration range of Xincheng district COD_{cr} with a high probability distribution was 150-450 mg/L, and its cumulative probability was 78.4%. As shown in Figure 2(c), the concentration range of the higher probability distribution of COD_{cr} in Xinshi town was 100-450 mg/L, and its cumulative probability was 87.7%.

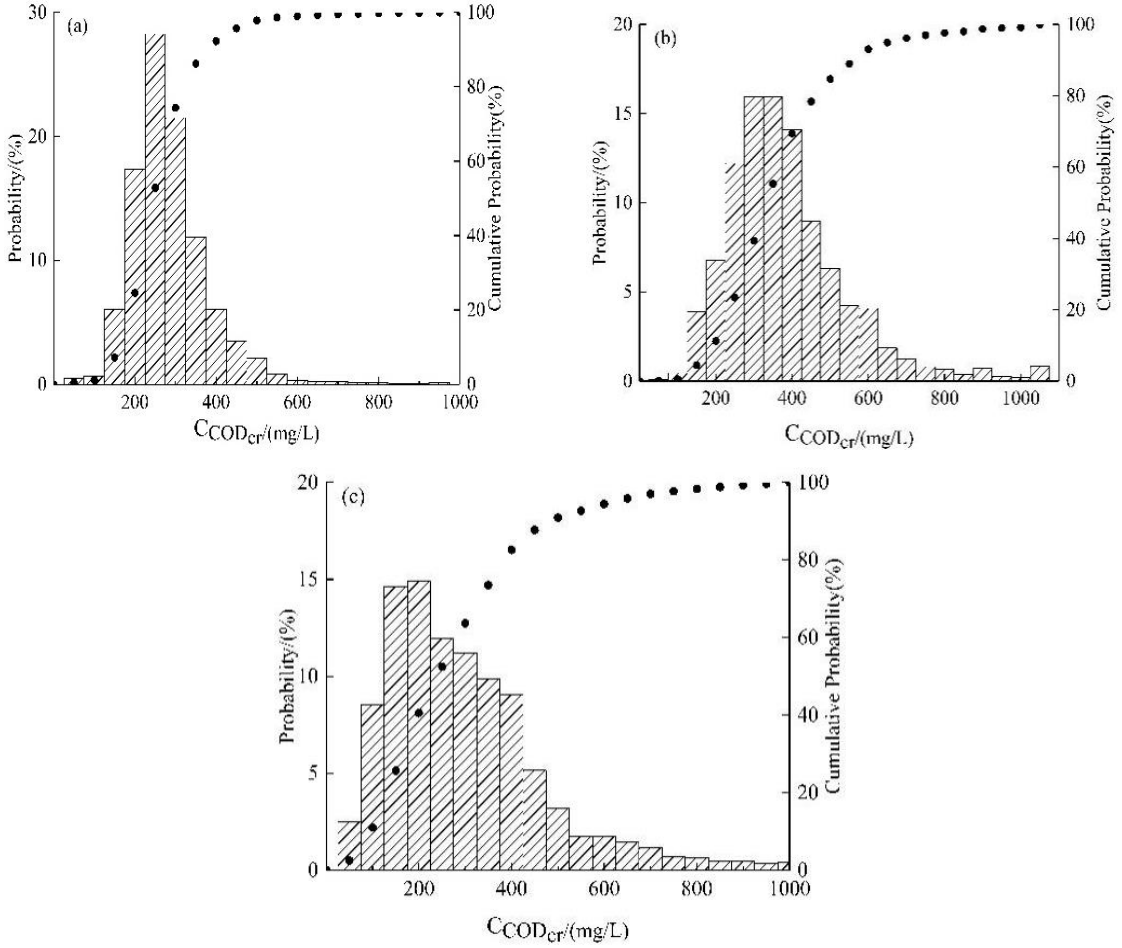

Figure 2. COD_{cr} cumulative probability curve

As shown in Figure 3(a), the concentration range of NH_3-N with a high probability distribution in the main urban area ranges from 20-45 mg/L, and its cumulative probability was 98.9%. As shown in Figure 3(b), the concentration range of Xincheng district NH_3-N with a high probability distribution was 20-50 mg/L, and its cumulative probability was 93.2%. As shown in Figure 3(c), the concentration range of NH_3-N in Xinshi town with a high probability distribution was 10-40 mg/L, and its cumulative probability was 93.0%.

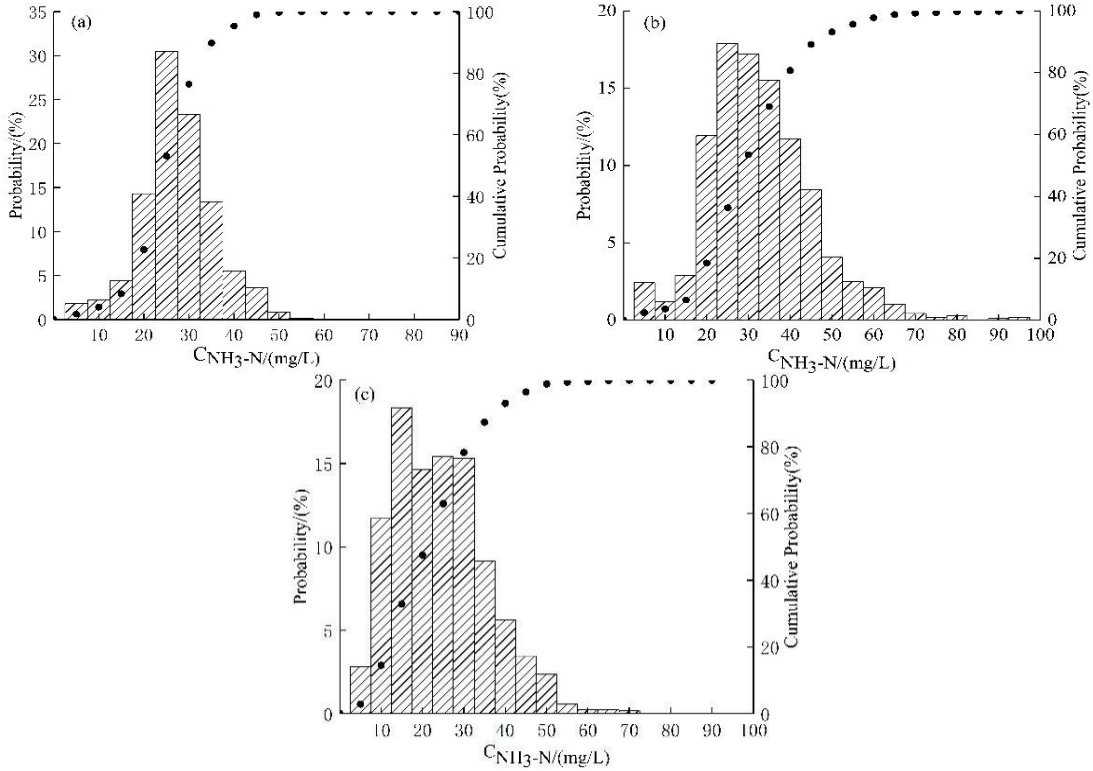

Figure 3. NH_3-N cumulative probability curve

3.3. Determine the Production Coefficient of Urban Living Source Pollutants

According to formula (1), the production coefficients of COD_{cr} and NH_3-N in different tiers are obtained, as shown in Table 3.

Table 3. Pollutant production coefficients [g/d.cap]

Paramater	Main urban area	Xincheng district	Xinshi town
COD_{cr}	75.60	66.95	28.02
NH_3-N	7.76	5.32	2.04

According to the literature [2-10], the production coefficients of different pollutants in different city were different. Based on the research results of urban sewage treatment plants [8-9], the COD_{cr} production coefficient was between 27.9 g/d.cap to 69.9 g/d.cap, with an average was 51.1 g/d.cap. The NH_3-N production coefficient was between 2.6 g/d.cap to 7.9 g/d.cap, with an average was 5.4 g/d.cap. In this study, in addition to Xinshi town COD_{cr}, both the main urban area and Xincheng district were higher than the earlier studies average. NH_3-N in addition to the main urban area, Xincheng district and Xinshi town were below the average in the previous study.

Huan Zhu [5] calculated that the results of Shanghai were COD_{cr} 54.5 g/d.cap, NH_3-N 6.4 g/d.cap. The average production coefficient of each pollutant in the main urban area of this study was higher 29.98% than the result of Zhu Huan. The COD_{cr} production coefficient of Xincheng district was higher 22.84% than that of Zhu Huan, and the NH_3-N production coefficient was lower 16.88% than that of Zhu Huan. The average coefficient of each pollutant calculated by Zhuhuan was higher 58.36% than Xinshi town.

4. Conclusion

The results show that the production coefficients of COD_{cr} and NH_3-N were both in the main urban area> Xincheng district > Xinshi town. The main urban area and Xincheng district were close to each

other in terms of the coefficient of pollutant production, but it was significantly different in Xinshi town. Therefore, carry out a stratified study was necessary in Shanghai. The layer-by-layer measurement of the pollutant production coefficient can more accurately reflect the pollution status of domestic pollution sources in Shanghai, and understanding the characteristics and rules of pollution production at different tiers. The coefficients measured in this study can provide a basis for environmental management departments to correctly judge the current status of the environment, especially for the total control of COD_{cr} and NH_3-N in Shanghai's 13th Five-Year Plan. This study used online monitoring data, only COD_{cr} and NH_3-N pollutants. In the next step, actual measurement methods can be use to monitor other water pollutants and calculating the production coefficient.

5. Acknowledgement

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