Discussion on the value of some parameters in the calculation of regional water pollutant discharge amount

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Abstract. Calculation of water pollutant discharge amount is the basis for compiling regional water pollution control plans and water resources protection plans. Although most of the calculation parameters can be obtained from the relevant standards or guidelines, the calculation and value method for some important parameters are not clear or have different reference standards, such as urban sewage treatment rate, rural domestic pollution discharge coefficient and sewage discharge amount from service industry. Take the calculation of pollutant discharge amount in Hangjiahu plain as an example, the calculation method and value range of the above parameters is discussed in this paper.

1. Introduction
The calculation of the pollutant discharge amount is the basis for compiling regional water pollution control plans and water resources protection plans. It is also the main content of the second national survey of pollution sources. For the calculation of pollutant discharge amount in a certain area, the method widely used at present is discharge coefficient approaches, that is, according to the social economic data such as population, industrial scale and land use in the region, the appropriate discharge coefficient is selected for calculation. The social economic data are from comprehensive statistical yearbook, urban-rural construction statistical yearbook, and environmental statistics, etc. The value of discharge coefficient can be in accordance with the manual of discharge coefficient for the survey of pollution sources, technical guide for the calculation of water environment capacity, relevant technical regulations and works. Although most of the calculation parameters can be obtained from the relevant standards or guidelines, the calculation and value method for some important parameters are not clear or have different reference standards, such as urban sewage treatment rate, rural domestic pollution discharge coefficient and sewage discharge amount from service industry. As a result, the results calculated by different researchers in the same area are quite different. Take the calculation of pollutant discharge amount in Hangjiahu plain as an example, the calculation method and value range of the above parameters is discussed in this paper.
Figure 1. River networks map of Hangjiahu plain.

2. Sewage centralized treatment rate
The sewage centralized treatment rate is a key parameter to calculate the discharge amount of urban sewage and pollutants. The calculation formula is given as,

\[ \text{Sewage centralized treatment rate} = \frac{\text{The amount of sewage centrally treated}}{\text{The amount of sewage produced}} \]  \hspace{1cm} (1)

In the formula, the urban sewage discharge amount can be estimated according to the tap water consumption, drainage permit, pollutant discharge permit and other data. The amount of sewage centrally treated is the amount of treated sewage in the urban sewage treatment plant. Groundwater, rainwater and river water are often mixed in the sewage to the sewage treatment plant due to abundant rainfall in Hangjiahu plain and incomplete separation of rainwater and sewage. The actual amount of sewage is lower than the measured inflow. At present, when calculating the sewage treatment rate, the amount of non-sewage mixed in the urban sewage collection pipe network is not fully considered in most cities, and the calculated value of sewage treatment rate generally exceeds 80%, significantly higher than the actual value. Therefore, in order to calculate the real value of urban sewage treatment rate, it is necessary to clarify the amount of non-sewage mixed in the urban sewage collection pipe network.

As an example, when calculating the discharge amount of urban sewage and pollutants in Hangjiahu plain, the computational procedure of the amount of non-sewage mixed in the urban sewage collection pipe network is as follows.

- Amount of groundwater infiltration: according to “Code of Urban Wastewater Engineering Planning (GB 50318-2017)”, the groundwater infiltration amount can be calculated as no less than 10% of the sewage amount; According to “Code for Design of Outdoor Wastewater Engineering (GB50014-2006)”, the amount of groundwater infiltration can be calculated according to 10-15% of...
the average daily total amount of domestic sewage and industrial wastewater. Referring to the results of related studies in and around the region[3,4], the amount of groundwater infiltration into the sewage pipe network in Hangjiahu plain can be calculated according to 10-20% of the sewage amount.

- Amount of mixed rainwater: The combined sewers are widely used in urban living areas and business districts in Hangjiahu plain, especially in the old city, villages in the city and urban-rural fringe area. Some industrial areas also use combined sewer system. According to the daily inflow data and daily rainfall data of urban sewage treatment plants in the region in 2017, and referring to relevant research results in similar area[5,6], the annual amount of rainwater entering the sewage pipe can be calculated as 7.5%-10% of the amount of sewage in the areas where the main drainage system is combined sewer system. According to the distribution of area with combined sewerage system in Hangjiahu plain, the annual amount of rainwater entering sewage pipes is about 2-10% of the amount of sewage.

- Amount of river water infiltration: The height of some sewage pipes in the area is lower than the water level of the river, and the pipeline leakage causes the water to enter the sewage pipes. According to the daily inflow data of the sewage treatment plant and the measured data of river water level during the dredging period, the annual amount of river water infiltration into the sewage pipe network in the area is about 5-15% of the amount of sewage.

Generally, the amount of groundwater, rainwater and river water entering the sewage pipe network in the study area is about 17-40% of the amount of sewage, which should be deducted from the inflow amount of urban sewage treatment plants as calculating the amount of sewage centrally treated. Use this method, the calculation results of urban sewage centralized treatment rate of major urban areas in Hangjiahu plain in 2017 are shown in the table below.

| Areas                      | The amount of sewage produced(million m$^3$) | The amount of sewage centrally treated(million m$^3$) | sewage centralized treatment rate |
|----------------------------|---------------------------------------------|------------------------------------------------------|----------------------------------|
| Hangzhou downtown (the area in Hangjiahu plain) | 399                                         | 348                                                  | 85.1%                            |
| Municipal district of Jiaxing | 145                                         | 112                                                  | 77.3%                            |
| Municipal district of Huzhou    | 123                                         | 99                                                   | 80.5%                            |

The calculated sewage treatment rate is less than the values in the yearbook, and the main reason is the difference in the amount of non-sewage mixed in the urban sewage pipe network.

3. Rural domestic pollutant discharge coefficient

Unlike domestic pollution sources in urban areas, the domestic pollutants discharge amount in rural area is largely influenced by people living habits, living standards, way of using water and other factors. The pollutants emission intensity varies greatly between different regions, so it is not reasonable to use uniform standards or calculation parameters. It is necessary to investigate the discharge of rural domestic sewage in the region. Most areas in Hangjiahu plain have carried out rural sewage collection and treatment. The domestic pollutants discharge amount in rural areas can be calculated by investigating domestic water consumption and concentration of pollutants in domestic sewage.

The domestic sewage amount is calculated by water consumption. According to “Code for Design of Outdoor Wastewater Engineering (GB50014-2006)”, the domestic sewage amount can be calculated according to 80% of the water consumption amount.

The concentration of pollutants in domestic sewage was calculated according to the average concentration of pollutants in the inlet water of rural domestic sewage treatment facilities. A few of treatment facilities are not included in the calculation because of the presence of livestock and poultry breeding wastewater resulting in high COD concentration. The sampling data of pollutant
concentration in some treatment facilities are shown in the table below.

Table 2 The sampling data of pollutant concentration in rural domestic sewage treatment facilities.

| Facilities number | Hangzhou | Jiaxing | Huzhou |
|-------------------|----------|---------|--------|
|                   | COD(mg/L)| NH₃-N(mg/L) | COD(mg/L)| NH₃-N(mg/L) | COD(mg/L)| NH₃-N(mg/L) |
| 1                 | 194.9    | 28.8    | 110.1  | 23.9    | 135.3  | 23.5    |
| 2                 | 203.0    | 27.3    | 89.9   | 14.4    | 383.8  | 44.5    |
| 3                 | 138.4    | 24.0    | 616.1  | 66.2    | 488.8  | 47.3    |
| 4                 | 474.7    | 68.3    | 454.5  | 48.0    | 330.3  | 62.4    |
| 5                 | 449.5    | 46.4    | 142.4  | 46.8    | 105.0  | 19.6    |

According to the amount of rural domestic sewage and the average pollutant concentration, the domestic pollutant discharge coefficient in rural area in Hangjiahu plain is calculated. The results are shown in the table below.

Table 3 Domestic pollutant discharge coefficient in rural area in Hangjiahu plain.

| Areas               | Sewage discharge (L/p/d) | Average CODₜ concentration (mg/L) | Average NH₃-N concentration (mg/L) | COD discharge coefficient (g/p/d) | NH₃-N discharge coefficient (g/p/d) |
|---------------------|-------------------------|-----------------------------------|-----------------------------------|----------------------------------|-----------------------------------|
| Hangzhou            | 127                     | 287.0                             | 42.8                              | 36.5                             | 5.45                              |
| Jiaxing             | 127                     | 260.5                             | 36.3                              | 33.0                             | 4.60                              |
| Huzhou              | 120                     | 285.4                             | 35.3                              | 34.3                             | 4.24                              |

The calculated results of domestic pollutant discharge coefficient in rural area is significantly lower than the urban pollutant discharge coefficient which are given in the manual of discharge coefficient for the survey of pollution sources, indicating that the per capita pollutant discharge amount in rural area is significantly lower than the per capita amount in urban area.

4. The amount of sewage from service industry

The pollutant discharge coefficients of various service industries are listed in detail in the manual of discharge coefficient for the survey of pollution sources, and the accuracy of the calculation method is relatively high. However, a large amount of basic data needs to be collected for the calculation, and most of the data is difficult to obtain, such as the number of seats and beds in all service enterprises in the region. In The discharge coefficient of domestic pollution source and instruction written by South China Institute of Environmental Sciences, the per capita sewage production amount of service industry in different regions of the country are listed. However, due to the large scope of the survey, the data in different regions inevitably have deviation with the actual situation. When calculating the sewage amount from service industry, the water consumption data in the region should be collected first, which are used to calculate the sewage amount and the per capita sewage discharge coefficient indirectly.

The calculation results of the amount of sewage from service industry and per capita sewage discharge amount in Hangjiahu plain in 2017 are shown in the table below.

Table 4 The amount of sewage from service industry in Hangjiahu plain in 2017.

| Areas                           | Permanent population(million) | The amount of sewage from service industry (million m³) | per capita sewage discharge amount (L/d) |
|---------------------------------|-------------------------------|--------------------------------------------------------|-----------------------------------------|
| Main urban area in Hangzhou city| 3.32                          | 261                                                    | 183                                     |
| Hangzhou (the area in Hangjiahu plain) | 4.72                          | 330                                                    | 163                                     |
| Jiaxing downtown                | 1.26                          | 40                                                     | 73                                      |
| Jiaxing                         | 4.66                          | 104                                                    | 52                                      |
Except for Hangzhou, the data of per capita amount of sewage from service industry in other regions have little difference, ranging from 52 to 73 L/d. The per capita sewage discharge amount of service industry in Hangzhou is much higher than that of other regions, and the reason may be that Hangzhou has developed tourism and commerce, and foreign tourists use a lot of water.

5. Conclusions and suggestions
Take the calculation of pollutant discharge amount in Hangjiahu plain as an example, the calculation method and value range of some important parameters is discussed in this paper. The conclusions and suggestions are as follows.

First, the amount of groundwater, rainwater and river water entering the sewage pipe network in the study area is about 17-40% of the amount of sewage, which should be deducted from the inflow amount of urban sewage treatment plants when calculating the amount of sewage centrally treated. Otherwise, the calculated sewage treatment rate will be higher than the actual value.

Second, based on the data of rural domestic water consumption, rural population and pollutant concentration in wastewater of rural sewage treatment facilities, the domestic pollution discharge coefficient in rural area of Hangjiahu plain was calculated. The per capita pollutant discharge amount in rural area is significantly lower than the per capita amount in urban area.

Third, based on the data of water consumption in service industry and permanent population data, the per capita amount of sewage from service industry in main cities in Hangjiahu plain is calculated. The per capita sewage discharge amount of tourism cities is much higher than that of other cities.

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