Research on the sewage treatment in high altitude region based on Lhasa Sewage Treatment Plant

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Abstract. Sewage treatment is of great significance to enhance environmental quality, consolidate pollution prevention and ecological protection, and ensure sustainable economic and social development in high altitude region. However, there are numerous difficulties in sewage treatment due to the alpine climate, the relatively low economic development level, and the backward operation and management styles, etc. In this study, the characteristics of influent quality in the sewage treatment plant in Lhasa are investigated by analysing the influent BOD5/COD and BOD5/TN, comparing key indexes recorded from 2014 to 2016 with the hinterland. Results show that the concentration of influent COD, BOD5, NH3-N and SS in the Lhasa sewage treatment plant, in which the sewage belongs to low-concentration urban sewage, is smaller than that in the domestic sewage treatment plants in the mainland. The concentration ratio of BOD5/COD and BOD5/TN is below 0.4 and 4, which indicates that the biodegradation is poor and the carbon sources are in bad demand. The consequences obtained play a vital role in the design, operation and management of sewage treatment plants in high altitude region.

1. Introduction
With the rapid development of society and economy, sewage discharge is gradually increasing in big cities in plateau. Sewage treatment is required to protect the environment in high altitude region, which will reduce both the organic and inorganic pollutants, especially nutrients like nitrogen and phosphorus. However, the operation of WWTPs in high altitude region faces several unusual obstacles caused by the extreme climatic conditions in high altitude region: strong solar radiation, sharp variation in temperature from day to night, rarefied air and low oxygen pressure. To be sure of the processing capacity and operating characteristics of sewage treatment facilities, we need to accurately grasp the water pollutant mass load in the sewage treatment plant[1-3].

In this study, we will take Lhasa sewage treatment plant as our research object, and analyze the variation rules of the concentration of primary contamination indexes in urban sewage in 2014, 2015, 2016 systematically, and the proportional relationships between the biodegradability, organic matter and nitrogen, and that we compared the influent key indexes with that in the hinterland. The aim is to provide scientific guidance for the actual operation of the urban sewage treatment plant in Tibet. Moreover, it also can provide theoretical and scientific basis for the design and determination of water pollutant mass load in newly-built sewage treatment plant in high altitude region.

2. Results and discussion
2.1. **Analysis of influent quality**

Figure 1 shows the fluctuations in the concentration of influent COD in Lhasa sewage treatment plant from 2014 to 2016. As we can see from the figure 1, it is on the decrease monthly and fluctuates widely in 2014. Similarly, in 2015, the influent COD concentration fluctuates greatly in August and its loading changes because of the largest rainfall in August. Besides, rainy seasons in Lhasa have much peculiarity, it rains generally at dawn and midnight. Consequently, the fluctuation of influent COD concentration changes a lot. Likewise, we can also conclude that the mean of COD ranges from 91.1 mg/L to 108.99 mg/L in 2016 without a large margin.

![Fig.1](image1.png)

**Fig.1** The fluctuations of influent COD in Lhasa sewage treatment plant in 2014, 2015 and 2016

Figure 2 shows the fluctuations in influent BOD₅ concentration of Lhasa sewage treatment plant in 2014, 2015 and 2016. Obviously, the fluctuation of influent BOD₅ concentration is relatively serious and the concentration reaches the peak in May. According to investigation, because Lhasa utilizes a kind of combined drainage system as sewage network collection system. Apart from the domestic sewage quality, influent quality is related to rainfall and so on. Additionally, it has distinct dry and wet season with concentrated precipitation in wet season, which generally rains from July to September when both the frequency and water consumption for shower rise remarkably because of the high temperature. Due to the increase of water consumption which mainly consists of shower sewage with large flow and low pollutant mass concentration and dilution effect on domestic sewage along with the rainy season, pollutant concentration keep it low between June and September. However, the
concentration of influent BOD$_5$ in May exceeds any other month. From figure 2, we also can see that the mean of BOD$_5$ range between 22.87 mg/L and 27 mg/L in 2015 and in 2016, it reach 22.83 mg/L - 26.53 mg/L, relatively stable.

Figure 3 shows the fluctuations in the concentration of influent NH$_3$-N in Lhasa sewage treatment plant from 2014 to 2016, from which we can see that in 2014, the concentration of influent NH$_3$-N declined along with the month going. Besides, in October 2014, the fluctuations of influent NH$_3$-N reached a peak, and there was also a big change in load. That is because the bath water consumption reduces sharply in October and the rainfall reduces [4]. According to figure 3, with a narrow fluctuation range, the average concentration of NH$_3$-N in 2015 and 2016 fluctuates between 12.09-17.09 mg/L and 11.69-17.16 mg/L.

Figure 4 shows the fluctuations in the concentration of influent SS in Lhasa sewage treatment plant from 2014 to 2016. As can be seen from it, the SS in August 2014 is the minimum when compared with other months, which is caused by relatively concentrated precipitation in Lhasa, mostly falling from July to September with the heaviest rainfall in August. The increase in rainfall contributes to dilution of domestic sewage, which makes the August influent SS is less than the others. Additionally, the concentration of influent SS in summer is lower than those in other months due to the decline in pollutant load with water increasing in combined sewer network during rainy season.
2.2. Analysis of influent BOD$_5$/COD and BOD$_5$/TN

BOD$_5$/COD is often used to predict the biodegradability of sewage. When BOD$_5$/COD ranges between 0.4 and 0.6, the biodegradability is considered to be fine. When BOD$_5$/COD range between 0.2 and 0.4, it indicates that the sewage contains refractory biodegradation $^{[5]}$. As seen from the figure 5, the average of influent BOD$_5$/COD in Lhasa sewage treatment plant is less than 0.4 and the biodegradability is poor. The main reason is that industrial wastewater tends to be mixed in Lhasa sewage collection pipe network, resulting in domestic sewage which consists of different types of refractory organic pollutants $^{[6-7]}$.

Sufficient carbon sources is the necessity of denitrification, which will be restricted if it were lacking carbon sources, then it would make total nitrogen removal rate of the system decrease. On the contrary, too much influent carbon sources will restrict denitrification as well, putting the efficiency of denitrification at low level. Meanwhile, the total rate of nitrogen removal cannot keep it high, so influent is needed to contain BOD$_5$/TN$^{[8]}$. Usually, when the BOD$_5$/TKN in the denitrification reactor is more than 4~6, the carbon source can be thought to be adequate. According to figure 6, the mean of BOD$_5$/TN is less than 4 in Lhasa sewage treatment plant, from which we can conclude that the plant lacks of carbon source in influent denitrification, which means the wastewater is sewage at low C/N ratio which requires to control appropriately additional carbon source.

![Fig.5](image1.jpg)

Fig.5 The value of influent BOD$_5$/COD in Lhasa sewage treatment plant in 2014, 2015 and 2016

![Fig.6](image2.jpg)

Fig.6 The value of influent BOD$_5$/TN in Lhasa sewage treatment plant in 2014, 2015 and 2016

2.3. The main indexes compared with the hinterland
We compare the range of various key influent indexes in Lhasa sewage treatment plant from 2014 to 2016 with the hinterland and the results are shown in Table 1:

| Year   | COD (mg/L)    | BOD₅ (mg/L)   | NH₃-N (mg/L) | SS (mg/L)     |
|--------|---------------|---------------|--------------|---------------|
| 2014   | 85.78-231.70  | 18.28-36.5    | 4-24.15      | 31.23-147.87  |
| 2015   | 70.52-126.30  | 18.21-31.88   | 8.18-21.50   | 42.40-85.72   |
| 2016   | 61.79-119.31  | 18.65-31.26   | 7.27-21.31   | 8.09-79.97    |
| Hinterland | 250-1000      | 100-400       | 15-50        | 100-350       |

According to the Table 1, the four key influent indexes in Lhasa sewage treatment plant are less than those in the hinterland. If this kind of sewage is treated in Lhasa sewage treatment plant, it will not only increase the operating burden, but also cause the waste of energy. Moreover, it will also affect the stability of sludge concentration in sewage treatment, which will further reduce the sludge activity and decrease the performance of the sewage biological treatment system. The possible reasons are described as followed: Firstly, urban population in Lhasa is still smaller than the hinterland, and the economy is underdeveloped as well. So sewage quantity and content index are relatively less than the hinterland. Secondly, Lhasa sewage collection pipe network is imperfect, and groundwater is abundant and seriously infiltrated, which will dilute the sewage to some extent. Thirdly, there is no train and Sewage Shunting collection System in the sewage collection pipe network underground in Lhasa, which increases the sewage flow and dilutes the sewage to some extent.

3. Conclusions

In the actual influent quality indexes of Lhasa sewage treatment plant in 2014, 2015 and 2016, the changes of COD, BOD₅, NH₃-N and SS in each month have both similarities and their own features. The average of influent BOD₅/COD in Lhasa sewage treatment plant is less than 0.4, and the biodegradability is poor. The average of influent BOD₅/TN are less than 4, in other word, domestic sewage is featured with low carbon and nitrogen ratio, which shows a serious shortage of carbon sources. The content of COD, BOD₅, NH₃-N, SS in Lhasa sewage treatment plant are all less than the scope of the same indexes in the hinterland sewage treatment plant. It is a typical low concentration of urban sewage, and the influent quality meets the level B standard of the Pollutant Discharge Standard of Municipal Wastewater Treatment Plant (GB18918-2002).

Based on the analysis of characteristics of influent quality for Lhasa Sewage Treatment Plant, we put forward the following suggestions: ① Perfecting the city pipeline in the plateau region, preventing groundwater from diluting sewage because of penetration. ② Building rain and Sewage Shunting collection System, prohibiting rain from diluting sewage to some degree. ③ Putting some fecal water to improve the processing efficiency. ④ Making some adjustments to sewage treatment according to the actual situation owing to the huge differences between the plain and the plateau. ⑤ Intensifying the research on sewage treatment as to developing the suitable technique for the sewage treatment in the plateau.

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