Analysis on biological stability influencing factors of living district water distribution system

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Abstract. The objective of this study was to evaluate the bistability of living district water distribution system and impact factors under different hydraulic operation conditions. In order to study bacterial regrowth potential in water distribution system, biodegradable dissolved organic carbon (BDOC) was taken as a tool. Total bacteria number showed a positive correlation with BDOC concentration in network water. However, Residual chlorine showed negative correlation with total bacteria number. Fe ion would lead to Turbidity rising in the water distribution system.

Introduction

The water plant provides drinking water that meets national standardization for industries and local customers. In order to guarantee water safe, the water works maintains an adequate disinfectant residual throughout the distribution system[1]. It has been used since the 1900s to control microbe regrowth and minimize risks to public health[2]. The water distribution system just like a huge reactor, where there are often sensory, physiochemical and microbial indexes change that deteriorate the water quality within the system[3]. The water works added adequate dose of chlorine to finished water for inhibiting bacteria growth. However, sustaining an effective chloramine level throughout the distribution system is practically challenging. These changes typically contain chlorine decay and formation of disinfection by-products[4], and these DPs do great harm to people health.

It is well known that chlorine is a strong oxidizing agent that can turn big natural organic matters into small molecule matters. Therefore, the amount of biodegradable dissolved organic carbon (BDOC) produced by ozonation is too high to enter the water distribution system[5]. Bacterial regrowth has been highlighted as the most likely source of organisms that is detected near the point of use in the distribution system[6]. The reason for bacterial living is due to the presence of natural organic matter (NOM) in the water distribution system. The fraction of NOM that can be used by microorganisms for growth is called biodegradable organic matter (BOM). BOM can be measured by a variety of methods that are typically operationally defined, the most common are assimilable organic carbon (AOC) and biodegradable dissolved organic carbon (BDOC) tests[7,8]. As for biologically mediated chlorine demand, the most appropriate term would be BDOC. BDOC has also been related to biological stability of drinking water[9]. The study took BDOC as the index to evaluate water biostabilty in northern living district water. There are a lot of water quality indexes can infect biostability of drinking water, such as temperature, pH, and turbidy[10]. The increase of

temperature can accelerate bacterial growth rate in water distrtution system. The influence of temperature on bacterial growth need to further investigated[11]. Finding the key factors influencing bacterial growth is the objective of this study.

MATERIALS AND METHODS

Sampling of living district. The study was conducted in a Chinese living district. Water source are coming from surface water, Songhuajiang River. The output of the water plant is 20×10^3 m^3/d, and the water treatment craftwork is classical. In order to guarantee water quality safety, the water plant add chlorine into output water. The concentration of residual chlorine in water distribution system is between 0.5 and 0.75 mg/L. To study water quality parameters under different hydraulic conditions, six monitoring sites were selected for the experiment. The information is shown in figure 1, site 1 is in the inlet of the network, and site 2-6 are set covering the entire living district.
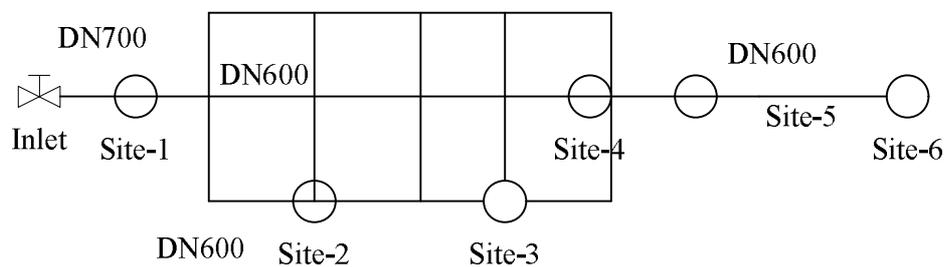

Fig. 1 Sampling sites in living district water distribution system

Glassware. All glassware contacting with water samples was rendered carbon-free. Glassware was leaned with phosphate-free detergent. First the glassware was immersed in 2% HCl solution for 2 h, then they were rinsed with deionized water, and at last was heated for 6 h at 550 ℃. This step was conducted to remove all phosphorus and carbon residuals from the glassware.

BDOC Analysis. BDOC determination procedure applied the technique according to a modified version by using a suspended inoculum of bacteria[12]. At first, the water samples were filtered by using a 60-ml polypropylene syringe, and then through a double thickness of carbon free glass fibre microfilter in an acetal resin syringe type filter holder. In order to assess background DOC, the residual 40 ml of filtrate was retained as a blank. The measurement of each different water sample used changed filter. Filters were firstly washed and rendered carbon-free by treatment at 450℃ for 6 h. Subsequently, the sample was distributed as 40-ml portions into 45-ml borosilicate tubes. All the water samples were treated with thiosulphate before the inoculation with 400 ml of river water inoculum. The DOC in three tubes (parallels) was measured once (day 0) to afford the initial DOC concentration. Three tubes were incubated in the dark at 20℃ without agitation. On day 28 these were filtered through a double thickness of glass filter and DOC was measured.

Results and discussions

The BDOC and Residual chlorine concentrations of six sampling sites during summer and winter were shown in figure 2 and figure 3. BDOC concentration gradually fell during the distance from inlet to site 6 in the living district network as shown in Fig 2. At sampling site 1-3, the concentration of BDOC is respectively 2.2mg/L, 1.76 mg/L and 1.43 mg/L, while at sampling site 4-6, the concentration of BDOC is separately 1.17mg/L, 0.93 mg/L and 0.87 mg/L. The reason lay in that the bacteria consuming more BODC than that residual chlorine oxidizing organic matter in water distribution system. Organic matters in water distribution system likely react with chlorine due to

high temperature in summer. At sampling site 4 in the water distribution system, the residual chlorine concentration decreased particularly, at the same time BDOC also declined considerably. This because more bacteria activity increased that induced a great deal of BDOC and Residual chlorine consume.
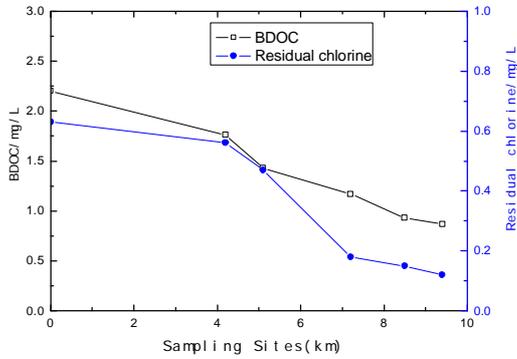

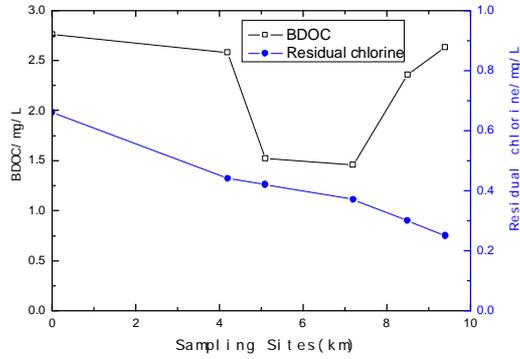Fig. 2 Variation of BDOC and Residual chlorine in water in summer

Fig. 3 Variation of BDOC and Residual chlorine in water in winter

The BDOC and residual chlorine measurement in winter was shown in figure 3. BDOC concentration between site 1 and 2 fell slowly, but it declined sharply at Sampling site 3. The reason is that first the bacteria consumed BDOC a little, which activity inhibited by low temperature in winter. Then the bacteria become more active due to residual chlorine decrease. The concentration of residual chlorine at monitoring site 6 is much lower, because where far away from the inlet, chlorine decayed due to bacteria consuming. From the site 4 to site 6, BDOC concentration was increasing in figure 3. The reason is that Residual chlorine oxidizing organic matters into micro-molecule carbon which add the BDOC concentration.
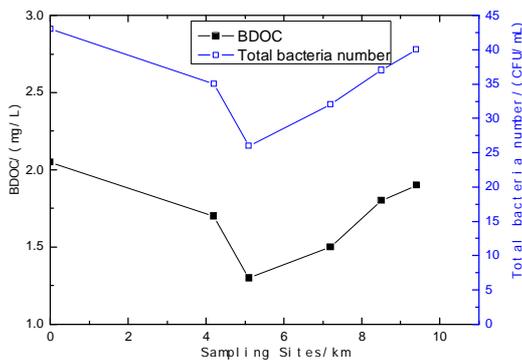

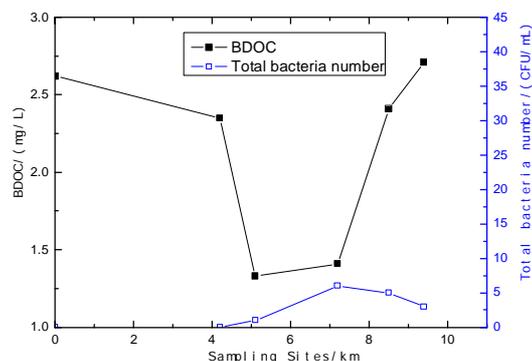Fig. 4 Variation of BDOC and Total bacteria number in water in summer

Fig. 5 Variation of BDOC and Total bacteria number in water in winter

Total bacteria number had a positive correlation with BDOC concentration in summer, for no doubt that BDOC is bacteria nutrients source. At site 2, BDOC concentration declined sharply because the bacteria consume BDOC. From site 3 to site 6, total bacteria number increase apparently due to Residual chlorine decayed in the water distribution system.

At first the concentration of BDOC decreased gradually, and then it increased little by little during the course from site 1 to site 6 in winter in figure 5. This phenomenon was also the result that chlorine oxidization increasing BDOC and bacteria consumption decreasing BDOC. For six Sampling sites, the bacteria number is all very few, especially at site 1 and site 2, which bacteria

number is both zero. The reason for that is site 1 and site 2 near to inlet where Residual chlorine is high, and the temperature is also lower in winter in figure 5.
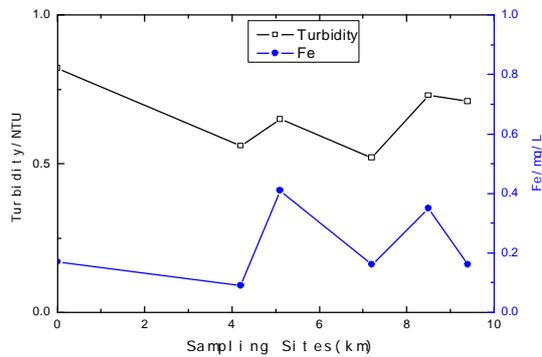

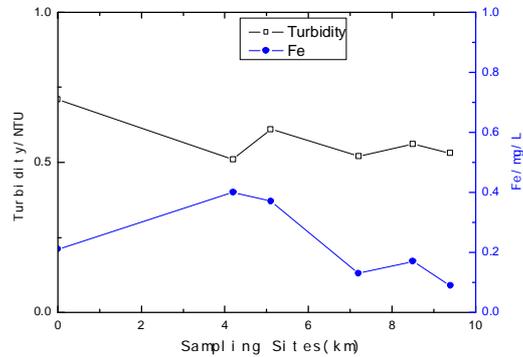Fig. 6 Variation of Turbidity and Fe concentration in water in summer

Fig. 7 Variation of Turbidity and Fe concentration in water in winter

From figure 6 and 7, Fe concentration and Turbidity change can be seen clearly. Fe and Turbidity had a positive correlation indicated that concentration of Fe increased can result in Turbidity rising. The Fe ion in network water came from cast iron pipes corrosion which were widely used in water distribution system, and some old pipes have been used for several decades in big cities in china. The bacteria metabolism activity is also a major source that caused Turbidity increasing.

Conclusions

Biostability studies and influencing factors analysis of the living district network suggested that BDOC concentration was a function of Residual chlorine and total bacteria number. This has significant implications for the drinking water biostability since BDOC has been correlated with increased bacterial populations in water distribution system, especially at low Residual chlorine. In winter BDOC concentration may rise among sites along the pipes. Bacteria activities were much intense in summer than that in winter according to total bacteria number. Increased Fe concentration will result in Turbidity rise in water distribution system.

Acknowledgements

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