

Form Distribution Characteristics of Nitrogen in a Reservoir as Drinking Water Source

Lahua Jin, Chen Zhao, Jiayi Wang

School of Environment, Jinan University, Guangzhou, China

Email: profjin@163.com

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Abstract

Based on field detected water quality data, the distribution characteristics of different forms of nitrogen in a reservoir as drinking water source in Dongguan, which locates at the Pearl River Delta of China, have been analyzed in order to provide theoretical bases for prevention and reduction of eutrophication. The analyzed results show that nitrogen forms in the influent area of the reservoir are given priority to ammonia nitrogen and nitrate nitrogen, whose proportion is more than 45% respectively, and this is probably caused by the pollution of inflow water quality; but in the effluent area, the forms are given priority to nitrate nitrogen, whose proportion is as high as 96% and above; also the proportion of ammonia nitrogen drops by more than 80% during the process from the influent area to the effluent area, and this shows that the natural process of nitrification and denitrification can be well accomplished in the reservoir. We recommend here that to reduce the input amount of ammonia nitrogen and organic nitrogen into the reservoir is the most efficient way to prevent or mitigate eutrophication of water body.

Keywords

Nitrogen Form, Reservoir for Drinking Water Source, Eutrophication, Dissolved Organic Nitrogen

1. Introduction

Nitrogen pollution in a reservoir not only can promote the degree of water body eutrophication, but also will generate disinfection by-products of nitrogen (N-DBPs) during the process of chlorine disinfection when the water is pumped to prepare for dinking. The N-DBPs are carcinogenic and most harmful to human health. In order to control this risk, it is necessary to make clear distribution regulation of nitrogen forms and their variation in a reservoir.

Figure 1. Plan of reservoir TS.

2.2. Survey Result

During the period from April 2014 to January 2016, we sampled water quality and nutritional level of the reservoir. According to the water quality requirement of *China National Environmental Quality Standards for Surface Water* (GB3838-2002), the single factor standard indexes of the water quality have been calculated out as shown in **Table 1** based on the detected data. It can be seen from the table that there exist five indexes exceeded the national standard, *i.e.*, COD_{Mn} , COD_{Cr} , ammonia nitrogen, BOD_5 and total phosphorus. Thus, it has been shown from this phenomenon that the reservoir has been obviously contaminated by organic and nutrient pollutants.

Based on the monitored data of water body nutritional level, the comprehensive nutritional status index of the reservoir has been calculated out as shown in **Figure 2** according to the improved comprehensive nutrition state index calculation method provided by Rui Zhang *et al.* [9]. It has been shown from **Figure 2** that the reservoir is at meso-eutrophic status, but its nutritional level has a decrease trend. But the degree of comprehensive nutrition in the effluent area is lower than that in the influent area of the reservoir. This shows that the reservoir has good self-purification ability because nutrient pollutants can be degraded obviously from influent area to effluent area.

3. Nitrogen Form Distribution Characteristics

Nitrogen in water can be mainly divided into inorganic nitrogen and organic nitrogen. Usually, inorganic nitrogen includes ammonia nitrogen and nitric nitrogen, in which the ammonia nitrogen includes free ammonia nitrogen (NH_3-N) and ammonium nitrogen (NH_4^+-N), and the nitric nitrogen includes nitrate nitrogen (NO_3-N) and nitrite nitrogen (NO_2-N). But organic nitrogen in water contains a lot of organic compounds, such as urea, amino acid, protein, nucleic acid, uric acid, fatty amine, organic base, amino sugar and so on. The concentration and proportion of different forms of nitrogen in water are often determined by specific circumstances of the water body.

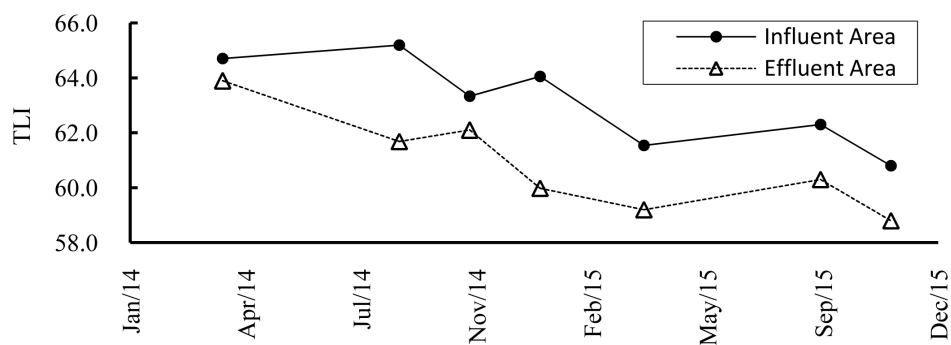


Figure 2. Variation of the comprehensive nutritional status index TLI of the reservoir.

Table 1. Present status of water quality standard indexes of the reservoir.

Item	Standard Index			Status
	Influent area	Effluent area	Average	
pH	0.085	0.098	0.091	Qualified
DO	0.273	0.204	0.239	Qualified
COD _{Mn}	1.080	0.963	1.022	Exceed standard
COD _{cr}	1.020	1.370	1.195	Exceed standard
Ammonia nitrogen	2.768	1.498	2.133	Exceed standard
BOD ₅	1.265	1.690	1.478	Exceed standard
TP	2.960	2.240	2.600	Exceed standard
Petroleum class	0.800	0.800	0.800	Qualified
Anionic surface-active agent	0.150	0.150	0.150	Qualified
Volatile phenol	0.100	0.100	0.100	Qualified
Sulfide	0.015	0.015	0.015	Qualified
Cyanide	0.003	0.003	0.003	Qualified
Zinc	0.010	0.008	0.009	Qualified
Copper	0.004	0.003	0.004	Qualified
Lead	0.001	0.001	0.001	Qualified
Cadmium	0.006	0.006	0.006	Qualified
Selenium	0.010	0.010	0.010	Qualified
Mercury	0.050	0.050	0.050	Qualified
Arsenic	0.023	0.024	0.024	Qualified
Chromium of six valence	0.040	0.040	0.040	Qualified
Fluoride	0.672	0.538	0.605	Qualified

3.1. Proportion of Different Forms of Nitrogen

The proportion of different forms of nitrogen in the reservoir has been analyzed based on the detected data of water quality, and the result shows that inorganic nitrogen oc-

cupies most proportion of total nitrogen, and its proportion is as high as over 92% in the influent area or over 84% in the effluent area at any time, but the organic nitrogen only occupies below 8% in the influent area or below 16% in the effluent area at any time, as shown in **Figure 3**.

The inorganic nitrogen in the reservoir is found to be composed of ammonia nitrogen and nitric nitrogen, and their average proportions during the detecting period are 49.9% and 50.1% in the influent area, and 48.5% and 51.5% in the effluent area respectively, as shown in **Table 2**.

The nitric nitrogen in the reservoir is also found to be composed of about 96% - 99% of nitrate nitrogen and 1% - 4% of nitrite nitrogen, as shown in **Table 3**.

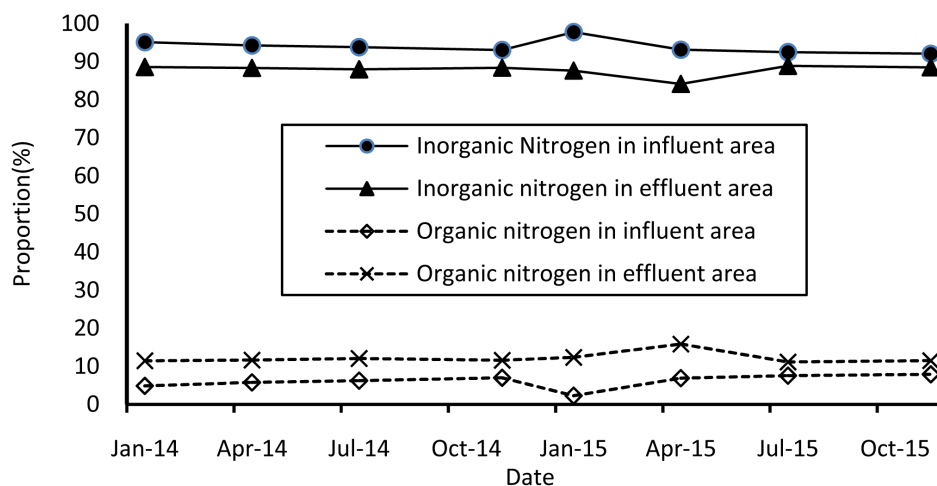


Figure 3. Variation of proportion of inorganic and organic nitrogen in the reservoir.

Table 2. Composition proportion of inorganic nitrogen in the reservoir.

Nitrogen form		Proportion (%)								
		Jan-14	Apr-14	July-14	Nov-14	Jan-15	Apr-15	July-15	Nov-15	Average
Ammonia Nitrogen	Influent	52	51	51	51	49	48	48	49	49.9
	Effluent	51	50	49	49	48	47	47	47	48.5
Nitric Nitrogen	Influent	48	49	49	49	51	52	52	51	50.1
	Effluent	49	50	51	51	52	53	53	53	51.5

Table 3. Composition proportion of nitric nitrogen in the reservoir.

Nitrogen form		Proportion (%)								
		Jan-14	Apr-14	July-14	Nov-14	Jan-15	Apr-15	July-15	Nov-15	Average
Nitrate Nitrogen	Influent	98	98	98	98	97	96	96	96	97.1
	Effluent	99	99	99	98	97	96	96	96	97.5
Nitrite Nitrogen	Influent	2	2	2	2	3	4	4	4	2.9
	Effluent	1	1	1	2	3	4	4	4	2.5

It can be concluded from the above analyses that the proportion of different forms of nitrogen in the reservoir are 45.0% of nitrate nitrogen, 44.7% of ammonia nitrogen, 9.1% of organic nitrogen and 1.2% of nitrite nitrogen.

3.2. Spatial Distribution of Different Forms of Nitrogen

The spatial distribution of inorganic nitrogen and organic nitrogen has obvious differences in the reservoir, *i.e.*, during the process from the influent area to the effluent area, the inorganic nitrogen will degrade about 6.1%, but the organic nitrogen will increase about 6.1%, as shown in **Figure 3**.

The degradation of inorganic nitrogen may be caused by the reaction of its nitrification and denitrification. This phenomenon demonstrates that the water quality is getting improved and the self-purification ability of water is strong in the reservoir.

4. Conclusions

Nitrogen forms in a reservoir as drinking water source behave as over 84% of inorganic nitrogen and below 16% of organic nitrogen. The inorganic nitrogen is composed of ammonia nitrogen and nitric nitrogen, in which the nitric nitrogen is mostly composed by nitrate nitrogen.

The proportion of inorganic nitrogen in the influent area is some higher than those in the effluent area, but the proportion of organic nitrogen is little lower in the influent area than those in the effluent area.

Reservoirs as drinking water source may have essential capability of self-purification to degrade nutrient pollution.

Acknowledgements

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