A Study of Water Quality Safety of Rural Water Supply Projects in the Pearl River Basin

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Abstract. In order to know the water quality of rural water supply projects, the water samples are collected from finished water and tap water of administrative villages in some counties and districts of the Pearl River Basin for sampling inspection in 2019. The water quality indexes and limits in Table 1 and Table 4 are taken from Standards for Drinking Water Quality for evaluation. The detection results showed that the water quality of finished water and the water source area was completely up to the standard. For 71 water samples collected from the finished water of the water treatment factory detected, except for some parameters that slightly exceeded the limits, the rate of reaching the standard is up to 97.2%. It can thus be seen that the water quality safety of the rural water supply projects in the Pearl River Basin area is highly reliable.

1. Introduction
The safety of drinking water in the rural area is a significant problem related to the health of farmers, and also an important symbol of improved rural living standards. In recent years, all localities have attached great importance to the safety of drinking water in the rural area. While strengthening the protection of water sources, the construction of drinking water safety projects in the rural area has been implemented, and the situation of drinking water in the rural area has been continuously improved. The safety of drinking water in the rural area is not only the basic requirement and core index of poverty alleviation, but also one of the key tasks of water conservancy supervision. Through carrying out dynamic monitoring of drinking water safety and water quantity and water quality of built projects, the purpose of the existing rural water supply projects is to ensure that the water quantity and water quality meet the standards and to truly realize the full coverage of safe drinking water so that people can have stable access to safe drinking water, thus providing strong guarantee for winning the fight against poverty.

2. Materials and Methods

2.1 The Samples
The water samples were collected from the finished water, tap water, surface water sources of some counties and administrative villages in Guizhou, Yunnan, Guangdong and Guangxi in the Pearl River Basin. 1,000 tons of the finished water samples collected from the water supply projects for 10,000
people and tap water samples collected from various villages were detected. Tap water samples collected from the water supply projects for a population of 1,000 or less were also detected. A total of 86 water samples were collected from the water supply projects in the rural areas of Guangdong, Guizhou, Guangxi and Yunnan. The sampling sites are shown in the following Figure 1.

![Figure 1. Distribution of Sampling Sites](image)

2.2 Detection Contents

2.2.1 Water Samples Collected from Finished Water and Tap Water

The water quality detection indexes for finished water and tap water include microbial index, toxicological index, sensory properties and general chemical index, with a total of 28 indexes as follows:

1. Microbial index: total number of colonies, total coliforms;
2. Toxicological indexes: arsenic, cadmium, chromium (hexavalent), lead, mercury, fluoride, nitrate;
3. Sensory properties and general chemical indexes: pH value, chroma, turbidity, odor and taste, visible matter, oxygen consumption, aluminum, iron, manganese, copper, zinc, chloride, sulfate, total dissolved solids, total hardness, ammonia nitrogen, sulfide, volatile phenols, anionic synthetic detergent.

2.2.2 Water Samples Collected from Sources of Surface Water

The following 23 indexes of surface water quality were detected: pH value, dissolved oxygen, turbidity, permanganate index, ammonia nitrogen, total phosphorus, total nitrogen, iron, manganese, copper, zinc, chloride, sulfate, nitrate, arsenic, cadmium, chromium (hexavalent), lead, mercury, volatile phenol, anionic surfactant, sulfide, fecal coliform.

2.3 Detection Methods

The collection, storage, transportation and experiment of water samples shall be carried out in accordance with General Principles for Standard Inspection Methods of Drinking Water (GB/T 5750.1-2006) [1]. Double sample parallel experiment and standard recovery rate were used for quality control.
2.4 Evaluation Standards

2.4.1 Water Quality Evaluation Standards. The water samples collected from finished water and tap water were evaluated using the “conventional indexes and limits” from Standards for Drinking Water Quality (GB5749-2006) as shown in Table 1 and “water quality indexes and limits for small-scale centralized and decentralized water supply in rural areas” as shown in Table 4 [2]. The water samples collected from sources of surface water were evaluated using the Class II water standards of Environmental Quality Standards for Surface Water (GB3838-2002) [3].

2.4.2 Evaluation Indexes of Drinking Water Safety in Rural Areas. Whether the drinking water in rural areas is safe is mainly evaluated according to Safety and Health Evaluation Index System for Drinking Water in Rural Areas issued by the Ministry of Water Resources and the Ministry of Health in 2004. The safety evaluation for drinking water in rural areas is divided into two levels: “safe” and “basically safe”, consisting of four indexes, namely, water quality, water quantity, convenience degree and assurance rate. If any one of the items fails to meet the basic safety indexes, it is considered that the drinking water is unsafe.

Table 1. Evaluation Indexes of Drinking Water Safety in Rural Areas

| Level          | Water Quality | Water Quantity<sup>a</sup> | Convenience Degree<sup>b</sup> | Assurance Rate |
|----------------|---------------|-----------------------------|--------------------------------|----------------|
| Safe           | Meet the requirements of the national Standards for Drinking Water Quality | No less than 40-60 L/day | The round-trip time for water supply to every household or manual water taking shall not exceed 10 minutes | The assurance rate of water sources shall not be less than 90% in severe water shortage areas and not less than 95% in other areas |
| basically safe | No less than 20-40 L/day | The round-trip time for manual water taking shall not exceed 10 minutes | |

<sup>a</sup> In arid and water-deficient areas where decentralized water supply is adopted, the amount of water available per person per day shall be not less than 20 L.

<sup>b</sup> Water supply can be provided to households in plain and hilly areas, and in remote mountainous areas and pastoral areas water is available in centralized water supply sites.

3. Results and Discussion

3.1 Overview of Safety Projects Construction for Drinking Water in Rural Areas within the Basin Area

The Pearl River basin area includes the Pearl River Basin, the Han River Basin, the international rivers to the east of Lancang River (excluding Lancang River), coastal rivers in Guangdong and Guangxi, as well as rivers in Hainan Province, which involves Yunnan, Guizhou, Guangxi, Guangdong, Hainan, Hunan, Jiangxi, Fujian provinces (autonomous regions) and Hong Kong and Macao Special Administrative Regions, with a total area of 658,400 km² (domestic area, the same below), accounting for about 6.8% of China’s national territorial area. Due to the limitations of geographical location, resources, environment and other conditions and historical reasons, the economic development within the basin area is extremely unbalanced. Water conservancy in rural areas has been gradually developing along with the management, development, utilization and protection of the basin area, and has some characteristics of its own such as gradualness, difference, imbalance and complexity [4].

A total of 2.369 billion yuan has been invested in Guangxi, which has solved the problem of drinking water safety for the remaining 3.434 million rural population in the 12th Five-Year Plan. At the same time, the construction of drinking water safety and water quality testing centers in rural areas has been accelerated, and 96 county-level regional water quality testing centers have been initially
completed and put into operation. During the 12th Five-Year Plan period, Yunnan Province has achieved full coverage of drinking water in rural areas. During the 13th Five-Year Plan period, the total planned investment was 5.286 billion yuan, and the plan was consolidated to increase the beneficiary population by 17.828 million. By 2020, the security level of drinking water in rural areas of Yunnan Province will be greatly improved; the centralized water supply rate will reach over 85%; the tap water popularization rate will reach more than 80%; and the water quality qualification rate will be significantly increased. Since the 12th Five-Year Plan period, Guizhou has solved the drinking water safety problem of 13.01 million farmers through the construction of a large number of key projects of water sources, multi-level drinking water pumping and irrigation stations and tap water connected to villages.

3.2 Overview of Water Quality

A total of 86 water samples were collected from water supply projects in rural areas of Guangdong, Guizhou, Guangxi and Yunnan. Among them, there are 12 water samples collected from water sources in four provinces, with a qualified rate of 100% (12/12, expressed as the number of qualified water samples / the number of water samples inspected, the same below); there are 3 finished water samples collected from water supply projects in rural areas, with a qualified rate of 100% (*3/3); the tap water samples collected from water supply projects in rural areas totals 71, which were evaluated according to Standards for Drinking Water Quality (GB5749-2006), and the qualified rate was 97.2% (69/71). Excessive contents of iron or zinc were detected in two of the water sample.

3.3 Evaluation of Single Water Quality Index

The 28 indexes of 3 water samples collected from the finished water are all up to the standard. The concentration of zinc in 71 water samples collected from water supply projects in rural areas ranged from < 0.0012 mg/L to 1.29 mg/L, and the control standard was < 1 mg/L. Only one water sample failed to meet the standard, and the qualified rate of zinc was 98.6%. The concentration range of iron was 0.002 mg/L to 0.853 mg/L, and the control standard was < 0.5 mg/L. Only one water sample failed to meet the standard. The qualified rate of zinc was 98.6%. In addition to total nitrogen, the other 22 indexes of water samples collected from water source areas all meet water standard of Class II. Total nitrogen is an indicator reflecting the degree of lake eutrophication. At present, the total nitrogen of river water quality is not used as the evaluation index of water quality. Furthermore, the total nitrogen has not been listed in the national Standards for Drinking Water Quality as a standard for drinking water quality, so the evaluation indexes of water quality in water source areas also do not include the total nitrogen.

3.4 Discussion

Water pipe pollution is mainly caused by chemical reaction, anaerobic bacteria breeding and impurity deposits due to a long time of being static through the main water pipelines. There are primary pollution of main pipelines and secondary pollution of reservoir pipelines. Secondary pollution refers to the pollution occurred in the process of transmitting water to each household after purification treatment in the water plant. What’s worse, the pollution can even lead to heavy metal poisoning, cancer, bacterial infection and other common diseases that would pose health hazards. The reason why the water pipes would be polluted is related to the flow state of tap water in the pipes. The water flow in the water pipes is too huge, and the high-pressure flow rate is fast, resulting in different water pressure. In addition, most of the water pipes are bent. With the increase of the residence time of tap water in the water pipes, the residual chlorine content in the water will decrease, but the turbidity, chroma, iron, manganese, lead, zinc, dissolved total solids, bacteria and other indexes may go up.

4. Conclusion and Suggestions

The detection results showed that the water quality of finished water and the water source area was completely up to the standard. For 71 water samples collected from the finished water of the water
treatment factory detected, except for some parameters that slightly exceed the limits, the rate of reaching the standard is up to 97.2%.

In order to meet the needs of simple laboratory construction in rural waterworks, in addition to the indexes of microorganism and disinfectant residues, it is suggested to purchase a rapid detection instrument to detect the tap water. At present, the rapid detection instrument can cover a detection of 24 water quality indexes, including 4 sensory indexes, 9 physical and chemical indexes, 4 toxicological indexes, 1 comprehensive index and 6 metal indexes. The fast water quality detection method combined with portable photoelectric colorimeter and solid reagent was used to conduct a fast detection of color, turbidity, chloride, sulfate, fluoride, arsenic, iron, manganese, chromium and cyanide.

One of the key aspects of water conservancy supervision is drinking water safety supervision in rural areas. Great attention should be paid to the risk of secondary pollution of water supply pipelines in rural areas. The main reason for the decline of water quality of the pipe network is the presence of small-diameter pipes, especially the internal pipelines of users in rural areas, which may hardly adopt protective measures such as coating and lining. The water supply volume of the rural water supply project used for sampling inspection reaches 1,000 tons for 10,000 people and less than 1,000 people. According to the water quality safety evaluation of drinking water safety evaluation indexes in rural areas, the assurance rate of water quality safety of rural water supply projects in the Pearl River Basin is high.

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