Cause Analysis and Management Countermeasures for Unsafe Drinking Water Quality in Rural Guangxi China

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Abstract. In recent years, as China has been vigorously promoting the construction of drinking water safety project in rural areas, rural drinking water safety is guaranteed to some extent, but the safety of water quality is still not up to standard in some areas. In view of the situation of drinking water safety in rural Guangxi China, according to the authoritative judgment method of safe drinking water, this thesis analyzes the present situation of rural drinking water safety in Guangxi, and decides that the major causes of unsafe drinking water quality in rural Guangxi include the exceedance of content standard of hazardous substances in drinking water sources, pollution in transportation and treatment process of drinking water, lack of water quality monitoring ability and imperfect management mechanism after the completion of water supply project. Furthermore, the thesis proposes management strategies to improve the safety of water supply quality in rural Guangxi, such as the construction of consolidation and promotion project of rural drinking water safety, the implementation of contiguous water supply project, the establishment and perfection of engineering operating mechanism, the strengthening of quality supervision on rural drinking water safety projects, the use of Internet of Things and big data technique for real-time monitoring, the strengthening of the management on drinking water conservation districts, the improvement of water treatment technique and timely check and solving of the defects. The aim is to enable more rural people to drink safe water with the above management strategies.

1. Status of drinking water in rural Guangxi China

1.1. Rural resident population and the ratio of rural resident population to total population in Guangxi China
It can be seen from the figure that, since 1990, the rural population in Guangxi has been decreasing year by year, for which the reasons may be as follows: first, most of the descendants of farmers who have been admitted to a university stay and work in the city after graduation, and few of them return to the countryside; second, migrant workers from the country are increasing; third, part of the rural population have become urban residents with the development of urbanization. Because of the large population base, although the proportion of permanent rural residents in Guangxi has decreased to 48.91% of the total population by 2019, the number of permanent residents is 24.26 million, the drinking water problem in rural areas can not be overlooked, and the safety of water quality is related to thousands upon thousands of families.
1. Status of drinking water safety in rural Guangxi China

The drinking water in rural Guangxi can be divided into underground water and surface water. The groundwater sources include shallow groundwater, deep groundwater, confined water and spring water. Groundwater is characterized by clear water quality, colourless and odourless, constant water temperature, not easily polluted, but its runoff is small, and its salinity and hardness (the concentration of calcium and magnesium ions) are high. Surface water mainly refers to the water in rivers, lakes and reservoirs. Because of the great impact of the natural environment in the drainage basin, the water quality tends to vary a lot. For example, the turbidity and temperature of surface water change in great amplitude throughout the year, the water quality is easy to be polluted, but the salinity and hardness of the water are low, the content of iron and other substances is small, the runoff volume is large, and the seasonal variations are obvious.

At present, the infrastructure of water supply in rural Guangxi is still weak. The current situation is characterized by "low level and narrow coverage", and the construction of rural water supply facilities lags behind that in cities. There is a big gap between the situation of rural Guangxi and that of foreign developed countries, and the situation is out of keeping with the requirements of integration of urban and rural development and building a moderately well-off society in an all-round way. To solve the drinking water problem faced by the large rural population in China, China's No.1 Central Document released in 2011 clearly pointed out that the problem of insecurity in rural drinking water should be basically solved by 2015, and proposed to construct nationwide rural drinking water safety project, which enables rural residents to timely and conveniently obtain plenty of clean and affordable domestic drinking water. According to statistics, since 2016, the rural drinking water safety project in Guangxi has involved 5.6192 million people, including 1.1894 million impoverished people, 17,660
new water supply projects, 6,224 water supply reconstruction projects, 72,169 water quality purification reconstruction facilities and 72,583 matched disinfection equipment(Gang, Xing, En-bin, Chun-mei, & Chun, 2020). However, there are still problems in rural water supply, such as small scale of water supply, low guarantee rate of water supply, incomplete water purification facilities, low coverage of family and low rate of reaching the standard of water quality. It will be a long-term task to ensure drinking water safety in rural areas.

2. Judgment method for safe drinking water
The basic sanitary requirements for drinking water are as follows: no pathogenic microorganisms; no chemicals harmful to human body; transparent and colorless; no abnormal and foreign odour. By judging whether there are visible objects and peculiar smell in water and touching the consistence of the water, the safety of drinking water quality can be preliminarily checked. The most authoritative method is to invite a qualified water quality testing center to test the water. To do well in the evaluation of rural drinking water safety, the Ministry of Water Resources and Ministry of Health of China divided the evaluation index system of rural drinking water safety into two grades on November 24, 2004, namely, safety and basic safety, which respectively consist of four indexes: water quality, water volume, convenience level and guarantee ratio. As long as one of the four indexes is lower than the minimum value of safety or basic safety, the drinking water can not be defined as safe water or basically safe water.

| Grade             | Water quality                                      | Water volume | Convenience level                                                                 | Guarantee rate |
|-------------------|----------------------------------------------------|--------------|-----------------------------------------------------------------------------------|----------------|
| Safety            | Meet the requirements of the national *Hygienic Standards for Drinking Water* | No less than 40-60L/d | The round-trip time of water supply to household or manual water taking shall not exceed 10 min | No less than 95% |
| Basic safety      | Meet the requirements of *Guidelines of Implementation of Hygienic Standards for Drinking Water* | No less than 20-40L/d | The round-trip time of manual water taking shall not exceed 20 min | No less than 90% |

3. Analysis of the major causes of unsafe drinking water quality in rural Guangxi

3.1. Harmful matter content in drinking water out of limit
The quality of drinking water source is an important guarantee for the water quality to reach the standard. At present, the drinking water sources in rural Guangxi still have the following problems: first, the biotic indexes represented by viruses and bacteria exceed the standard. More than 90% of the water quality problems in Guangxi are bacteria out of limit. At present, 80% of the enteric infectious diseases in China occur in rural areas, and most frequently occur in rural schools; second, the organic matters (oxygen consumption) represented by pesticides and humic substances exceed the standard; the ionic indexes represented by fluorine, arsenic and metals exceed the standard. The cause of metal contamination is generally artificial industrial pollution. The human body ingests ions that exceed the normal physiological requisite amount through drinking water, food, air and other channels for a long term, thereby leading to generalized chronic cumulative poisoning, which can do extreme harm; third, the turbidity mainly involving suspended solids and impurities exceeds the standard. In November 2020, the Centre for Ecology&Hydrology of Guangxi Zhuang Autonomous Region monitored 21 important rural drinking water sources in Nanning, Guilin, Qinzhou, Guigang, Baise, Laibin and Chongzuo, and found that the qualified rate of water quality was 81.0%. The unqualified items include five-day bod, total phosphorus, chemical oxygen demand and manganese. Hence, the water quality safety of rural drinking water sources in Guangxi needs to be further strengthened.
3.2. Drinking water pollution in transportation and treatment processes
In the process of water transportation and storage, the inferior water pipes and other materials or equipment used by the construction side may lead to the dissolution of harmful chemicals into drinking water, besides, algae and fungi can produce secondary pollution. Whether surface water or groundwater is used as water supply source, it can be affected by rainfall, domestic or industrial water, and its self-purification capacity is poor, so purification and disinfection facilities are needed. The material quality and conservation management of water pipelines, water storage equipment and water treatment facilities are closely related to the safety of drinking water quality.

3.3. Inadequate water quality monitoring capability
In 2020, the information center of the Ministry of Water Resources and the Centre for Ecology&Hydrology of Guangxi Zhuang Autonomous Region invited open tenders for the operating maintenance and monitoring project of the monitoring system of Guangxi national groundwater monitoring project (water conservancy part). The system covers one provincial center, nine city centers and 124 monitoring stations in Guangxi Zhuang Autonomous Region. However, the number of monitoring personnel and equipment that have been already implemented is still small, there is only a small number of monitoring centers that have been put into operation, and the coverage rate is still low.

3.4. Imperfect management mechanism after the completion of the water supply project
The imperfect long-term operation and management mechanism after the completion of the water supply project is an important influencing factor of the water quality safety(Liu, 2011). The vast majority of drinking water has no regular disinfection system, and some lacks special management, leaves and other debris, flies, mosquitoes and larvae appear in pools at times, thereby leading to serious secondary pollution and poor water quality.

4. Countermeasures for improving water supply quality in rural Guangxi

4.1. Strengthening the construction of consolidation and improvement project of rural drinking water safety
Since the implementation of the project of rural drinking water safety, the problem of rural drinking water safety in the district has been basically solved by the end of 2015. The rural centralized water supply rate, tap water popularizing rate and water quality passing rate in Nanning, the provincial capital of Guangxi, respectively increased from 83.2%, 80.5% and 44.9% at the end of 2015 to 91.92%, 91.32% and 70.55% in 2020. The construction of consolidation and improvement project of rural drinking water safety can effectively promote steady enhancement of the guarantee level of drinking water safety. However, the rural drinking water safety in some areas is not firm enough, the problems can be easily repeated, and there are still some vulnerable spots in aspects of water volume and water quality guarantee and long-term operation. Only by consolidating and improving rural drinking water safety and laying a solid foundation for sustainable development of the project, can pipeline leakage be reduced and the convenience level and passing rate of water quality be improved, and can the mass peasants drink safe water. The most prominent weak link of completing the building of a moderately prosperous society lies in the fact that there are still some poverty stricken population in Guangxi. The key to the consolidation and improvement of rural drinking water safety is linking up with targeted poverty alleviation, so as to make full use of advantageous water sources, comprehensively adopt methods such as new construction, supporting, transformation, upgrading and networking, actively develop centralized water supply project, implement household tap water project, and improve passing rate of water supply quality and guarantee extent of drinking water.

4.2. Implementation of contiguous water supply project
Contiguous water supply is more stable and safer, and it’s an effective way to improve the safety level of rural drinking water. A pattern of large water source, large pipe network, big connection and great transformation of urban and rural water supply should be developed in whole Guangxi, no effort
should be spared to promote the integration of urban and rural water supply as well as the scaled, standardized and intelligent construction of rural water supply, and priority should be given to the development of regional scaled contiguous water supply projects. Continuous water supply not only solves the water utilization problem of single household, but also lays a foundation for the development of poverty alleviation industry and county economy. A number of villages that have enjoyed the benefits of finished contiguous water supply projects are focusing on the stabilization of water sources and planning new industrial projects, thereby further consolidating the achievements of poverty alleviation and increasing the income of villages and towns.

4.3. Establishing and perfecting engineering operation mechanism
The project construction management organization should be established and perfected, the project property rights should be clarified, the management and protection subjects, responsibilities and funds of the project should be implemented, the operating management and protection system should be perfected, the rural water supply price should be reasonably determined, a reasonable water price formation mechanism should be developed, and the project maintenance and maintenance funds should be implemented. Moreover, the "three responsibilities" and "three systems" for rural drinking water safety management should be consolidated, the emergency rural water supply plan in county level should be further improved, the collection work of water charges should be vigorously promoted, and the healthy operation of rural drinking water projects should be ensured.

4.4. Strengthening quality supervision on rural drinking water safety projects
China has introduced the Opinions on Further Strengthening the Management of Pipe Materials for Rural Drinking Water Safety Projects, which strictly stipulates the quality standards and bidding conditions for pipe materials and the bidding and tendering management of pipe materials, strengthens the quality inspection of pipe materials, and stipulates that the project construction unit shall randomly select 30% of samples for inspection. Guangxi should arrange special funds from the government budget to entrust qualified testing unit to carry out casual inspection of pipe quality, and publicize the results. For unqualified pipes, the responsibility for breach of contract should be strictly investigated and affixed, and the materials should be blacklisted and even cleared out from Guangxi construction market for rural drinking water safety project.

4.5. Real-time monitoring by big data technology of Internet of Things
The big data technology of Internet of Things and remote sensing(Sagan et al., 2020), should be made full use of to connect all kinds of monitoring data to the network, thereby realizing the interconnectivity and management of people, machines and things at any time and any place. In the future, relevant departments and individuals can open the Internet page to view the quality status report of centralized drinking water source and monitor point locations, evaluation criteria and other relevant data. Besides, the monitoring range and depth of Internet of Things should be further expanded to achieve the goal of real-time monitoring of water quality.

4.6. Strengthening the management of protection zones of drinking water sources
Water source protection is the primary line of defense to ensure the safety of water quality, as well as the most effective measure to reduce the cost of water treatment(Chiueh, Shang, & Lo, 2012). However, as far as the present demarcation of drinking water protection areas is concerned, the demarcation of water source protection areas or protection scope seriously lags behind, so it is necessary to adjust the original protection areas and re-demarcate the protection areas. Meanwhile, the mechanism of information disclosure and public participation for water source protection should be established and improved, and the publicity of rural drinking water source protection should be strengthened. Besides, typical areas can be selected to do pilot projects, the information of rural water sources and water quality can be gradually opened to the public, and a platform for public participation can be developed.
4.7. Improving water treatment technique and using new technique
The new ultrafiltration membrane and ultra-low pressure nanofiltration membrane have longer life and better cleaning restoring ability, and the membrane life is 8-10 years. Furthermore, with extremely high resistance to pollutants adsorption and high water permeability, the membrane performance can be more easily recovered through cleaning. Besides, the filter precision is higher and thus the water quality is ensured. The high-precision membrane can ensure the removal of all particles, bacteria, viruses and colloids under various inflow water qualities, thereby providing safe and reliable effluent quality. The operating cost for each ton of water is less than 0.3 yuan, and the cost can be reduced.

4.8. Timely check and solving of the defects
Rural drinking water projects are affected by multiple factors such as water source change, seasonal water shortage and management, and the problem of drinking water safety repeatedly appears in a few villages. In view of this, relevant departments should constantly strengthen daily monitoring, repeatedly troubleshoot problems, supervise the rectification of problems, solve the problems in the initial state, and give ear to the masses. For example, the social safety telephone hotline should be open to the public, a special WeChat Official Account should be created, a special edition for drinking water complaints can be set up, and the problems fed back by the masses should be timely grasped and solved. Finally, it is recommended to introduce the third-party evaluation and entrust a third-party organization to evaluate the operating status of the 2016-2020 drinking water safety projects as well as the status of reaching standard of rural drinking water safety, so as to guide following work according to the evaluation results.

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