Preplanned Studies

Sanitary Evaluation of Rural Water Supply Projects — China, 2020

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Summary

What is already known about this topic?

Over the last decade, the centralized water quality and supply have been substantially enhanced in rural China. However, compared with the urban water supply, most of the rural Water Supply Projects (WaSPs) are small in scale, simple in engineering facilities, and poor in management.

What is added by this report?

Most of the rural WaSPs have been basically guaranteed sustainable sources of water. More measures should be taken to improve water disinfection effects, water losses control, and operational and maintenance management. The WaSPs with water supply <3,000 m^3/d need to be paid more attention.

What are the implications for public health practice?

Laws and regulations requiring rural WaSPs to carry out a sanitary evaluation should be established. WaSPs should use tools such as World Health Organization Water Safety Plans to identify and control risks.

Safe drinking water is one of the most important factors affecting health (*1*). China's rural centralized water supply coverage has improved significantly since 2005. More than 9.31 million rural Water Supply Projects (WaSPs) have been constructed and the rate of central water supply directed at rural areas reached 88% by 2020 (*2*). Compared with the urban water supply, most of the rural WaSPs are smaller in scale, simpler in design, and poorly managed (*3*). This study aimed to understand the evidence provided by the Sanitary Evaluation of Rural Water Supply Projects (SERWaSP) using 160–180 typical rural WaSPs to identify potential water quality risks. The study was conducted between August and November, 2020 in 66 counties within 18 provincial-level administrative divisions (PLADs) in China. The results demonstrated that the rural water supply could be sustained and that most water sources and WaSPs were well protected. However, sanitation related to water disinfection effectiveness, water losses control, and Operations and Maintenance (O&M) management needs further improvement. Laws and regulations requiring rural WaSPs to carry out a sanitary evaluation should be established. WaSPs should use tools such as World Health Organization (WHO) Water Safety Plans to identify and control risks.

In total 178 rural WaSPs were evaluated in this study, of which 34.3% were in eastern China, 22.5% in central China, 43.3% in western China. In addition, 67.4% of samples came from surface water sources and 32.6% were from groundwater sources. Of the 178 rural WaSPs, 21.9% were built before 2005, 18.5% were built between 2005 and 2009, 27.0% were built between 2010 and 2014, and 32.6% were built after 2005. Meanwhile, 33.7% had a water supply of 3,000 m^3/d or above and 66.3% had less than a 3,000 m^3/d water supply. Together all 178 WaSPs provide water for about 5.6 million residents. The standardized evaluation process of each rural WaSP follows the directions and guidelines issued by *National Center for Rural Water Supply Technical Guidance* (NCRWSTG) from China CDC. The first procedure of SERWaSP is to organize an expert team and then do a data review, water quality assessment, and field survey. This study includes information on water source, water distribution system, water treatment process and technology, operation management, and other factors. The SERWaSP report based on the work above was done by an expert team and was returned to the evaluated WaSPs for their continued improvement. The data used in this study were collected by each WaSP expert team using the questionnaire made by NCRWSTG.

As presented in Table 1, the proportion of WaSPs with continuous water supply (i.e., 24 h × 7 day water supply) was 89.9% and the proportion of WaSPs with a guarantee probability of water supply higher than 90% was 94.3%. In addition, 91.0% of WaSPs were delineated source water protection areas as the *Technical Guideline for Delineating Source Water Protection Areas* requests, and 93.3% did not have pollutants in its primary protected area of drinking water source. About 92.1% of WaSPs had disinfection

TABLE 1. Key points from 178 rural Water Supply Projects evaluated in 2020 in China.

Segments	Risk points	≥3,000 m^3/d WaSPs			<3,000 m^3/d WaSPs			Total		
		N	Yes (%)	No (%)	N	Yes (%)	No (%)	N	Yes (%)	No (%)
Water supply	Continuity*	60	60 (100.0)	0 (0.0)	118	100 (84.7)	18 (15.3)	178	160 (89.9)	18 (10.1)
	Guarantee†	60	58 (96.7)	2 (3.3)	118	110 (93.2)	8 (6.8)	178	168 (94.3)	10 (5.6)
Water source	Protection areas	60	60 (100.0)	0 (0.0)	118	102 (86.4)	16 (13.6)	178	162 (91.0)	16 (9.0)
	Pollutants in first-grade protection zones	60	3 (5.0)	57 (95.0)	118	9 (7.6)	109 (92.4)	178	12 (6.7)	166 (93.3)
Treatment process	Disinfection procedures	60	60 (100.0)	0 (0.0)	118	104 (88.1)	14 (11.9)	178	164 (92.1)	14 (7.9)
	Disinfection equipment used properly	56	56 (100.0)	0 (0.0)	104	80 (76.9)	24 (23.1)	160	136 (85.0)	24 (15.0)
	Accurate dosage of disinfectants	55	54 (98.2)	1 (1.8)	90	77 (85.6)	13 (14.4)	145	131 (90.3)	14 (9.7)
	Filter material seriously worn or lost	53	0 (0.0)	53 (100.0)	78	2 (2.6)	76 (97.4)	131	2 (1.5)	129 (98.5)
	Well protection of regulating structures	60	54 (90.0)	6 (10.0)	118	91 (77.1)	27 (22.9)	178	145 (81.5)	33 (18.5)
Pipelines	High leakage§	58	28 (48.3)	30 (51.7)	111	40 (36.0)	71 (64.0)	169	68 (40.2)	101 (59.8)
	Long-term low disinfectant level of tap water	60	0 (0.0)	60 (100.0)	99	7 (7.1)	92 (92.9)	159	7 (4.4)	152 (95.6)
Plant area	Soak away toilets, pits or effluent discharges within 30 m	60	0 (0.0)	60 (100.0)	118	7 (5.9)	111 (94.1)	178	7 (3.9)	171 (96.1)
	Pile garbage, excrement or waste residue within 30 m	60	0 (0.0)	60 (100.0)	118	4 (3.4)	114 (96.6)	178	4 (2.2)	174 (97.8)
Management	Sanitary management systems	60	60 (100.0)	0 (0.0)	118	101 (85.6)	17 (14.4)	178	161 (90.4)	17 (9.6)
	Emergency response plan	60	52 (86.7)	8 (13.3)	118	89 (75.4)	29 (24.6)	178	141 (79.2)	37 (20.8)
	Cleaning, disinfection, operating and maintenance procedures	60	54 (90.0)	6 (10.0)	118	79 (66.9)	39 (33.1)	178	133 (74.7)	45 (25.3)
	Organized training for personnel	60	54 (90.0)	6 (10.0)	118	76 (64.4)	42 (35.6)	178	130 (73.0)	48 (27.0)
	Authorized hygienic license	60	49 (81.7)	11 (18.3)	118	45 (38.1)	73 (61.9)	178	94 (52.8)	84 (47.2)
Water quality examination	Detection by qualified organization before water-supply	60	56 (93.3)	4 (6.7)	118	105 (89.0)	13 (11.0)	178	161 (90.4)	17 (9.6)
	Index and frequency requirements	60	47 (78.3)	13 (21.7)	118	47 (39.8)	71 (60.2)	178	94 (52.8)	84 (47.2)

Abbreviation: WaSPs=Water Supply Projects; N=number.
* Continuity: 24 hour/day water supply.
† Guarantee: guarantee probability of water supply ≥90%.
§ High leakage: leakage rate of pipes >12%.

procedures, 90.3% of WaSPs used accurate disinfectant dosage, and 90.4% of WaSPs had sanitary management systems. Before formal supply water, 90.4% could be detected water quality by qualified organizations. All the WaSPs with water supply ≥3,000 m^3/d have established a 24 h/d water supply, source water protection areas, disinfection procedures, and sanitary management systems.

The SERWaSP also showed that the pipe leakage rate in 40.2% of the WaSPs was higher than 12%. As for management of WaSPs, 20.8% did not have an emergency response plan for unsafe drinking water conditions, 25.3% had no cleaning, disinfection, operating, or maintenance procedures, and 27.0% did not have regular training for personnel. The detection index and frequency of 47.2% of WaSPs did not meet the requirements according to *Technical Specification for Water Supply Projects in Towns and Villages* issued by Ministry of Water Resources in 2019. Of the WaSPs with water supply <3,000 m^3/d, 11.9% had no disinfection procedures, 23.1% could not use disinfection equipment properly, 14.1% could not

measure disinfectants accurately, and 14.4% had not well-established their sanitary management systems.

According to the most recent water quality reports of these WaSPs provided by CDC, the qualified rates of finished water and tap water were 79.7% and 74.7%, respectively. Most qualified rates of water quality indices were higher than 90% except for microbial indices. Detailed data were shown in Table 2.

DISCUSSION

The National Rural Drinking Water Quality Monitoring System has shown that the qualified rate of drinking water quality in rural areas has increased but is still lower than that of urban areas. Overall, China's rural water supply has been improving, but there are still deficiencies.

The *Technical Specification for Water Supply Projects in Towns and Villages* issued in 2019 suggests that drinking water should be disinfected. Since this study evaluated the whole water treatment process at each WaSPs, we observed that while most WaSPs used a water treatment procedure, more than 10% of WaSPs' water supply with <3,000 m^3/d had no disinfection procedures and were used improperly. The disinfection procedure rate of 403 WaSPs in 6 PLADs of China in 2015 was found to be 39.5% (*4*). This may be the result of a higher proportion of small-scale WaSPs investigated in 2015 and therefore disinfection was given more attention. Water disinfection is efficient at inactivating pathogens (*5*). For drinking water safety, the WaSPs should be equipped with disinfection facilities and use disinfectants accurately.

In this study, we found that both large and small WaSPs have problems with high rates of pipeline leakage. The *Water Pollution Control Action Plan* issued in 2013 stated that the leakage rate in the public water supply network should be limited to 12% by 2017 and 10% by 2020. About two-fifths WaSPs do not meet this requirement. The high leakage rate increases the risk of microbial and chemical re-contamination and causes water resource waste and economic losses for water supply enterprises. The higher leakage rate could be attributed to aging pipes and gate valves, poor quality of pipes, unstable water pressure, or other reasons. The pipe leaks were also related to the year last serviced. The WaSPs with water supply ≥3,000 m^3/d had a higher ratio of leakage, which may be related to many of their pipelines running longer in this study. The reasons for the high leakage rate should be uncovered quickly and targeted measures such as pipeline renovation and replacement or water supply pressure control should be taken according to the actual situation.

Operations and Maintenance management remains a long-standing problem, as the studies of water safety plans implemented in 311 water systems of China from 2004 to 2018 revealed the prevalence of insufficient overall management capacity in rural WaSPs (*6*). O&M is fundamental to WaSPs because failure to adequately address O&M can result in process failures, contamination events, water-borne

TABLE 2. Water quality of 178 rural Water Supply Projects evaluated in 2020 in China.

Water types	Regular indices	≥3,000 m^3/d WaSPs		<3,000 m^3/d WaSPs		Total	
		N	Qualification (%)	N	Qualification (%)	N	Qualification (%)
Finished water							
	Toxicology	60	59 (98.3)	117	116 (99.1)	177	175 (98.9)
	Microbiology	60	56 (93.3)	117	93 (79.5)	177	149 (84.2)
	Physical and chemical parameters	60	56 (93.3)	117	110 (94.0)	177	166 (93.8)
	Disinfectants	60	59 (98.3)	117	116 (99.1)	177	175 (98.9)
	Total	60	52 (86.7)	117	89 (76.1)	177	141 (79.7)
Tap water							
	Toxicology	60	58 (96.7)	118	116 (98.3)	178	174 (97.8)
	Microbiology	60	51 (85.0)	118	87 (73.7)	178	138 (77.5)
	Physical and chemical parameters	60	56 (93.3)	118	111 (94.1)	178	167 (93.8)
	Disinfectants	60	59 (98.3)	118	117 (99.2)	178	176 (98.9)
	Total	60	48 (80.0)	118	85 (72.0)	178	133 (74.7)

Abbreviation: WaSPs=Water Supply Projects; N=number.

diseases, and economic losses (*7*). Nearly half WaSPs cannot carry out the necessary water quality index assessments at the frequency required. The regular monitorings by the WaSPs themselves are able to discover problems quickly. The detection and frequency of index assessments can be increased according to raw water quality, water treatment process, water supply scale, etc. When the results do not meet the standards, the risks should be quickly identified and countermeasures should be enacted. Emergency plans should be launched when necessary.

The *Administrative Measures for Sanitary Evaluation of Rural Drinking Water Safety Projects (Trial)* issued in 2008 proposed sanitary evaluations should be carried out in rural WaSPs with water supply ≥3,000 m^3/d to ensure safe water supply. In addition, the document suggested that SERWaSP results were one of the important conditions for the water supply permissions in rural WaSPs. However, many of the WaSPs with water supply ≥3,000 m^3/d had not carried out SERWaSPs before they were put to use. The results showed WaSPs with a water supply <3,000 m^3/d had more problems during the process of SERWaSP, such as water source protection, disinfection procedures, water quality, and sanitary management. This study's findings point out that the laws and regulations on sanitary evaluation for centralized rural supply should be reinforced. Rural WaSPs covering both large and small, newly constructed, or reconstructed must pass SERWaSP before supplying water. WaSPs in use shall also be subjected to the sanitary evaluation, supervision, and inspection.

However, this study was subject to some limitations. First, the real-world WaSP conditions may be more challenging considering that more WaSPs with water purification treatment were selected in this study. Second, some water quality reports used to carry out SERWaSPs were from months ago, and the water quality might have changed. *Opinions on comprehensively promoting rural revitalization and accelerating the modernization of agriculture and rural areas* issued in 2021 call for the implementation of projects to ensure rural water supply and to strengthen the construction and protection of water sources such as small and medium-sized reservoirs (*8*). The implementation of SERWaSPs is a better choice for water supply safety, which can strengthen the sanitary management of the WaSP in O&M and analyze the water quality safety risks that should be addressed in priority order. The risk management tool, called Water Safety Plans (WSPs) proposed by the WHO, contributes to improving O&M by supporting the systematic assessment, prioritization, and management of risks from catchment to consumer, which might also be applied in rural WaSPs (*6*,*9*). Lastly, a multi-department management mechanism should be operated to promote the development of SERWaSPs and better serve the drinking water safety of rural residents.

Conflicts of Interest: No conflicts of interest reported.

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