ACCSCIENCE PUBLISHING

Asian Journal of Water, Environment and Pollution

ORIGINAL RESERACH ARTICLE

A retrospective assessment of rural drinking water quality and influencing factors in Weifang City

Supplementary Files

Table S1. Weifang City rural drinking water safety projects monitoring points

Counties/cities/ development areas	Total					Pipeline extension projects					Large-scale water supply projects					Joint-villages water supply projects					Single-village water supply projects		
	NP	NV	PC	FOS	TWS	NP	NV	PC	FOS	TWS	NP	NV	PC	FOS	TWS	NP	NV	PC	FOS	TWS	NP/NV	PC	TWS
Anqiu	140	866	55.06	6	39	1	47	4.29	1	2	9	689	44.67	5	17	0	0	0	0	0	130	6.09	20
Changyi	3	631	30.54	2	13	1	229	9.03	1	5	2	402	21.51	1	8	0	0	0	0	0	0	0	0
Gaomi	5	734	52.16	3	22	2	380	28.66	1	12	3	354	23.50	2	10	0	0	0	0	0	0	0	0
Qingzhou	335	983	59.26	15	60	4	122	7.42	2	3	9	516	31.38	5	8	15	38	2.52	8	12	307	17.93	37
Shouguang	8	950	51.39	5	17	3	302	14.14	2	6	5	648	34.58	3	11	0	0	0	0	0	0	0	0
Zhucheng	75	1315	66.62	5	56	1	126	7.69	1	4	6	1,115	58.25	3	20	1	7	0.69	1	4	67	2.67	28
Linqu	99	346	72.32	5	38	1	28	10.38	1	5	5	220	52.90	2	17	3	8	1.09	2	4	90	7.95	12
Changle	45	370	24.12	2	18	0	0	0	0	0	3	328	22.11	2	10	0	0	0	0	0	42	2.01	8
Weicheng	3	292	16.70	2	5	0	0	0	0	0	3	292	16.70	2	5	0	0	0	0	0	0	0	0
Kuiwen	1	101	13.87	1	7	1	101	13.87	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0
Hanting	1	321	23.21	1	12	1	321	23.21	1	12	0	0	0	0	0	0	0	0	0	0	0	0	0
Fangzi	6	479	44.27	4	20	1	63	4.42	1	6	5	416	39.85	3	14	0	0	0	0	0	0	0	0
Binhai	3	48	8.44	2	3	3	48	8.44	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	724	7436	517.95	53	310	19	1,767	131.6	14	65	50	4,980	345.45	28	120	19	53	4.30	11	20	636	36.65	105

Abbreviations: FOS: Factory outlets sampling points; NP: Number of projects; NV: Number of villages covered; PC: Population coverage (10,000 people); TWS: Terminal water supply sampling points.

Table S2. Complete descriptive statistics of all 38 water quality indicators (*n* = 1452)

Indicator	Detection range	Mean	Median (P25, P75)	Standard limit	Detection limit
Microbial indicators					
Total coliforms (MPN/100 mL)	0–540	3.334	0 (0, 0)	0	–
Escherichia coli (MPN/100 mL)	0–23	3.558	0 (0, 0)	0	–
Total bacterial count (CFU/mL)	0–5,100	110.114	15 (0, 76)	≤100 (C); ≤500 (D)	–
Toxicological indicators					
Arsenic (mg/L)	0–0.0050	0.000671	0 (0, 0)	0.010	0.0010
Cadmium (mg/L)	0–0.0050	0.000615	0 (0, 0)	0.005	0.0010
Chromium (VI) (mg/L)	0–0.0710	0.004150	0 (0, 0)	0.050	0.0040
Lead (mg/L)	0–0.0025	0.000789	0 (0, 0)	0.010	0.0010
Mercury (mg/L)	All ND	0.000722	0 (0, 0)	0.001	0.0001
Cyanide (mg/L)	All ND	0.000623	0 (0, 0)	0.050	0.0020
Fluoride (mg/L)	0–0.8900	0.322000	0.20 (0.10, 0.42)	1.000	0.1000
Nitrate (as nitrogen, mg/L)	0–38.3000	6.540000	4.70 (2.50, 8.50)	≤10.000 (C); ≤20.000 (D)	1.0000
Chloroform (μg/L)	0–53.0000	0.005130	0 (0, 0.28)	60.000	0.1200
Monochlorodibromomethane (μg/L)	0–17.2000	0.005220	0 (0, 0.21)	100.000	0.2510
Dichloromonobromomethane (μg/L)	0–19.0000	0.004580	0 (0, 0.22)	60.000	0.2900
Bromoform (μg/L)	0–33.0000	0.004420	0 (0, 1.10)	100.000	0.2510
Trihalomethanes (μg/L)	0–1.2100	0.257000	0.02 (0, 0.11)	1.000	–
Dichloroacetic acid (μg/L)	0–42.0000	0.011500	0 (0, 0)	50.000	3.7000
Trichloroacetic acid (μg/L)	0–80.0000	0.013100	0 (0, 0)	100.000	4.4000
Chlorite (mg/L)	0.0010–0.6900	0.204000	0.02 (0, 0.06)	0.700	0.0024
Chlorate (mg/L)	0–0.6900	0.131000	0.03 (0, 0.11)	0.700	0.0050

(cont'd...)

Table S2. (*Continued*)

Indicator	Detection range	Mean	Median (P25, P75)	Standard limit	Detection limit
Sensory and general indicators					
Color (degrees)[a]	0–10.000	1.7680	0 (0, 0)	15.00	5.00
Turbidity (NTU)	0–3.720	0.2900	0.100 (0, 0.230)	≤1.00 (D); ≤3.00 (C)	0.10
pH	6.610–8.410	7.7200	7.700 (7.510, 7.900)	6.50–8.50	–
Aluminum (mg/L)	0–0.150	0.0420	0.005 (0, 0.019)	0.20	0.01
Iron (mg/L)	0–0.270	0.0647	0.005 (0.020, 0.100)	0.30	0.01
Manganese (mg/L)	0–0.180	0.0169	0 (0, 0.020)	0.10	0.01
Copper (mg/L)	0–0.130	0.0219	0 (0, 0.050)	1.00	0.01
Zinc (mg/L)	0–0.160	0.0325	0 (0, 0.025)	1.00	0.01
Chloride (mg/L)	6.100–289.900	58.5200	43.200 (25.600, 81.600)	250.00	1.00
Sulfate (mg/L)	8.900–204.000	82.1500	83.000 (53.450, 133.750)	250.00	1.00
Total dissolved solids (mg/L)	26.000–1,521.000	428.9800	402.000 (327.800, 542.000)	1,000.00	–
Total hardness (as calcium carbonate, mg/L)	29.400–628.600	289.6500	279.300 (194.000, 336.000)	450.00	1.00
Permanganate index (mg/L)	0.046–2.900	1.9790	1.250 (0.670, 1.800)	3.00	0.05
Ammonia (as nitrogen, mg/L)	0–0.920	0.0659	0.010 (0.010, 0.020)	0.65	0.02
Free chlorine (mg/L)[b]	0–0.830	0.2140	0.100 (0.040, 0.130)	≥0.30/0.05	0.01
Chlorine dioxide (mg/L)[b]	0–0.670	0.1065	0.050 (0.020, 0.080)	≥0.10/0.02	0.01

Notes: [a]Color is measured in platinum–cobalt color units, commonly abbreviated as “degrees” in Chinese drinking water standards (GB/T 5750.4-2022); [b]Centralized supply; Residual disinfectant standards are lower limits (≥).
Abbreviations: C: Centralized supply; D: Decentralized supply; ND: Not Detected.

Table S3. Final model of multiple logistic regression results

Variable	β	SE	Wald χ^2	*p*-value	OR	95% CI
Project type						
Urban extension	–	–	–	–	1.000	–
Large-scale	0.986	0.374	6.926	0.008	2.679	1.286–5.582
Joint-village	−0.193	0.565	0.117	0.732	0.824	0.272–2.495
Single-village	−0.838	0.614	1.866	0.172	0.432	0.130–1.440
Water source type						
Reservoir	–	–	–	–	1.000	–
Deep well	1.057	0.279	14.370	< 0.001	2.877	1.666–4.969
Shallow well	3.435	0.372	85.082	< 0.001	31.021	14.952–64.358
Spring	1.764	0.412	18.318	< 0.001	5.837	2.602–13.094
Treatment method						
Full treatment	–	–	–	–	1.000	–
No treatment	2.801	0.470	35.494	< 0.001	16.459	6.550–41.361
Sample type						
Factory outlet	–	–	–	–	1.000	–
Tap water	1.333	0.334	15.945	< 0.001	3.794	1.972–7.301
Constant	−5.017	0.482	108.268	< 0.001	0.007	

Notes: Variable assignments: Project type (1 = Urban extension, 2 = Large-scale, 3 = Joint-village, 4 = Single-village); Water source (1 = Reservoir, 2 = Deep well, 3 = Shallow well, 4 = Spring); Treatment (0 = Full, 1 = None); Sample type (1 = Factory outlet, 2 = Tap water).
Abbreviations: CI: Confidence interval; OR: Odds ratio; SE: Standard error.

Table S4. Detailed thematic analysis from focus group discussions

Theme	Sub-theme	Key findings	Representative quotes
Theme 1: Water quality perceptions and evaluation criteria	Sensory-based evaluation	Participants primarily assessed water quality based on taste, odor, and visual appearance rather than technical parameters. Changes following rainfall strongly influenced perceptions of safety.	"When the water becomes cloudy or has an unusual smell, people immediately feel uneasy, even before using it." (Community resident, personal communication, March 15, 2026)
	Visible indicators of poor quality	Rapid scale formation during boiling and water discoloration were widely perceived as indicators of contamination and health risk.	"White scale builds up very quickly when we boil water, which makes us wonder about the water quality." (Community resident, personal communication, March 15, 2026)
	Perceived instability and decline	Drinking water quality was perceived as unstable and deteriorating compared to the past, contributing to uncertainty and dissatisfaction.	"The water quality is not stable; it changes from time to time." / "In the past, the water felt better. Now it seems worse than before." (Community residents, personal communication, March 15, 2026)
	Urban-rural comparison	Rural water supplies were consistently perceived as inferior to urban water supplies in quality and reliability.	"When I stay in the city, I do not worry about drinking tap water, but at home I avoid it." (Community resident, personal communication, March 15, 2026)
Theme 2: Health concerns and uncertainty	Non-specific health symptoms	Participants reported occasional gastrointestinal discomfort and skin irritation but avoided attributing these to water quality.	"I am not sure if it is caused by the water, but sometimes after drinking it, I feel stomach discomfort." / "After bathing, my skin sometimes feels itchy, especially in winter." (Community residents, personal communication, March 15, 2026)
	Concerns for vulnerable populations	Heightened concern was expressed for children and older adults, who were perceived as more susceptible to water-related health risks.	"Adults may tolerate it, but I worry more about children and older people." (Community resident, personal communication, March 15, 2026)
	Short-term versus long-term uncertainty	While acute symptoms were described as mild or infrequent, uncertainty about long-term health effects was a prominent concern.	"Even if nothing happens immediately, people still worry about long-term effects." (Community resident, personal communication, March 15, 2026)
	Anxiety driven by information gaps	Perceived health risks were closely linked to a lack of clear information, contributing to ongoing anxiety among residents.	"Not knowing the real situation makes people more anxious about their health." (Community resident, personal communication, March 15, 2026)
Theme 3: Water supply reliability	Intermittent supply and pressure fluctuations	Participants reported inconsistent water pressure, unexpected interruptions, and seasonal variations that disrupted daily routines.	"The water supply is not very stable. Sometimes the pressure is low, and sometimes there are short interruptions." / "In summer, the water pressure drops more often, especially during busy hours." (Community residents, personal communication, March 15, 2026)
	Impacts on daily activities	Supply disruptions affected cooking, washing, and personal hygiene, creating significant inconvenience for households.	"When the water is cut off, even simple things like cooking become difficult." (Community resident, personal communication, March 15, 2026)
	Coping through water storage	Households commonly stored water in advance to address anticipated interruptions.	"We usually store water ahead of time; if not, daily life becomes very inconvenient." (Community resident, personal communication, March 15, 2026)
	Differential vulnerability	Experts noted that smaller or rural systems were more vulnerable to instability due to capacity limitations. Local officials acknowledged that areas farther from main networks experienced more frequent problems.	"Rural systems are more likely to experience instability due to limited infrastructure." (Technical expert, personal communication, March 15, 2026) / "Areas farther from the main network experience more frequent supply problems." (Local official, personal communication, March 15, 2026)

(*cont'd...*)

Table S4. (*Continued*)

Theme	Sub-theme	Key findings	Representative quotes
Theme 4: Household coping strategies and burdens	Boiling as a universal practice	Boiling drinking water was the most common household strategy, viewed as a habitual and reliable method to reduce perceived health risks.	"We boil water every day. It has become a habit, and it makes us feel safer." (Community resident, personal communication, March 15, 2026)
	Reliance on bottled water and filters	Some households used bottled water for drinking and cooking, particularly for children, despite higher costs. Others purchased filtration devices but expressed uncertainty about maintenance.	"We mainly use bottled water for drinking, especially for children, even though it is more expensive." / "We bought a filter, but we do not really know how effective it is or when to change it." (Community residents, personal communication, March 15, 2026)
	Economic burden of coping	Cost was a major barrier to adopting safer water practices, particularly for low-income households. During supply disruptions, purchasing bottled water added to household expenses.	"Not every family can afford bottled water or good filtration devices." (Community resident, personal communication, March 15, 2026) / "When there is no water, we have to buy bottled water, which becomes an extra cost." (Community resident, personal communication, March 15, 2026)
	Limitations of individual solutions	Experts emphasized that household-level practices cannot substitute for a safe and reliable public water supply.	"Individual coping measures are limited and cannot replace a safe public water system." (Technical expert, personal communication, March 15, 2026)
Theme 5: Trust, information, and governance	Limited confidence despite compliance	Overall confidence in drinking water safety was limited, largely due to uncertainty and lack of visible evidence, even when water met technical standards.	"We are told the water is safe, but I do not feel very confident about it." / "I cannot say the water is unsafe, but I do not really trust it either." (Community residents, personal communication, March 15, 2026)
	Information asymmetry	Participants reported limited access to timely and understandable water quality information. Testing results were rarely communicated to communities.	"We rarely see updated information about water quality." / "If test results were made public, people would feel more assured." (Community residents, personal communication, March 15, 2026)
	Ineffective communication channels	Existing communication channels were perceived as unclear or ineffective, especially during water-related incidents.	"When problems occur, we do not know whom to ask or where to get information." (Community resident, personal communication, March 15, 2026)
	Governance constraints	Local officials cited resource limitations and unclear responsibilities as barriers to regular information disclosure. Experts emphasized that effective governance requires both technical performance and transparent communication.	"At the local level, we lack resources to share information regularly." (Local official, personal communication, March 15, 2026) / "Meeting standards alone is not enough; communication is equally important." (Technical expert, personal communication, March 15, 2026)