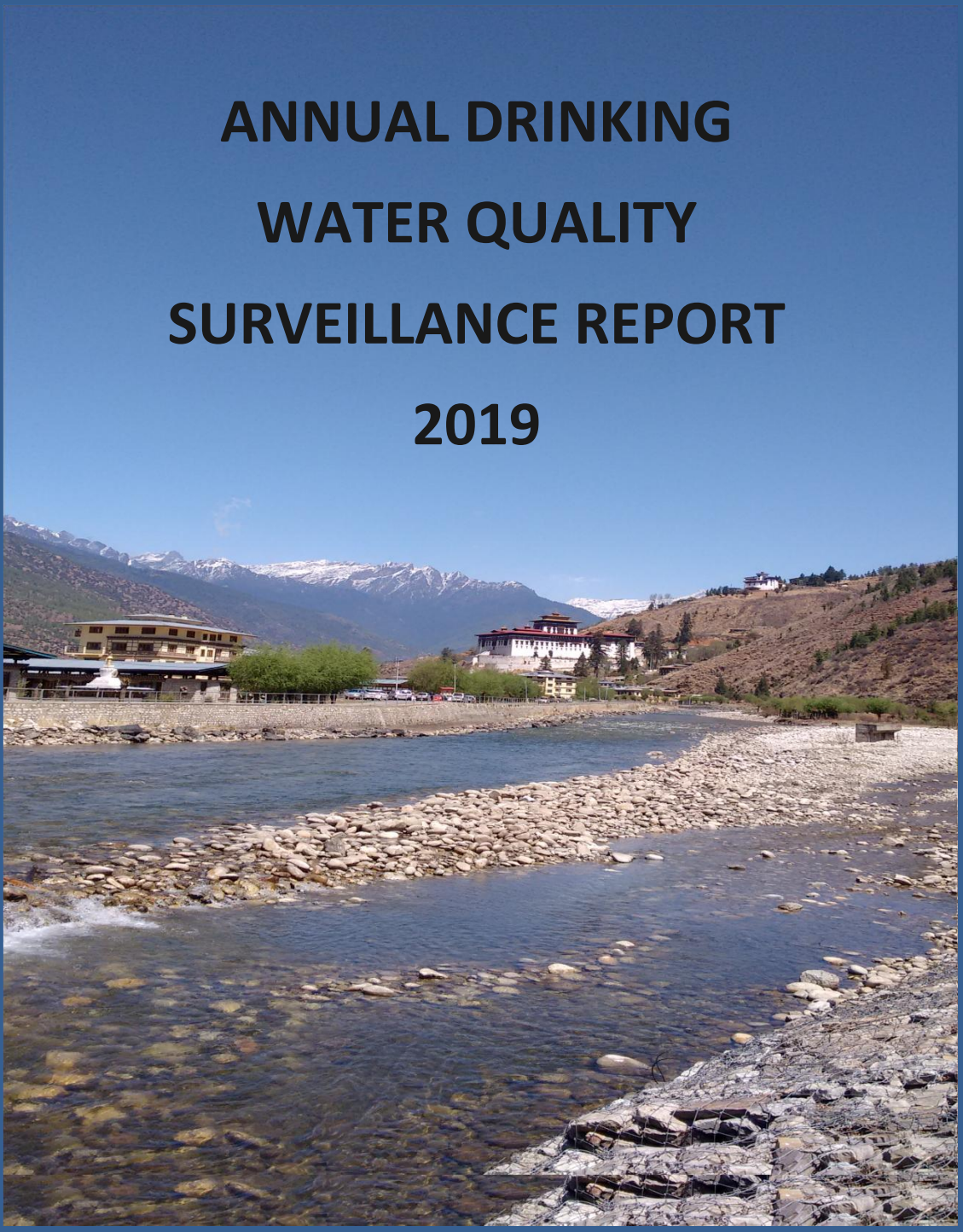
ANNUAL DRINKING WATER QUALITY SURVEILLANCE REPORT 2019



National Water Reference Laboratory

Royal Center for Disease Control

Ministry of Health

Contents

Abbreviation

BDL:	below detection limit
BDWQS:	Bhutan Drinking Water Quality Standard
CFU:	colony forming unit
E. Coli	Escherichia Coli
mg:	milligram
mL:	milliliter
ND:	not detected
NR:	not reported (no report)
NT:	not tested
NTU:	Nephelometric Turbidity Units
ppm:	parts per million or milligrams per liter (mg/L)
ppb:	parts per billion (µg/l)
RCDC:	Royal Center for Disease Control
WaQMIS:	Water Quality Monitoring Information System
WHO:	World Health Organization
WTP:	Water Treatment Plant

Background

This annual Drinking Water Quality Report includes details on the Physical, Chemical and Microbiological parameters of the drinking water supplied to the communities in urban and rural areas in the year 2019. The tests are conducted by the drinking water quality surveillance centres. There are 34 urban health centres and 274 rural health centres identifies as water quality surveillance centres. The laboratory staffs in the urban health centres and the Health Assistants in the rural health centres are trained to carry out the water quality testing.

The water quality test results from the respective health centres are compared with the standard compliance values in Bhutan Drinking Water Quality Standard (BDWQS) 2016.

Contaminants that may be present in Bhutan drinking water sources:

Most of the drinking water sources in Bhutan are from the streams and springs. However, with the increase in urban population and the drying of sources, rivers and ground water are also being abstracted for drinking. Since there are many drinking water sources in the country, some of the water from these sources may contain some contaminants. The presence of contaminants does not necessarily indicate that the water poses a health risk. Drinking water contaminants may pose a threat to human health if the quantity of the contaminant exceeds the recommended standard values. The contaminants (referred to as parameter) that require regular monitoring in Bhutan drinking water are given in the BDWQS which are classified based on risk category.

The general parameters that are currently monitored in Bhutan are:

- **Physical parameters** which primarily impact the physical appearance or other physical properties of water are Turbidity and pH of water.

- **Microbial parameters** are organisms in water such as viruses and bacteria that may come from sewage treatment plants, septic systems, agricultural livestock operations and wildlife. The measurement of direct pathogen is expensive and also time consuming. Therefore, for drinking water quality surveillance, an indicator organism is used to gauge the probability of the presence of pathogens. Currently Thermotolerant Coliform is monitored for urban drinking water quality and E. Coli for Rural drinking water quality.

- **Inorganic parameters** are chemicals such as salts and metals that can be naturally occurring or man-made that results from piping system, industrial or domestic wastewater discharges, surface runoffs, mining or farming.

1. Urban Drinking Water Quality Monitoring System

1.1. Parameters for Urban Health Centers

- ✓ Thermotolerant Coliform
- ✓ Turbidity
- ✓ pH
- ✓ Residual Chlorine (Wherever chlorination is carried out for disinfection)
- ✓ Color
- ✓ Odor

1.2. Monitoring Frequency

The monitoring is carried out once a month and reporting is made through Water Quality Monitoring Information System (WaQMIS) every month.

1.3.Water Treatment

Figure 1: General treatment process in urban areas

Most of the water treatment plants in Bhutan are using the basic treatment method with sand filters and sedimentation tanks (*figure 1*).

Chlorine in the form of Calcium Hypochlorite (Bleaching Powder) is used as disinfectant but only in few treatment plants.

Few treatment plants (eg.Gelephu Treatment Plant, Chamgang Water Treatemnt Plant, Trashigang Water Treatment Plant has more stages of treatment plant which includes combination of sand filters, pressure sand filters bio-ball filters and disinfection by Chlorine)

Annex 1 explains some of treatment techniques that are available across the country.

1.4.Report

1.4.1. Bacteriology (Thermotolerant coliform)

Thermotolerant Coliforms are bacteria that can beintroduced into drinking water supplies through human or animal faeces. For water to be considered safe, Thermotolerant Coliforms should not be detected in a 100mL sample of drinking water. If detected, it is an indication of the contamination of drinking water by faeces and also suggests that other potentially-harmful microbes may be present.

A total of 1951 samples were collected and tested for Thermotolerant coliformfrom 34 urban health centers in the country for routine water quality surveillance. Out of which 52.6% of samples were found safe (0 CFU/100mL) and rest were found unsafe (>1 CFU/100mL Thermotolerant Coliform).

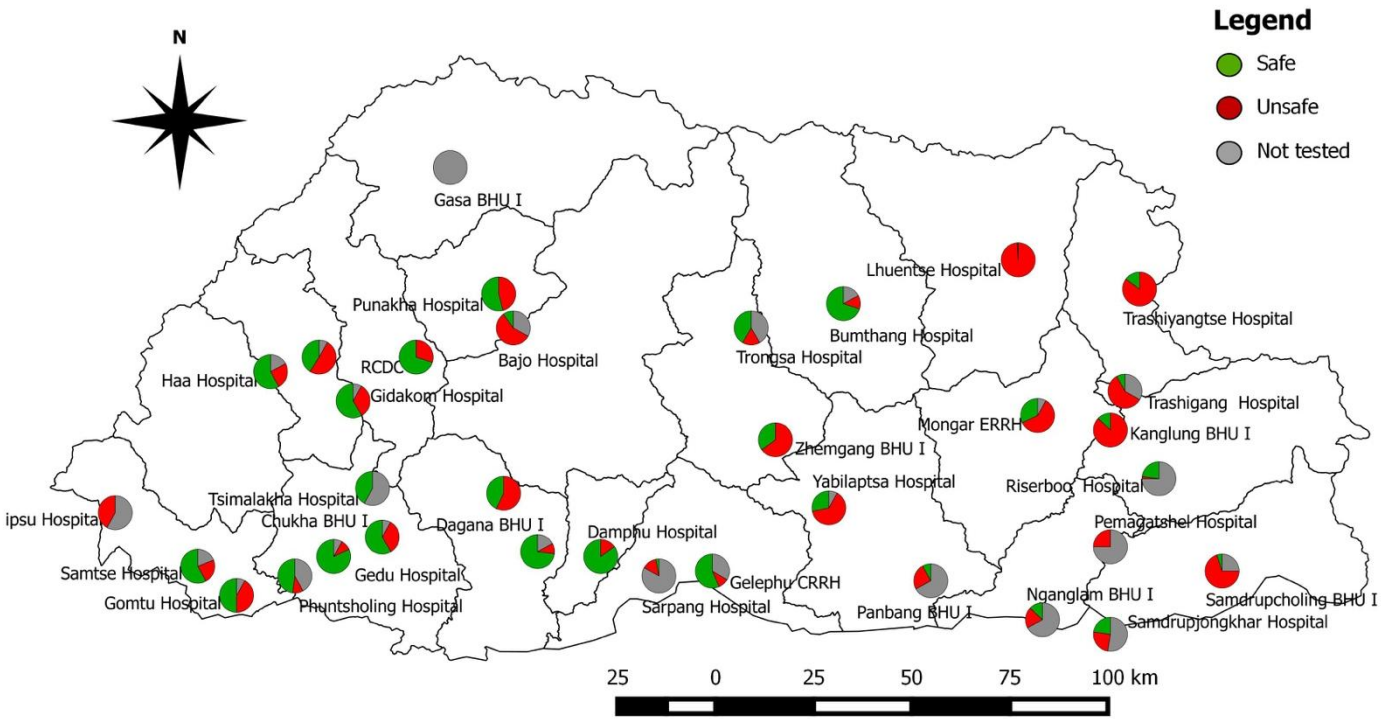


Figure 2: Bacteriology test report of 34 hospitals/BHU-1 in urban area

The annual national surveillance data show that the samples tested by Sibsoo BHU and Pemagatshel hospital were found 100% unsafe. Similarly, reports from Lhuentse hospital and Samdrupchholing BHUI reported more than 90% of the samples unsafe. Some of the sampling points from health centers like Bumthang Hospital, Kanglung BHU I, Lhuentse Hospital, Mongar Hospital, SamdrupjongkharHospiotal, are consistently grossly polluted (>50 CFU/100mL Thermotolerat Coliform) (detail report given in *Annex 1*). On the other hand, Tsimalakha hospital tested 35 samples and all were found safe. 870 samples out of total samples are treated which are collected from WTP by 21 health centers (*see annex 1*). 59% of the total treated samples are found safe (*figure 3*). 28% of the total annual samples were not tested *(see table 2 for details)*.

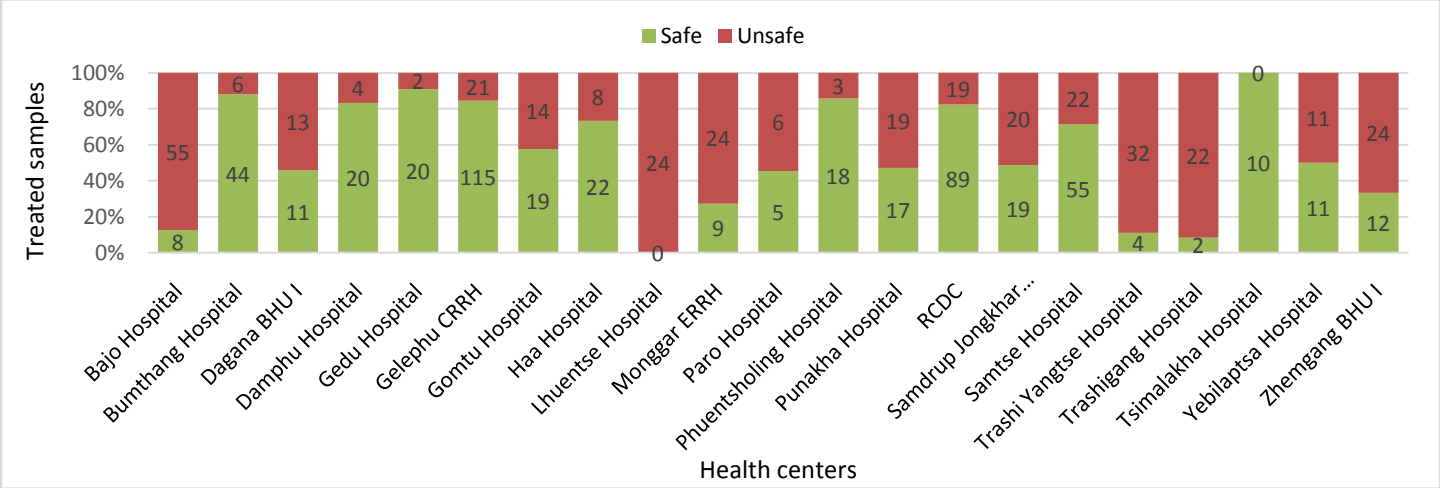


Figure 3: quality of treated water from urban water supply

Table 1: Monthly water quality from various sampling points of urban health centers

Dzongkhag	Center	Total Samples to be tested	Total Samples Tested	Safe Water	Unsafe water	% of samples not tested
Bumthang	Bumthang Hospital	84	70	59	11	17
Chhukha	Chhukha BHU I	48	44	28	16	8
Chhukha	Phuentsholing Hospital	108	63	52	11	42
Chhukha	Gedu Hospital	84	77	69	8	8
Chhukha	Tsimalakha Hospital	84	35	35	0	58
Dagana	Dagana BHU I	60	60	26	34	0
Dagana	Dagapela Hospital	60	50	44	6	17
Gasa	Gasa BHU I	48	0	0	0	100
Haa	Haa Hospital	60	50	35	15	17
Lhuentse	Lhuentse Hospital	72	72	1	71	0
Mongar	Monggar ERRH	84	77	27	50	8
Paro	Paro Hospital	96	88	39	49	8
Pemagatshel	Pemagatshel Hospital	72	18	0	18	75
Pemagatshel	Nganglam BHU I	60	20	8	12	67
Punakha	Punakha Hospital	72	72	39	33	0
Samdrupjongkhar	Samdrupchholing BHU I	60	45	3	42	25
Samdrupjongkhar	SamdrupJongkhar Hospital	120	57	27	30	53
Samtse	Sibsoo BHU I	72	30	0	30	58
Samtse	Gomtu Hospital	72	66	36	30	8
Samtse	Samtse Hospital	108	88	63	25	19
Sarpang	Sarpang Hospital	72	12	2	10	83

Sarpang	Gelephu CRRH	204	136	115	21	33
Thimphu	Gidakom Hospital	48	44	28	16	8
Thimphu	Royal Centre for Disease Control	132	132	92	40	0
Trashigang	Trashigang Hospital	48	32	4	28	33
Trashigang	Kanglung BHU I	84	84	11	73	0
Trashigang	Riserboo Hospital	84	21	19	2	75
Trashiyangtse	Trashi Yangtse Hospital	84	84	13	71	0
Trongsa	Trongsa Hospital	84	49	35	14	42
Tsirang	Damphu Hospital	72	72	61	11	0
Wangduephodrang	Bajo Hospital	84	56	8	48	33
Zhemgang	Panbang BHU I	60	20	5	15	67
Zhemgang	Yebilaptsa Hospital	60	55	17	38	8
Zhemgang	Zhemgang BHU I	72	72	25	47	0
		2712	**1951**	**1026**	**925**	**28**

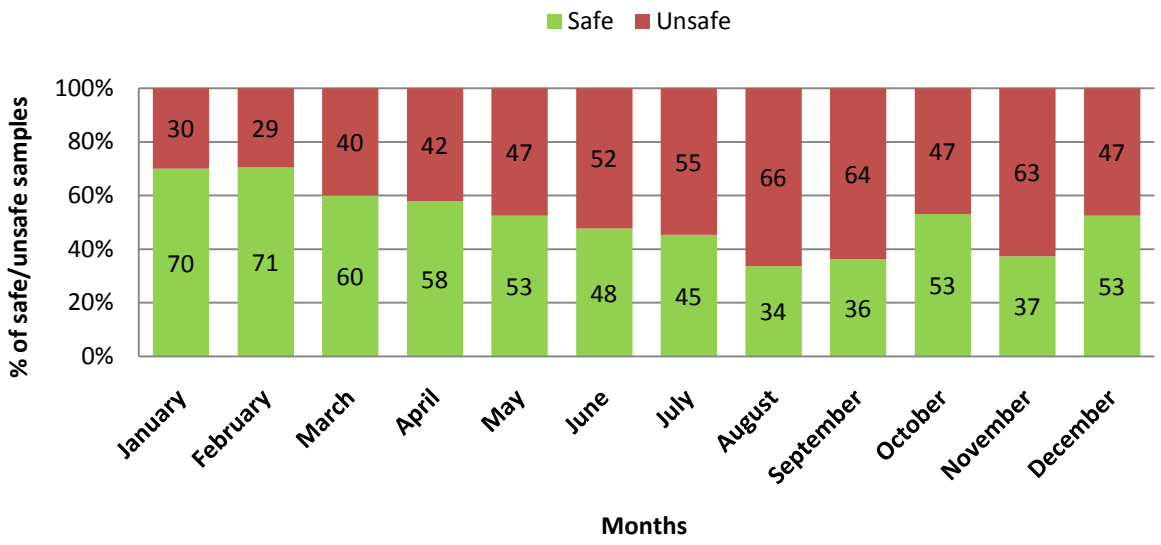


Figure 4: Seasonal variation of water quality (Based on Thermotolerant coliform report)

The annual monthly graph for Thermotolerant coliform indicates that the total number of safe wateris usually higher during dry seasons. Maximum unsafe was observed during rainy season indicating water quality has deteriorated during rainy season *(figure 4)*.

Table 2: Consistency in reporting

Reporting Center	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bajo Hospital	NR	NR	NR	R	R	R	R	R	R	R	R	NR
Bumthang Hospital	NR	R	NR	R	R	R	R	R	R	R	R	R
Chhukha BHU I	R	R	R	R	R	R	R	R	NR	R	R	R
Dagana BHU I	R	R	R	R	R	R	R	R	R	R	R	R
Dagapela Hospital	R	R	R	NR	R	R	R	R	R	R	R	NR
Damphu Hospital	R	R	R	R	R	R	R	R	R	R	R	R
Gasa BHU I	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Gedu Hospital	R	R	R	R	R	R	R	R	R	R	NR	R
Gelephu CRRH	R	R	R	R	R	NR	R	R	NR	R	NR	NR
Gidakom Hospital	R	R	R	R	R	NR	R	R	R	R	R	R
Gomtu Hospital	NR	R	R	R	R	R	R	R	R	R	R	R
Haa Hospital	NR	R	NR	R	R	R	R	R	R	R	R	R
Kanglung BHU I	R	R	R	R	R	R	R	R	R	R	R	R
Lhuentse Hospital	R	R	R	R	R	R	R	R	R	R	R	R
Monggar ERRH	NR	R	R	R	R	R	R	R	R	R	R	R
Nganglam BHU I	R	NR	NR	R	NR	NR	NR	NR	R	NR	R	NR
Panbang BHU I	NR	NR	NR	R	NR	NR	NR	R	R	NR	NR	R
Paro Hospital	R	NR	R	R	R	R	R	R	R	R	R	R
Pemagatshel Hospital	R	NR	NR	NR	NR	R	R	NR	NR	NR	NR	NR
Phuentsholing Hospital	R	R	R	R	NR	R	R	NR	NR	NR	NR	R
Punakha Hospital	R	R	R	R	R	R	R	R	R	R	R	R
Riserboo Hospital	R	NR	R	NR	NR	NR	NR	R	NR	NR	NR	NR
Royal Centre for Disease Control	R	R	R	R	R	R	R	R	R	R	R	R
SamdrupJongkhar Hospital	NR	NR	NR	NR	NR	R	NR	R	R	R	R	R
Samdrupchholing BHU I	NR	R	R	NR	R	NR	R	R	R	R	R	R
Samtse Hospital	R	NR	R	R	R	R	R	R	R	R	R	R
Sarpang Hospital	NR	NR	R	NR	NR	NR	NR	NR	NR	R	NR	NR
Sibsoo BHU I	R	NR	NR	R	NR	NR	R	R	NR	NR	NR	R
Trashi Yangtse Hospital	R	R	R	R	R	R	R	R	R	R	R	R
Trashigang Hospital	R	R	R	R	R	NR	R	R	R	NR	NR	NR
Trongsa Hospital	R	R	R	NR	NR	R	R	R	R	NR	NR	NR
Tsimalakha Hospital	R	NR	R	R	R	NR	NR	R	NR	NR	NR	NR
Yebilaptsa Hospital	R	R	R	R	R	R	R	R	R	R	R	NR
Zhemgang BHU I	R	R	R	R	R	R	R	R	R	R	R	R

Note:
R=Reported
NR=Not reported

1.4.2. Physio-Chemical report

a) Turbidity

- Turbidity is a measure of the cloudiness of the water caused by suspended particles or colloidal matter. It indicates the effectiveness of the treatment plants. Although turbidity may not have direct health effect it may have a negative impact on consumer acceptability

Figure 5: wire mesh used to remove debris to reduce turbidity in some rural water supply

- A total of 1662 samples were monitored for turbidity from 34 urban health centers for routine water quality surveillance. Out of which 94.7% of the samples were found within acceptable limit (<5NTU).
- The *figure 6*indicates maximum number of turbid samples observed in August followed by February, May and September. The detailed monthly variation of turbidity is given in *Annex 2*

Figure 6: Seasonal variation of turbidity from 34 health centers

Table 3: Turbidity Compliance

Dzongkhag	Center	Compliant (≤5 NTU)	Non compliant (> 5NTU)
Bumthang	Bumthang Hospital	70	0
Chhukha	Chhukha BHU I	38	6
Chhukha	Gedu Hospital	77	0
Chhukha	Phuentsholing Hospital	63	0
Chhukha	Tsimalakha Hospital	35	0
Dagana	Dagana BHU I	60	0
Dagana	Dagapela Hospital	50	0
Gasa	Gasa BHU I	0	0
Haa	Haa Hospital	50	0
Lhuentse	Lhuentse Hospital	72	0
Mongar	Monggar ERRH	66	11
Paro	Paro Hospital	80	8
Pemagatshel	Nganglam BHU I	20	0
Pemagatshel	Pemagatshel Hospital	18	0
Punakha	Punakha Hospital	72	0
Samdrupjongkhar	SamdrupJongkhar Hospital	45	12
Samdrupjongkhar	Samdrupchholing BHU I	42	3
Samtse	Gomtu Hospital	66	0
Samtse	Samtse Hospital	82	6
Samtse	Sibsoo BHU I	29	1
Sarpang	Gelephu CRRH	136	0
Sarpang	Sarpang Hospital	11	1
Thimphu	Gidakom Hospital	39	5
Thimphu	Royal Centre for Disease Control	128	4
Trashigang	Kanglung BHU I	84	0
Trashigang	Riserboo Hospital	21	0
Trashigang	Trashigang Hospital	32	0
Trashiyangtse	Trashi Yangtse Hospital	76	8
Trongsa	Trongsa Hospital	49	0
Tsirang	Damphu Hospital	64	8
Wangduephodrang	Bajo Hospital	54	2
Zhemgang	Panbang BHU I	20	0
Zhemgang	Yebilaptsa Hospital	54	1
Zhemgang	Zhemgang BHU I	61	11
		1864	**87**

b) pH

The allowable range for pH is 6.5 to 8.5 as per BDWQS. Out of 1803 samples tested only 2.5% of the samples were found non-compliant. The highest pH tested was found to be 9 and the lowest value was tested 5.

Figure 7:Chlorine dosing machine used in some WTP

c) Chlorine

Out of 34 urban reporting centers, only six health centers (Bajo, Bumthang, Gelephu, Phuntsholing, RCDC and Samtse) monitor chlorine level in drinking water as there are no treatment facilities in other urban areas or some treatment plant do not use chlorine for disinfection.

A total of672 treated samples were tested for Residual Chlorine. Out of which only18.90% were adequately chlorinated. From rest of the samples 76.19% were either not chlorinated or were found below 0.2mg/L of residual chlorine while 4.91% exceeded the recommend residual chlorine level in drinking water i.e>5mg/L. *(figure 8).*

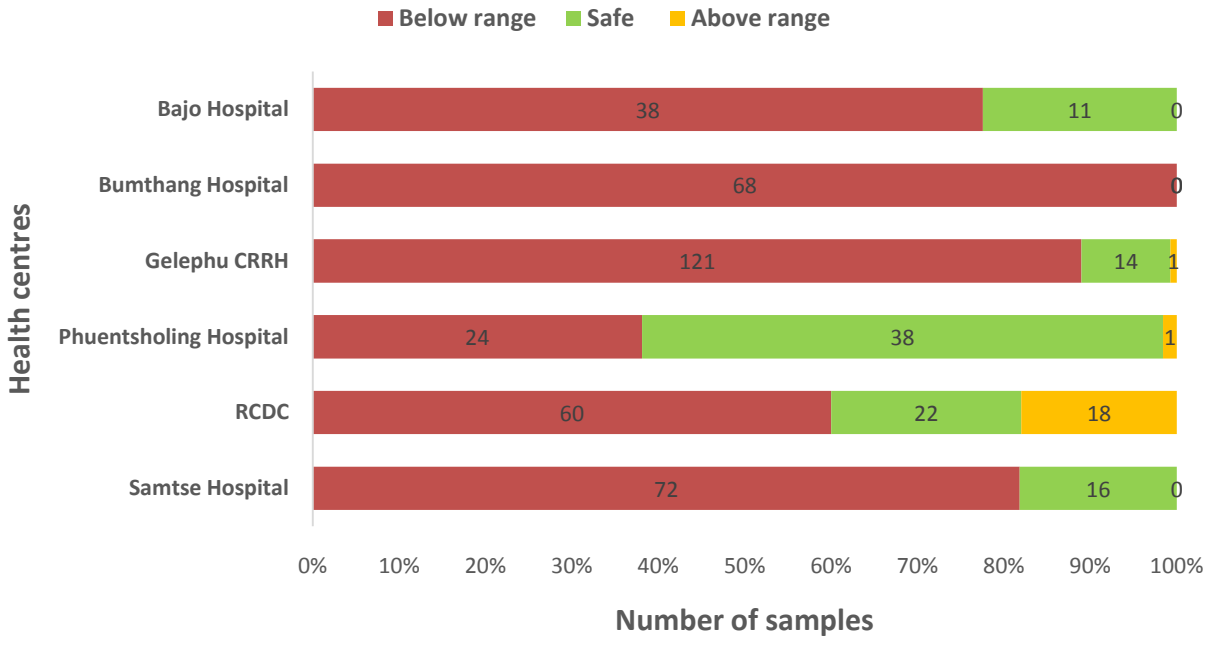


Figure 8: Residual Chlorine maintained at different Urban drinking water treatment facilities

1.4.3. Chemical report

The water samples were analyzed for the concentration of soluble heavy metals. The concentration of heavy metals in most of the samples was within the acceptable limit. In a few samples metal concentration was below the detection limit and in most of the samples metals was not detected. Some of the samples were not tested for few parameters.

- In samples from Chhukha and Zhemgang Arsenic was found in higher concentration which was almost equivalent to recommended level in BDWQS.
- In a sample from Chhukha Cadmium is found to be 0.034 ppm it is above the permissible limit of 0.003 ppm as per recommended level in WHO guideline for drinking water quality.
- In sample some samples from Bumthang, Chhukha and Punakha Lead content were found to be 0.029 ppm, 0.042 ppm and 0.014 ppm respectively, which is above the permissible limit of 0.01 ppm.
- In sample some samples from Bumthang, Chhukha, Punakha and Thimphu Iron content were found to be 0.531 ppm, 0.305 ppm, 0.458 ppm and 0.337 ppm respectively, which is above the permissible limit of 0.3 ppm

1.4.4. Major Sources of Chemical contaminants in drinking water:

a) Arsenic

- Arsenic has been linked to a number of cancers and also has some health effects.
- It can contaminate drinking water through erosion of natural deposits and is feasible to achieve arsenic concentrations of 10 µg/l should be achievable by conventional treatment (e.g. coagulation).

b) Cadmium

- There is no evidence of carcinogenicity of Cadmium by the oral route but it can be carcinogenic by the inhalation route. The kidney is the main target organ for cadmium toxicity.

- Cadmium is commonly used in batteries. They can be release to environment and water from fertilizers. Cadmium can alsocontaminate drinking water by impurities in the zinc of galvanized pipes and solders and some metal fittings. It can be treated by coagulation.

c) Lead

- If present, increased levels of lead can cause serious health issues including various neurodevelopmental effects, mortality (mainly due to cardiovascular diseases), impaired renal function, hypertension, impaired fertility and adverse pregnancy outcomes.
- Lead in drinking water is primarily from materials and components associated with service lines and home

d) Iron

- Iron is abundantly found in earth's crust. Iron may also be present in drinking-water as a result of the use of iron coagulants or the corrosion of cast iron pipes during water distribution. Though it is not of health concern at the level found in drinking water, it may affect acceptability of drinking water beyond recommended level

Table 4: Chemical Test reports from 44 urban sampling points

Sl. No.	Dzongkhag	Parameter	Al	As	Ba	Cd	Cr	Cu	Mn	Ni	Pb	Se	Zn	Fe
		BDWQS (ppm)		**0.01**					**0.4**		**0.01**			**0.3**
		WHO (ppm)	**0.9**	**0.01**	**0.7**	**0.003**	**0.05**	**2**	**0**	**0.07**	**0.01**	**0.04**	**3**	
		Treatment Plant												
1	Bumthang	BumthangLamaygoenpa	0.0297	0.0062	ND	ND	ND	ND	0.0022	ND	ND	ND	0.0112	NT
2	Bumthang	Nasphel water source	NT	NT	NT	0.002	0.011	0.004	0.004	ND	**0.029**	NT	0.011	**0.531**
3	Chhukha	Phuentsholing Booster tank	0.0493	0.0035	0.0507	ND	ND	0.0025	0.0013	ND	ND	ND	0.0155	NT
4	Chhukha	Phuentsholing WTP	ND	BDL	0.0060	0.0007	ND	0.0010	ND	ND	ND	ND	0.0145	NT
5	Chhukha	Tsimalakha water supply tank	0.0658	0.0017	0.0033	0.0005	ND	0.0013	0.0077	ND	ND	ND	0.0883	NT
6	Chhukha	Tsimalakha near Central School	0.0163	**0.0105**	0.0040	ND	ND	0.0013	0.0027	ND	ND	ND	0.0095	NT
7	Chhukha	Kabreytar Treatment Plant (Phuentsholing)	NT	NT	NT	**0.034**	0.036	0.037	0.037	ND	**0.042**	NT	0.073	**0.305**
8	Chhukha	Gedu Treatment plant	NT	NT	NT	ND	ND	ND	ND	ND	ND	NT	ND	ND
9	Dagana	Dagana	0.0267	ND	ND	ND	ND	0.0012	0.0010	ND	ND	ND	0.0127	NT
10	Dagana	Dagapela town	0.0243	0.0002	0.0030	ND	ND	0.0022	0.0015	ND	ND	ND	0.0208	NT
11	Dagana	Dagapela	NT	NT	NT	BDL	BDL	0.001	0.003	ND	0.004	NT	0.008	0.122
12	Gasa	Gasa urban water supply	NT	NT	NT	ND	BDL	0.002	0.005	ND	0.006	NT	0.028	0.158
13	Haa	Haa urban water supply	NT	NT	NT	0.001	BDL	0.001	0.003	ND	0.004	NT	0.011	0.125
14	Lhuentse	Lhuentse treatment plant	NT	NT	NT	ND	BDL	0.001	0.013	ND	0.004	NT	0.008	0.189
15	Mongar	Yankpongang urban water supply	NT	NT	NT	ND	BDL	0	0.02	ND	0.002	NT	0.002	0.106
16	Mongar	Zimzorong urban water supply	NT	NT	NT	ND	BDL	0.006	0.019	ND	0.002	NT	0.015	0.147
17	Panbang	Panbang urban water supply	ND	ND	0.0730	0.0007	ND	0.0013	0.0010	ND	ND	ND	0.0120	NT
18	Panbang	Panbang town	ND	0.0068	0.0737	ND	ND	ND	0.0010	ND	ND	ND	0.0135	NT
19	Pemagatshel	Pemagatshel Hospital	0.0220	ND	0.0215	0.0013	ND	0.0087	ND	ND	ND	ND	0.1490	NT
20	Pemagatshel	PemagatshelTsangtseri	0.0503	0.0023	0.0310	0.0013	ND	0.0063	0.0010	ND	ND	ND	0.0057	NT
21	Pemagatshel	Ngangam town A	NT	NT	NT	ND	BDL	0.001	0.024	ND	0.003	NT	0.004	0.273

22	Punakha	Kabesa source	NT	NT	NT	ND	BDL	0.005	0.008	ND	**0.014**	NT	0.335	**0.458**
23	Samdrupjongkhar	Charkilo source	NT	NT	NT	ND	BDL	0.001	0.031	ND	0.002	NT	0.007	0.161
24	Samdrupjongkhar	Phuntshothang (Samdrupchholing)	NT	NT	NT	BDL	BDL	0.002	0.006	ND	0.004	NT	0.004	0.104
25	Samtse	Tashicholing (Sibsoo)	NT	NT	NT	ND	BDL	0.001	0.001	ND	0.003	NT	0.005	0.135
26	Samtse	Samtse Treatment plant	NT	NT	NT	ND	BDL	0.002	0.001	ND	0.003	NT	0.029	0.085
27	Samtse	Gomtu urban water supply	NT	NT	NT	ND	BDL	0.001	0.003	ND	0.002	NT	0.011	0.069
28	Sarpang	Sarpang urban water supply	ND	0.0055	0.0050	0.0005	ND	ND	ND	ND	ND	ND	0.1393	NT
29	Sarpang	Lodrai source	NT	NT	NT	ND	BDL	0.001	0.001	ND	0.001	NT	0.001	ND
30	Thimphu	Gidakom Reservoir tank	0.0477	ND	0.0045	0.0008	ND	0.0040	0.0030	ND	ND	ND	0.1280	NT
31	Thimphu	Jangsa Treatment Plant	NT	NT	NT	ND	BDL	0.004	0.002	ND	0.004	NT	0.022	0.101
32	Thimphu	Motithang Treatment Plant	NT	NT	NT	BDL	0.01	0.003	0.006	ND	0.005	NT	0.011	**0.337**
33	Thimphu	Jungshina Treatment Plant	NT	NT	NT	BDL	BDL	0.003	0.004	ND	0.005	NT	0.031	0.215
34	Trashigang	Kanglung college	0.0917	ND	ND	0.0005	ND	0.0012	0.0027	ND	ND	ND	0.0137	NT
35	Trashigang	Wamrong town	0.0210	ND	0.0425	0.0005	ND	0.0015	0.0030	ND	ND	ND	0.1325	NT
36	Trashigang	Trashigang Treatment Plant	NT	NT	NT	ND	BDL	0.001	0.008	ND	0.003	NT	0.004	0.175
37	Trashigang	Rangjung Treatment Plant	NT	NT	NT	ND	BDL	BDL	0.016	ND	0.002	NT	0.136	0.093
38	Trashiyangtse	Trashiyangtse	NT	NT	NT	ND	BDL	0	0.017	ND	0.004	NT	0.018	0.089
39	Trongsa	Trongsa Treatment plant	NT	NT	NT	BDL	BDL	0.001	0.012	ND	0.004	NT	0.019	0.186
40	Tsirang	Damphu Treatment Plant	NT	NT	NT	ND	BDL	0.004	0.011	ND	0.008	NT	0.444	0.118
41	Wangdiphodrang	Bajo Treatment Plant	NT	NT	NT	ND	BDL	0.001	0.021	ND	0.003	NT	0.01	0.209
42	Zhemgang	Yebilaptsa Hospital	0.0623	**0.0108**	0.0185	ND	ND	0.0012	0.0043	ND	ND	ND	0.0177	NT
43	Zhemgang	Zhemgang Treatment Plant	NT	NT	NT	ND	BDL	0.001	0.007	ND	0.005	NT	0.018	0.108
44	Zhemgang	Tingtibi Treatment Plant	NT	NT	NT	ND	BDL	0.001	0.004	ND	0.004	NT	0.206	0.151

2. Rural Drinking Water Quality Monitoring (RDWQM)

2.1. Overall status

RDWQM is carried out bi-annually (once in February-March and once in July-August) by 255 health centers from across the country. Unlike urban drinking water quality monitoring, currently only Escherichia Coli (E. Coli), appearance and odor are monitored for rural drinking water quality monitoring. E. Coli is tested using 3M Petrifilm E.Coli test kit.

2.2. Report

A total of 1854 samples were collected and tested for E. Coli. Out of which almost 65.32 % is found safe. From the unsafe samples, 31.28% is of low health risk category, 3.34 % is intermediate to high health risk and 0.05% were grossly polluted(Detailed health risk category of the samples are shown in figure 9). Most of the samples are found unsafe in wet season as depicted in *figure 9* and *table 5*

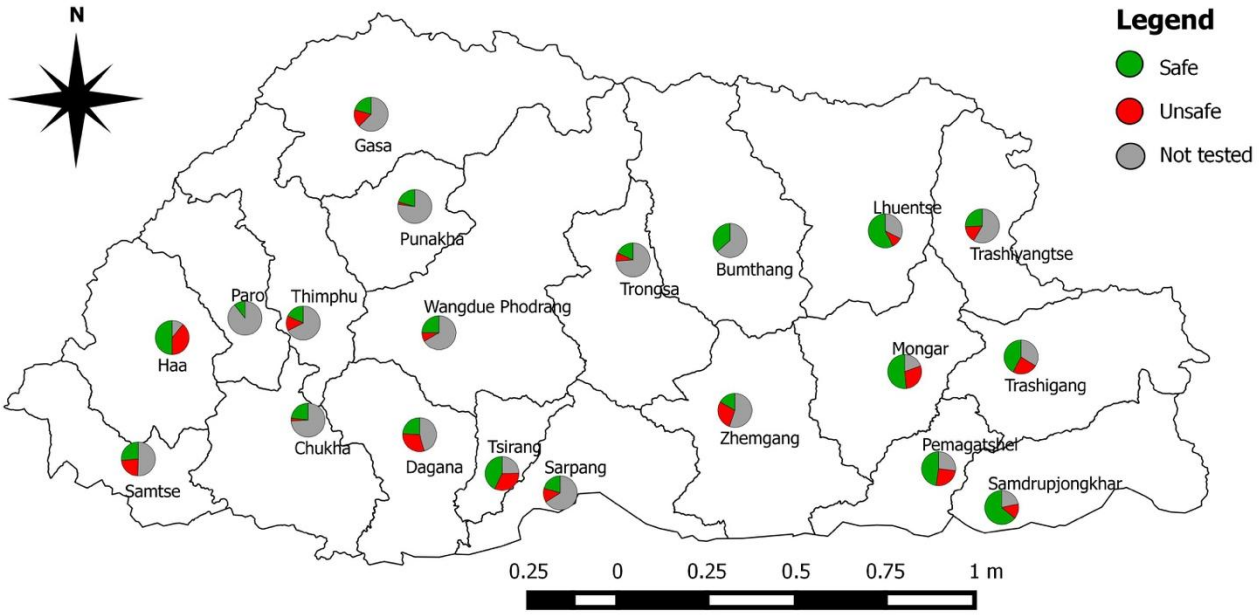


Figure 9: Overall rural drinking water quality in terms of Thermotolerant coliform at dzongkhag level

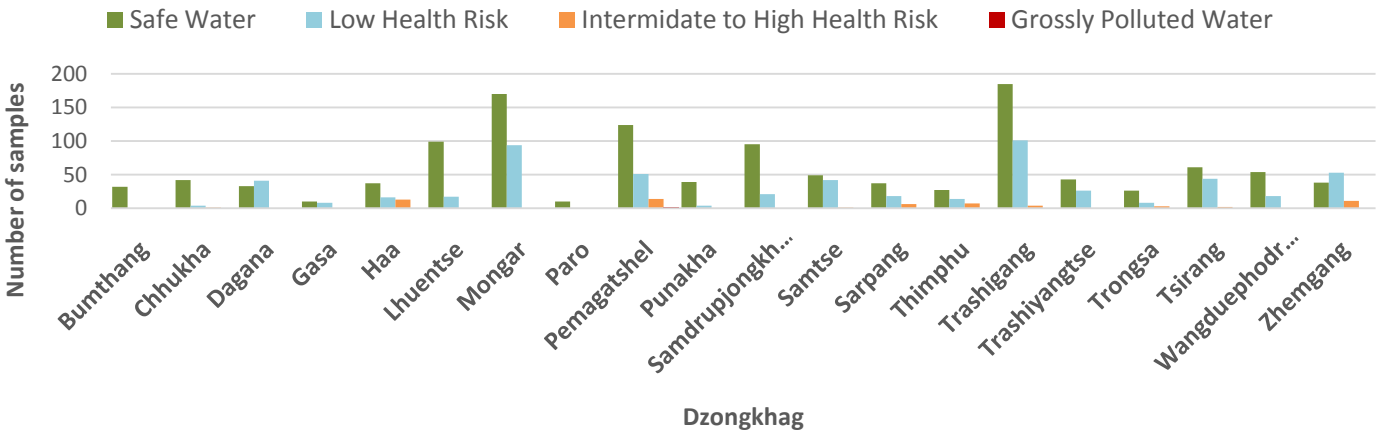


Figure 10: Health risk category of the water quality results from different dzongkhags

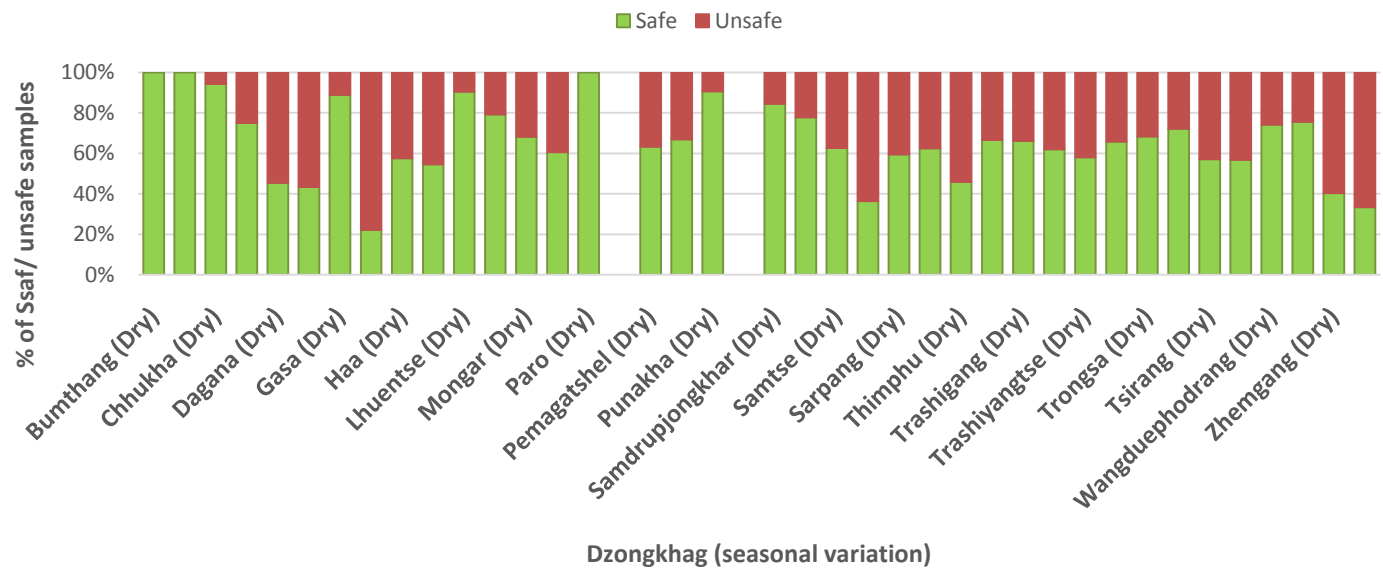


Figure 11: Seasonal variation of rural drinking water quality

Table 5: Seasonal variation of water quality in rural area

Sl. No.	Dzongkhag	Safe (Wet)	Unsafe (Wet)	Safe (Dry)	Unsafe (Dry)
1	Bumthang	12	0	20	0
2	Chhukha	9	3	33	2
3	Dagana	13	17	20	24
4	Gasa	2	7	8	1
5	Haa	18	15	19	14
6	Lhuentse	42	11	57	6
7	Mongar	80	52	90	42
8	Paro	0	0	10	0
9	Pemagatshel	69	34	55	32
10	Punakha	0	0	39	4
11	Samdrupjongkhar	35	10	60	11
12	Samtse	12	21	37	22
13	Sarpang	15	9	22	15
14	Thimphu	16	8	11	13
15	Trashigang	103	63	82	42
16	Trashiyangtse	25	13	18	13
17	Trongsa	13	5	13	6
18	Tsirang	29	22	32	24
19	Wangduephodrang	31	10	23	8
20	Zhemgang	15	30	23	34

3. Limitation of the report

1. All the data are collected from Water Quality Monitoring Information System (WaQMIS)

2. Some health centers have not reported consistently
3. Some dzongkhags have more health centers and consequently more sampling stations compared to other districts.
4. Some of the water monitoring sites have private water sources (eg.in some schools). This report includes all the water samples monitored by surveillance sites both urban water supply and private water supplies.

4. Issues and recommendation:

1. Some of the treatment facilities are not utilized and are bypassed due to increased demand from the consumers (eg.LhuentseWTP, Mongar WTP, Trashiyangtse WTP and Haa WTP)

Figure 12: Underutilized treatment plants

Recommendation: There is need to make optimum use of all the treatment plant facilities to improve existing water quality.

2. Most of the caretakers handling water treatment plants are not trained to operate treatment plant and many of them do not have minimum required qualification *(Annex1).*

Figure 13: pipelines laid out through storm water drain and abandoned chlorination tank

Recommendation: minimum training must be provided to all the water caretakers in handling chlorine and performing treatment.

3. There is no action taken on the report submitted to dzongkhags from surveillance body.

   Recommendation: see recommendations under section 4.1

4. Operational monitoring is not conducted in most of the treatment plant.

   Recommendation: It is important to conduct operational monitoring of all the water treatment plants to improve water quality supplied to the consumer.

4.1. Recommendations from WaterCaRD (Water Capacity Rating Diagnostic) Assessment

To improve the drinking water quality surveillance, a assessment was carried out using a n assessment tool called WaterCARD. This assessment includes a more detailed review of water quality surveillance and associated remedial responses to strengthen understanding and inform action planning. It was applied to examine water quality testing practices, monitoring record reviews, sanitary inspections, and data management and use.

From the assessment there are some critical recommendations as follows:

a) Elevated E. coli levels in municipal distribution systems should always be compared against free chlorine levels. Adequate free chlorine levels in the distribution systems (greater than or equal to 0.2 mg/L should significantly reduce the noted thermotolerant bacteria levels).
b) Free chlorine levels in municipal distribution systems should be closely monitored.
c) District hospitals should share their water quality surveillance data with municipalities on a regular basis.
d) The linking of RCDC's and MoWHS' databases should be linked as reportedly planned. In addition, coordination meetings on a regular basis at the district level between at a minimum district water engineer(s) and district hospital Water Quality lab contact/lead are recommended.
e) Enforcement actions should be prioritized based on potential impact to public health. Recommend that all WQ problem-related remedial actions taken in response to noncompliance with the 2016 drinking water standard be documented in writing at a

minimum in a logbook. It should be formally clarified which institution will be responsible for water quality enforcement actions. Regular meetings among agencies implementing water quality surveillance would be useful to coordinate related outreach approaches. The BDWQS 2016 states that the NEC Secretariat shall: "Coordinate meetings among the implementing agencies for the effective implementation of the standard at least once a year."

f) Regular sharing of municipal WTP operational data with district hospitals will allow the district hospital to observe the lack of chlorine testing.

g) District level coordination meetings on a regular basis between at a minimum district water engineer(s) and district hospital Water Quality lab contact/lead to discuss such issues are recommended.

5. Annex1: Urban Water Treatment Plant details

Urban Drinking Water Treatment Plants									
Sl.no	Dzongkhag	Source type	Treatment type		Operational Monitoring	Disinfection by Chlorine	Availability of resources (equipment/human resource)		
			Sand filter	Sedimentation tank			Turbidity meter	Chlorine meter	Trained caretaker (Chlorination)
1	Lhuntse	Stream	Yes	No	No	No	No	No	No
2	Mongar	Stream	Yes	Yes	Yes	Yes	Yes	No	Yes
3	Trashiyangtse	Stream	Yes	No	No	No	No	No	No
4	Rangjung	Stream	Yes	No	Yes	Yes	No	Yes	Yes
5	Trashigang	Stream	Yes	Yes	Yes	Yes	Yes	Yes	No
6	Kanglung	Stream	No	No	No	No	No	No	No
7	Wamrong	Stream	No	No	No	No	No	No	No
8	Pemagatshel	Stream	No	No	No	No	No	No	No
9	Bangtar	Stream	No	Yes	No	No	No	No	No
10	S/Jongkhar	Stream	No	No	Yes	Yes	No	No	No
11	Nganglam	Stream	No	No	No	No	No	No	No
12	Punakha	Stream	Yes	Yes	No	No	No	No	No
13	Gasa	Spring	No	No	No	No	No	No	No
14	Gidakom	Stream	No	Yes	No	No	No	No	No
15	Haa	Stream	Yes	Yes	No	No	No	No	No
16	Paro	River	No	Yes	Yes	Yes	Yes	Yes	No
17	Tsimalakha	Stream	No	Yes	No	No	No	No	No
18	Chukha	Stream	No	Yes	No	No	No	No	No

19	Gedu	Stream	Yes	Yes	No	Yes	No	No	No
21	Phuntsholing, South Treatment Plant	Stream	Yes	Yes	Yes	Yes	No	No	No
22	Phuntsholing, Kabreytar	Stream	Yes	Yes	Yes	Yes	No	No	Yes
23	TrashiChholing, Sibsu	Stream	No	No	No	Yes	No	No	No
24	Samtse	River	Yes	Yes	Yes	Yes	Yes	No	Yes
25	Gomtu	Stream	Yes	Yes	Yes	Yes	No	No	Yes
26	Wangdue	Stream	Yes	Yes	Yes	Yes	Yes	Yes	Yes
27	Trongsa	Stream	Yes	Yes	No	Yes	Yes	Yes	Yes
28	Zhemgang	Stream	Yes	Yes	Yes	Yes	No	No	No
29	Panbang (BHU-I)	Stream	No	No	No	No	No	No	No
30	Panbang (Market)	Stream	No	No	No	No	No	No	No
31	Yebilaptsa (Hospital)	Stream	No	No	No	No	No	No	No
32	Yebilaptsa (Tingtibi)	Stream	Yes	Yes	No	Yes	No	No	Yes
33	Damphu	Stream	No	No	No	No	No	No	No
34	Dagapela (Hospital)	Stream	No	No	No	No	No	No	No
35	Dagapela (Market)	Stream	No	No	No	No	No	No	No
36	Dagana	Stream	Yes	Yes	Yes	Yes	Yes	Yes	Yes
37	Gelephu (Lodrai)	Stream	Yes	Yes	Yes	Yes	Yes	Yes	Yes
38	Gelephu (Mao Khola)	River	Yes	Yes	Yes	Yes	Yes	Yes	Yes
39	Sarpang	Stream	No	Yes	No	Yes	Yes	Yes	Yes