National Guideline for Drinking Water Quality Surveillance, First edition, 2019

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Department of Public Health
Ministry of Health
PO Box 667, Serbithang,
Thimphu, Bhutan
Tel: (+975) 02-323317 Fax: (+975) 02-332464
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1 Table of Content

Foreword

Abbreviations and definitions

BHU-Basic Health Unit

Bhutan Drinking Water Quality Standard: means rules established to control the level of contamination in drinking water in the prescribed standard conditions.

DHO-District Health Officer

Drinking water: means water that is suitable for human consumption such as drinking and cooking. It is also called potable water.

Monitoring: means routine collection of water samples for analysis to determine water quality

MoWHS: Ministry of Works and Human Settlement

NEC: National Environment Commission

NWRL: National Water Reference Laboratory

Operational monitoring: means routine collection and testing of water samples and/or visual inspection of the water supply system to ensure the functionality of the system by the water service providers.

RCDC: Royal Centre for Disease Control

RDWQMS: Rural Drinking water quality monitoring system

Rural water supply system (RWSS): means domestic water supply systems that provide water to rural areas which are designed and constructed to RWSS standards.

Rural: means any area or settlement outside the declared municipal boundary.

Safe drinking water: means water with microbial, chemical and physical characteristics that meet Bhutan Drinking Water Quality Standard (BDWQS) on drinking water quality.

SMS reporting system: means a data reporting system through the SMS technology of the mobile phone services.

SOP: Standard Operating Procedure

Surveillance body: means the Ministry of Health, more specifically the RCDC, District hospitals, and Basic Health Units.

Surveillance: means a process of checking if monitoring of drinking water supplies conforms to the BDWQS conducted by the surveillance body and may include sanitary inspection, water monitoring, data processing, and analysis and reporting.

The Water Safety Plan (WSP): means effective ways of consistently ensuring safe drinking water supply through a risk assessment and risk management approach to a water supply chain, beginning from its catchment to consumer point.

Thromde: means a municipality declared by the Parliament.

UDWQMS-Urban drinking water quality monitoring system

Urban water supply system (UWSS)**:** means a system where water is abstracted from various sources and processed through different treatment units to make water clean, safe and compliant to the BDWQS and distributed to the urban area through piped network.

Urban: means any area or settlement within the declared municipal boundary.

Water service providers: means any person or entity, government or private company responsible for source development, water abstraction, treatment and distribution of water. Such entities include the Thromdes, the Dzongkhag Administration and the communities in the rural areas.

WHO:World Health Organization

HEALTH: Water Quality Monitoring Information System

WUA: Water Users' Association: Association formed as Section 50 of water Act 2011. WUA are not governed by Civil Society Organization (CSO) Act of Bhutan.

2 Introduction

With the enactment of **Water Act of Bhutan, 2011**, Ministry of Health is mandated to look after the drinking water quality in the country. The Royal Centre for Disease Control (RCDC) under Ministry of Health is the lead institution to manage the testing and monitoring of drinking water quality.

Drinking water quality monitoring plays a vital role to provide safe drinking water to the consumer. The quality of drinking water supplied to the consumers must be verified to meet the maximum permissible value as mentioned in the **Bhutan Drinking Water Quality Standard, 2016**. Monitoring is required to be carried out by the water service providers (*Operational monitoring*) and the surveillance agency (*Compliance monitoring*).

Though these activities are being carried out on a routine basis by the water service providers and the surveillance body there is no proper system of information sharing. This limits the stakeholders to provide intervention measures to supply safe drinking water to the consumer. Therefore the "**National Guideline for Drinking Water Quality Monitoring"** aims to overcome this problem and establish a proper working modality and information sharing among all the stakeholders.

Further the guideline will also provide guidance to the surveillance agency to standardize all the procedures carried out in the laboratory such as sample collection, preservation, transportation, testing and reporting.

3 Aim and Objectives

Aim

To provide clear guidance to the key players to ensure safe drinking water through the implementation of BDWQS 2016.

Objectives

1. Provide guidance to carry out drinking water quality surveillance in both urban and rural drinking water supplies.
2. Provide guidance to operational monitoring in urban drinking water supply system.
3. Define roles and responsibilities of all the key players.
4. Define various levels of reporting and feedback system.
5. Advocacy at various levels of relevant key players on drinking water quality.

4 Key players and their Roles & Responsibilities

4.1 Ministry of Health

4.1.1 Royal Centre for Disease Control (RCDC)

National Water Reference Laboratory (NWRL) under RCDC is responsible for ensuring regular testing and reporting of drinking water quality in the urban and the rural areas in the country. The laboratory provides surveillance reports to water service providers to improve drinking water quality and also to the health care providers for advocacy. Following are the roles and responsibilities of NWRL:

1. Monitor drinking water quality in Thimphu Thromde as required by BDWQS, 2016 or as and when required.
2. Provide support and technical assistance to the health centres to carry out drinking water quality surveillance.

3. Assess and certify the technical competency of drinking water quality testing laboratories.
4. Carry out pre-feasibility water quality testing for any new sources for the Urban and peri-urban centers.
5. Verify and validate the reports submitted to RCDC from health centres within two weeks from the date of reporting.
6. Follow up with non reporting health centres.
7. Analyse and generate report for urban DWQM on quarterly basis and disseminate the report through RCDC quarterly disease surveillance bulletin.
8. Analyse and generate report for rural DWQM annually and disseminate report to PHED and district administration.
9. Analyse and generate annual report on drinking water quality and submit to NEC.
10. Event report on water quality to Water and Sanitation Division, MoWHS (for urban water) or PHED, MoH (for rural water).
11. Manage and monitor Water Quality Monitoring Information System (WAQMIS).
12. Provide help and support to the WAQMIS registered users.

4.1.2 Regional Referral Hospital/District Hospital/BHU I*[1]

There is no dedicated laboratory for monitoring drinking water quality for the urban areas in the districts, therefore, the activity is carried out by the medical laboratories under the Regional Referral Hospital, District Hospital and some BHU-I. The laboratories are responsible for conducting the test on a routine basis (monthly) and enter the data into WAQMIS. Detailed responsibilities are as follows:-

4.1.2.1 Laboratory

1. Carry out drinking water quality testing once a month.

[1] BHU I*- BHU I included in UDWQMS

2. Enter the water quality data of every month into the Water Quality Monitoring Information System (WAQMIS) latest by 7th day of next month.
3. For routine samples, disseminate water quality test reports immediately to the water service providers (through email/printout).
4. For samples other than routine samples, disseminate report to respective beneficiaries immediately (through email/printout).
5. Carry out pre-feasibility water quality testing for any new source/scheme upon request.
6. Ensure standard testing equipment are in place/available.
7. Provide water quality testing support to other health facilities upon request.
8. Proper use and care of equipment (Develop SOP for care and use of equipment and maintain equipment log book)
9. Seek technical support from RCDC as and when required.
10. During suspected water borne disease outbreak provide support if required.

4.1.2.2 Administration (Laboratory Incharge/ DMO/CMO/MS)

1. Ensure that health center under its jurisdiction are carrying out the drinking water quality surveillance as per the schedule.
2. In case of non compliance the relevant agency must be notified to rectify and improvise drinking water quality.
3. Prepare annual indent for reagents and equipment for water quality testing based on need.
4. Take necessary action during equipment breakdown.
5. Appoint focal person to carry out drinking water quality testing.
6. Notify RCDC during transfer of water quality testing focal person.

NOTE:- Actions are taken by relevant administrative official.

Limitations:

1. Testing should be conducted for the samples meant for drinking purpose only.
2. Testing should not be carried out for the samples meant for commercial purpose.
3. Laboratory should not issue certificate on quality of drinking water.

4.1.3 BHU I**[2]/BHU II/CHU/RHU/Sub-post

There is no dedicated laboratory for monitoring drinking water quality for the rural areas in the districts, therefore, the activity is carried out by the health workers in BHU-I, BHU-II, CHU, RHU and Sub-post. They are responsible for conducting the test on a routine basis and enter the data into WAQMIS. Detailed responsibilities are as follows:-

1. Undertake water quality testing at least once a year. If possible twice in a year (February-March and July-August)[3].
2. Carry out water quality testing for any new source upon request.
3. Carry out advocacy and awareness programmes on safe drinking water as and when feasible.
4. Prepare annual indent for reagents and equipment for water quality testing based on need.
5. For routine samples, disseminate water quality test reports immediately to the Gewog Administration.
6. For samples other than routine samples, disseminate report to respective beneficiaries immediately.
7. Submit the water quality report latest by 7th April for February-March testing and 7th September for July-August testing.

[2] BHU I**-BHU I included in RDWQMS

[3] To evaluate the quality variations with seasonal change

8. Ensure availability of standard testing reagents and equipments.
9. Develop SOP for care and use of equipment and maintain equipment log book.
10. Seek technical support from RCDC if required.
11. During suspected water borne disease outbreak provide support if required.

Limitation:

1. Testing should be conducted for the samples meant for drinking purpose only.
2. Testing should not be carried out for the samples meant for commercial purpose.
3. Health facility should not issue certificate on quality of drinking water.

4.1.4 Public Health Engineering Division

The Rural Water Supply and Sanitation Programme under Public Health Engineering Division (PHED) was started in 1974 with the mandate to provide safe drinking water supply to all rural areas in the country. Till 1995 the program was funded by UNICEF for procurements of hardware material and SNV has provided with technical assistance since 1989 onwards in developing the capacity within national engineers. In 1998 the RWS Programme was transferred to the Ministry of Health from the Ministry of works & Human Settlement in view of the advantageous position Health was in to mobilize funds and accelerate its implementation by involving the health workers at the grassroots level. Above all the transfer was anticipated to have a much greater impact on the health of the people as water and sanitation is one of the basic components of the primary health care.

Now Rural Water Supply programme under PHED plays a vital role to facilitate Dzongkhags and Gewogs to achieve universal access to safe and adequate drinking water. Further, RWS programme helps to sustain functionality of water supply scheme above 95% for all time. The following are roles and responsibilities to improve the drinking water quality:

1. To conduct capacity building which includes trainings on RWS surveying and designing, Water Safety Plan (WSP) and water caretaker;
2. Verify reports from surveillance agency and advice dzongkhag engineers and WUA/WSP team for the corrective measures such as source improvement, repairing of Ferro Cement tanks, fixing leaking plumbing etc. if necessary;
3. To research, develop and promote alternative technologies to improve the quality of drinking water;
4. To ensure quality construction of RWS schemes carried out by dzongkhags;
5. To compile and maintain Geog based Rural Water Supply MIS annually;
6. Ensure to involve health workers to carry out water quality testing for any new water source/schemes.

4.2 Ministry of Work and Human Settlement

4.2.1 Water and Sanitation Division (Department of Engineering Services)

The Water and Sanitation Division (Department of Engineering Services) looks after the provision of safe and affordable drinking water, adoption of measures to combat the impacts of climate change on drinking water, protection of environment and health by establishing sustainable waste water and solid waste management systems in every Bhutanese town.

Roles and Responsibilities in Drinking Water Quality:

1. Operational monitoring of water quality within urban drinking water supply systems.
2. Provide water quality testing kits and related trainings to Engineers, technicians, and water caretakers.
3. Maintain and update inventory on water infrastructure and quality (Water and Sanitation Information System-WaSIS)

4. Assist urban drinking water suppliers in development and implementation of WSPs.
5. Monitor and evaluate WSPs of Urban Water Suppliers.
6. Carry out advocacy and awareness programmes on safe drinking water.
7. Provide technical backstopping in planning and designing infrastructure for providing safe drinking water.
8. Coordinate with MoH (RCDC and PHED) and NEC on issues related drinking water quality.
9. Provide and assist in developing SOPs for operational monitoring of urban drinking water supply systems.
10. Ensure safe drinking water to all consumers in Bhutan.

4.3 District Administration

4.3.1 District Health Office

Dzongkhag Health Sector is collecting annual data on drinking water such as coverage of RWSS, Functionality of tap and submission of the data to HMIS and more over doing data analysis at Dzongkhag level and developing our own strategies to overcome the burden. Health Sector also conducts awareness and sensitization on importance of safe drinking water during Dzongkhag Tshogdu. Specifically Dzongkhag Health Sector is carrying out following activities to improve the drinking water quality.

1. Ensure that all health centers within its jurisdiction are carrying out the drinking water quality surveillance as per the schedule.
2. In case of non compliance the relevant agency must be notified to rectify and improvise drinking water quality.
3. The overall drinking water quality report must be presented and discussed during annual review cum planning meeting with health workers and take necessary interventions if required.

4. Create advocacy/awareness programs to relevant key personals and agencies in Dzongkhag Tshogdu/Public meeting.

4.3.2 Water Service Providers

4.3.2.1 Urban Drinking Water Service Providers (Thromde/Municipality)

The water supply section under the infrastructure division of Thimphu Thromde is responsible to provide and ensure safe, adequate, affordable and supply of potable water to promote and sustain health, happiness, economic growth and prosperity of the residents of Thimphu Thromde at all times.

Similarly the activities in the districts are carried out by the Thromde and Municipal in their respective dzongkhags. Following are the main roles and reponsiblities for Thromde and dzongkhag municipalities:

1. Ensure operational monitoring of drinking water supply system is carried out as reflected in BDWQS 2016.
2. In case of non compliance a mitigation measure must be implemented and inform surveillance body for retest the samples to ensure safe drinking water.
3. Ensure to involve health workers to carry out water quality testing for any new water supply schemes.
4. Maintain and update inventory on water infrastructure and quality (Water and Sanitation Information System-WaSIS)
5. Develop and implement WSPs for all drinking water supply system.
6. Coordinate with MoWHS and RCDC on issues related drinking water quality.
7. Prepare SOPs for operational monitoring of urban drinking water supply systems.
8. Coordinate with surveillance body to monitor urban drinking water quality at random household at least once in a year.

4.3.2.2 Rural Drinking Water service providers (Community: WUA/ WSP team)

In line with the government's decentralisation policy, the procurement of RWSS materials was fully decentralize to Dzongkhags. PHED and Dzongkhag Engineer Sector provides technical support in developing RWSS and also monitors all the RWSS new construction and maintenance works. However WUA and WSP team plays vital role in providing safe and adequate drinking water at consumer level. The following are their main roles and responsibilities:

1. To conduct capacity building which includes trainings on RWS surveying and designing, Water Safety Plan (WSP) and water caretaker;
2. Verify reports from surveillance agency and advice dzongkhag engineers and WUA/WSP team for the corrective measures such as source improvement, repairing of Ferro Cement tanks, fixing leaking plumbing etc. if necessary;
3. To research, develop and promote alternative technologies to improve the quality of drinking water;
4. To ensure quality construction of RWS schemes carried out by dzongkhags;
5. To compile and maintain Geog based Rural Water Supply MIS annually;
6. Ensure to involve health workers to carry out water quality testing for any new water source/schemes.

4.3.2.3 District Administration/Gewog Administration

Dzongkhag Engineer Sector provides technical support in developing RWSS and also monitors all the RWSS new construction and maintenance works. Sector also carry out the training on Water safety plan to community people at Dzongkhag level when fund is provided by PHED, Ministry of Health.

1. In case of non compliance a mitigation measure must be implemented to ensure safe drinking water;

2. Ensure to involve health workers to carry out water quality testing for any new water supply schemes;
3. Maintain and update inventory on water infrastructure and quality (Rural water supply monitoring Information System;
4. Coordinate with PHED and RCDC on issues related drinking water quality.

4.4 National Environment Commission

Water Resources Coordination Division (WRCD)

The WRCD is the Apex body on water resources in terms of coordination and regulation of water resources issues. The Division is among others, vested with the mandates of water quality monitoring, development of appropriate standards, and coordination of the management of water resources in accordance with relevant laws, policies and regulation of the kingdom of Bhutan.

Roles relevant to the current guideline:

1. Ensure implementation and enforcement of the drinking water quality standard.
2. Review and revise, as needed the, drinking water quality standard in consultation with relevant stakeholders.
3. Take necessary action against non compliant cases forwarded by the Surveillance body.
4. Publish and disseminate annual report on national drinking water quality.
5. Coordinate meetings at least once a year among the key agencies for the effective implementation of the standard.
6. Encourage and support programmes to enhance technical capacity in managing drinking water quality.

4.5 UDWQMS Data Flow & Feedback Mechanism

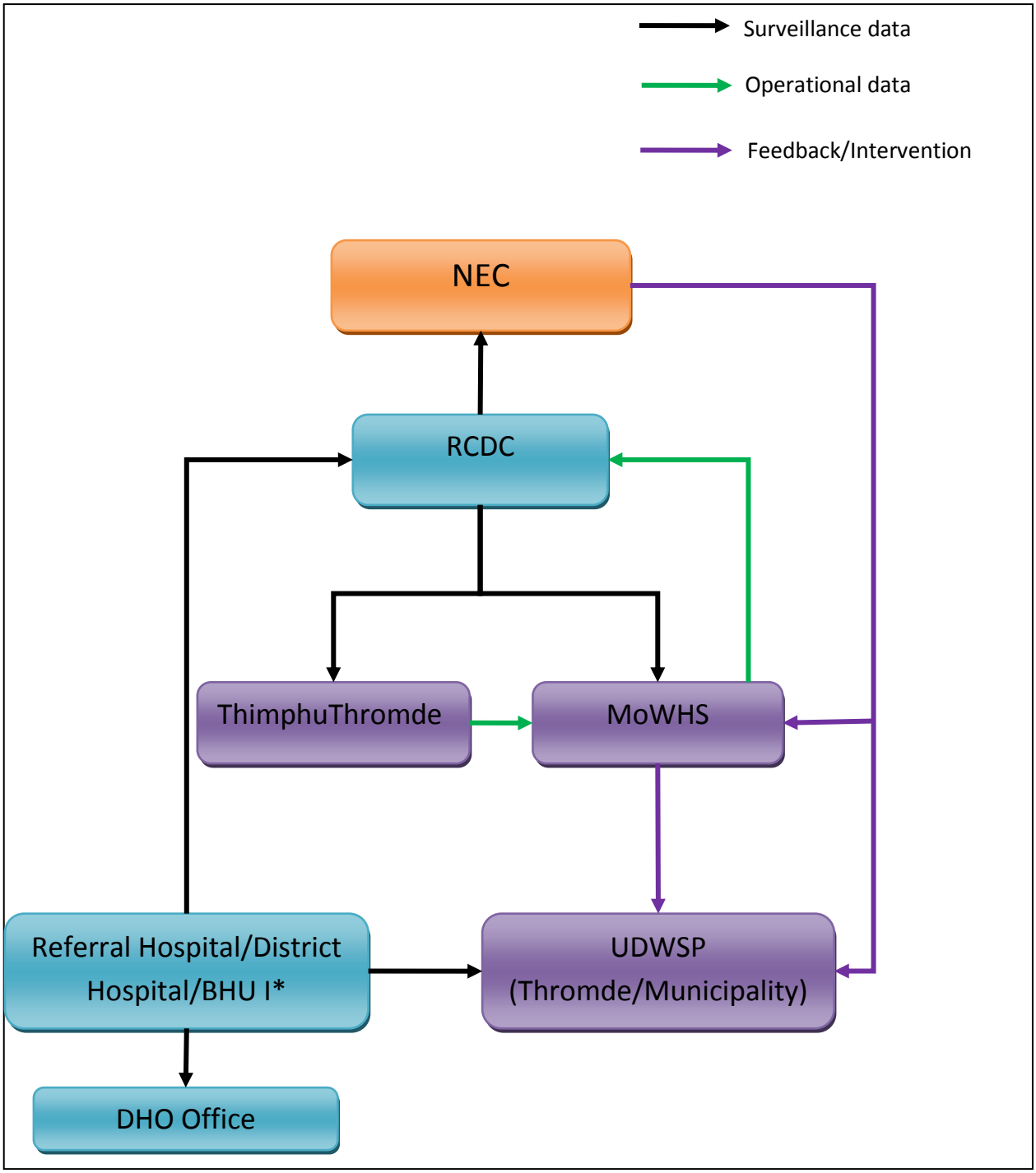

Figure 1: Urban Drinking Water Quality monitoring data flow and feedback mechanism

4.6 RDWQMS Data Flow & Feedback Mechanism

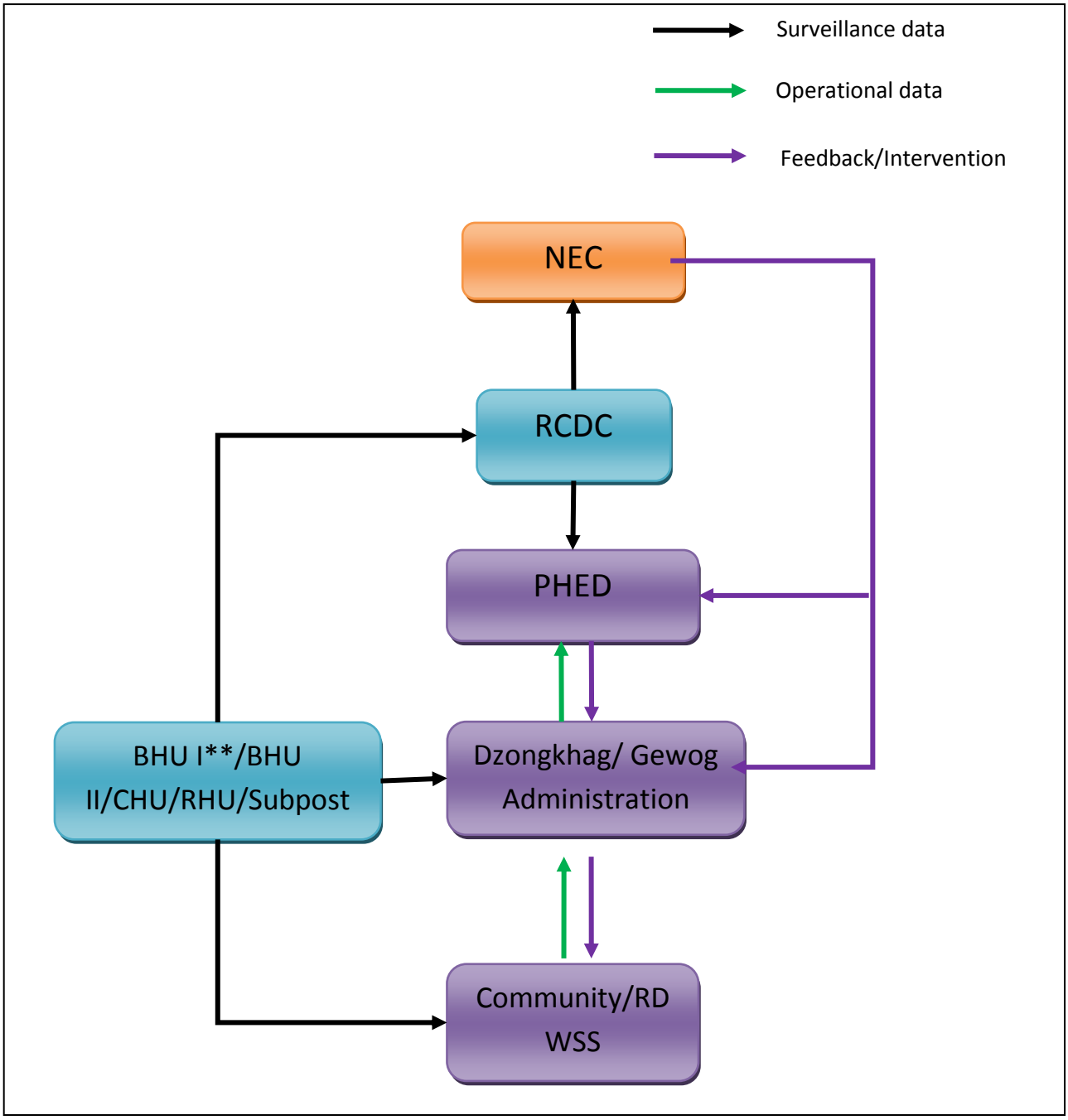

Figure 2: Rural Drinking Water Quality Monitoring data flow and feedback mechanism

5 The Surveillance System

The Drinking Water Quality Surveillance is divided into two categories, Urban Drinking Water Quality Monitoring System (UDWQMS) and Rural Drinking Water Quality Monitoring System (RDWQMS). The UDWQMS covers all the urban and some peri-urban towns where the drinking water is supplied by the Thromde or municipalities. The RDWQMS covers all the rural areas where the drinking water is supplied through Rural Water Supply System (RWSS).

5.1 Urban Drinking Water Quality Monitoring System (UDWQMS)

Table 1: UDWQMS Table of parameters and the guideline values

Characteristics	Sl.No	Parameter	Unit	Guideline value	Test to be conducted by
Physical Parameters	1	Colour (TCU)	Hazens Unit	15	District laboratories
	2	Odour	-	non-objectionable	District laboratories
	3	pH	-	Acceptable range 6.5 – 8.5	District laboratories
	4	Taste	-	non-objectionable	District laboratories
	5	Turbidity	NTU	5	District laboratories
General Chemical Parameters causing undesirable effect	1	Calcium	mg/L	No permissible limit but recommended < 75	RCDC
	2	Free Residual Chlorine	mg/L	Target range 0.2 – 0.5	District laboratories
	3	Iron	mg/L	No permissible limit but recommended < 0.3	RCDC
	4	Manganese	mg/L	0.4* Maximum permissible limit	RCDC
	5	Sulphate	mg/L	No permissible limit but recommended < 250	RCDC
Chemical parameters of health concern	1	Fluoride (to be tested for ground and spring water only)	mg/L	1.5	RCDC
	2	Nitrates	mg/L	50	RCDC
	3	Arsenic	mg/L	0.01	RCDC
	4	Lead	mg/L	0.01	RCDC
	5	Mercury	mg/L	0.006	RCDC
Microbiological parameter	1	E.Coli	CFU/100ml sample	0	District laboratories

5.1.1 Criteria for selection of sampling stations

- ✓ All sampling stations should be within urban areas (check with the dzongkhag for boundary demarcation).
- ✓ The sampling station must be selected from all distribution network for urban drinking water supply (some urban centers have more than one distribution network).
- ✓ All the sampling stations should be fixed.
- ✓ Stations must be selected where there is high concentration of population.
- ✓ Sampling stations must be uniformly distributed within the urban area.

NOTE:

- ✓ *The health facility must contact RCDC to add or delete sampling stations.*
- ✓ *If any new drinking water supply scheme is established notify RCDC to add sampling station in the system.*

5.1.2 Frequency of Monitoring

- ✓ For routine samples, sampling and testing should be carried out on monthly basis (Refer Table 2).
- ✓ For samples other than routine samples should be carried out as and when required.
- ✓ Sources and reservoir should be monitored upon request and if there is contamination in the tap point.

Table 2: Frequency of Monitoring for various Parameters

Sl.No	Parameter	Monitoring Frequency
1	Colour (TCU)	Monthly
2	Conductivity	Monthly
3	Odour	Monthly
4	pH	Monthly
5	Taste	Monthly
6	Turbidity	Monthly
7	Calcium	Yearly
8	Free Residual Chlorine[4]	Monthly
9	Iron	Yearly
10	Manganese	Yearly
11	Sulphate	Yearly
12	Fluoride (applicable to ground and spring water only)	Yearly
13	Nitrate	Yearly (where surface water source is vulnerable to nitrate sources, frequency to be at least half yearly)
14	Arsenic (applicable to ground water only)	Yearly
15	*E. coli*	Monthly

[4] Monitor only in systems using chlorine as disinfectant

5.1.3 Sample Collection, Preservation, Transportation and Processing

5.1.3.1 Collection and labeling

- ✓ Before collecting sample make sure appropriate form is filled to collect the details of sample collection (*Annex 1*).
- ✓ SOP should be followed to collect water sample. Detailed instruction for sample collection analysis is given in *Annex 2*.

5.1.3.2 Preservation and transportation

- ✓ Sample transported from sampling point to the laboratory at required temperature is necessary to obtain a quality result.
- ✓ SOP must be followed to preserve and transport water sample. Detailed instruction for sample storage and transportation is given in *Annex 3*.

5.1.3.3 Bacteriological testing

- ✓ The greatest risk to public health from microbes in water is associated with consumption of drinking-water that is contaminated with human and animal excreta, although other sources and routes of exposure may also be significant5. Therefore bacteriological assessment must be carried out on routine basis. For UDWQMS membrane filtration technique is followed to assess Thermotolerant coliforms.
- ✓ Membrane-filtration method gives a direct count of Thermo tolerant coliforms present in a given water sample.
- ✓ SOP must be followed to carry out bacteriological testing for water sample. Detailed instruction for membrane filtration technique is given in *Annex 4*.

5.1.3.4 Physio-chemical testing

- ✓ The physico-chemical tests for routine monitoring includes pH, residual chlorine, turbidity, total dissolved solid, conductivity, colour and odor.

[5] WHO Guidelines for Drinking-water Quality fourth edition, 2011

- ✓ The appearance, taste and odour of drinking-water should be acceptable to the consumer.
- ✓ SOP must be developed and followed to carry out all the procedures for physio-chemcal testing. Detailed instructions to carry out testing are given in *Annex-5*

5.1.3.5 Chemical testing

- ✓ District laboratories which do not have capacity to carry out chemical testing should preserve the sample following protocols given in *Annex 2* and Annex 3 and ship the sample to RCDC.
- ✓ RCDC should carry out the chemical testing for the samples received from the districts
- ✓ RCDC must develop SOP and must be followed to carry out all the chemical tests. All methods must comply with Standard Methods for the Examination of Water and Wastewater *(Joint publication by the American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF)).*

Limitations

- ✓ Should not carry out testing for the water meant for commercial purpose (bottled water).
- ✓ Should not certify the quality of drinking water.
- ✓ Should not carry out testing for the samples not meant for drinking purpose.

5.1.4 Data management and reporting

1. RCDC has developed water quality monitoring information system.

2. All the reports submitted from district hospitals will be shared with UDWS, DHO and RCDC;
3. Operational monitoring data of UDWS will be accessible to MoWHS via WaSIS;
4. RCDC shall share surveillance report of Thimphu thromde drinking water quality to Thimphu Thromde;
5. RCDC shall share surveillance report of Urban drinking water quality to MoWHS.
6. All the reports submitted by health centers will be verified by RCDC within 2 weeks;
7. RCDC will analyse and generate report for urban DWQM on quarterly basis and disseminate the report at RCDC web site;
8. RCDC will analyse and generate annual report for urban DWQM and submit to NEC;
9. NEC will publish and disseminate annual report on national drinking water quality.

5.2 Rural Drinking Water Quality Monitoring System (RDWQMS)

Table 3: RDWQMS Table of parameters and the Guideline values

	Sl.No	Parameter	Unit	Maximum permissible limit	
Physical Parameters	1	Conductivity	µS/cm	1000	
	2	Odour	-	Un-objectionable	
	3	Appearance		Un-objectionable	
	4	pH	-	6.5 – 8.5	
	5	Taste	-	Un-objectionable	
	6	TDS	mg/L	500	
	7	Turbidity	NTU	5	
Microbiological parameter	1	E.Coli	CFU/ml	0	Safe Water
				1-10	Low Health Risk
				11-50	Intermediate to High Health Risk
				>50	Grossly Polluted

5.2.1 Selection of sampling stations

- ✓ For routine drinking water quality monitoring all the sampling station must be tap points at consumer level and not source.
- ✓ Sampling stations should be fixed.
- ✓ Station must be selected where there is high concentration of population.

5.2.2 Frequency of Monitoring

- ✓ For routine samples, sampling and testing should be carried out at least once a year. If possible twice in a year (February-March and July-August).

- ✓ The activity should be tied up with other activities (ORC, house hold visit etc.)
- ✓ Other than routine samples test should be carried out as and when required.

5.2.3 Sample processing

5.2.3.1 Collection and labeling

- ✓ Before collecting sample make sure appropriate form is filled to collect the details of sample collection (*Annex 1* 1b).
- ✓ SOP must be followed to collect water sample. Detailed instruction for sample collection analysis is given in Annex 2.

5.2.3.2 Storage and transportation

- ✓ Sample transported from the collection source to the laboratory at required temperature is for necessary to obtain a quality result.
- ✓ SOP must be followed to store and transport water sample. Detailed instruction for sample storage and transportation is given in *Annex 3*.

5.2.3.3 Bacteriological testing

- ✓ For RDWQMS 3M Petrifilm E. Coli technique is used to detect presence of Escherichia Coli in drinking water.
- ✓ 3M Petrifilm E. Coli technique gives a direct count of Escherichia Coli present in a given water sample.
- ✓ SOP must be followed to carry out bacteriological testing for water sample. Detailed instruction for membrane filtration technique is given in *Annex 6*.

5.2.3.4 Physio-chemical testing

- ✓ For RDWQMS the routine physico-chemical tests includes pH, turbidity, conductivity, colour and odor.

- ✓ The appearance, taste and odour of drinking-water should be acceptable to the consumer.
- ✓ SOP must be developed and followed to carry out all the procedures for physio-chemcal testing. Detailed instructions to carry out testing are given in *Annex-5*

5.2.4 Data management and reporting

- ✓ All the reports for rural drinking water quality will be made through web based or SMS based reporting system from BHUs.
- ✓ All the reports submitted from health centers will be accessible to DHO and RCDC.
- ✓ All the reports submitted by district will be verified by RCDC within 2 weeks.
- ✓ RCDC will analyse and generate report for rural DWQM bi-annualy and disseminate the report at RCDC web site.
- ✓ RCDC shall share RDWQ report with PHED.
- ✓ PHED shall verify reports from surveillance agency and take necessary action.
- ✓ RCDC will analyse and generate annual report for rural DWQM and submit to NEC.
- ✓ NEC will publish and disseminate annual report on national drinking water quality.

Annex 1: Sample detail form for UDWQMS

Annex 1a

Table 4: Sample detail form for UDWQMS

Water Sample collection details														
Sl. No.	Sampling station	Source	Collection			Analysis			pH	Residual Chlorine	Turbidity	Odor	Color	Thermotolerant Coliform
			Name	Date	Time	Name	Date	Time						

Note:*Location details like latitude, Longitude and Altitude should be collected for all sampling point. For routine samples detail is collected only once.*

Annex. 1b

Table 5: Sample detail form for Rural Drinking Water Quality Monitoring

Water Sample collection details for RDWQMS													
Sl. No.	Sampling station	Source	Collection			Analysis			pH	Turbidity	Odor	Color	E. Coli count
			Name	Date	Time	Name	Date	Time					

Note: *Location details like latitude, Longitude and Altitude should be collected for all sampling point. For routine samples location detail is collected only once.*

Annex 2: Sampling method for bacteriological and chemical testing

1. Sampling method for bacteriological and chemical testing

1.1. Sampling methods for bacteriological testing

Required volume of water should be collected in an aseptic manner using appropriate containers. Care must be taken to ensure that external contamination is not introduced into the samples.

1.1.1. Sample volume

1. For UDWQMS: 200 ml of water should be collected in sterile container.

2. For RDWQMS: 10-100 ml of water should be collected in sterile container (only 1mL is required for testing)

1.1.2. Preservation

Samples should be refrigerated at 2-8^{o} C in case the test is delayed (Refer *Annex 3*).

1.1.3. Procedure

Preparation of sampling containers

1.1.3.1. Wash thoroughly with tap water.

1.1.3.2. Cap the bottles (incase of autoclaveable plastic containers do not close the cap tightly as this may cause bottles to crush).

1.1.3.3. Autoclave the bottles at 121^{o}C at 15 PSI for 15 minutes.

1.1.3.4. Add 0.1 ml of 3% Sodium thiosulphate solution to the sampling bottle if the drinking water is chlorinated. Make sure these bottles are labeled accordingly.

1.1.4. Collection Procedure

1.1.4.1. Label the sample container with sample ID No.

1.1.4.2. Fill out the form with all the necessary details (*Annex 1*).

1.1.4.3. Clean the mouth of the tap carefully with spirit. If the tap is made of metal, it can be flamed.

1.1.4.4. Open the tap fully and allow water to flow from the tap for 1-2 minutes.

1.1.4.5. Reduce the flow and collect the sample. Do not fill the bottle completely (Leave some airspace for uniform mixing before filtration).

1.1.4.6. Close the cap tightly and place the bottle in sample box or cold-chain box accordingly (if the time between sample collection and processing exceeds 3hrs, use cold chain to transport the sample).

1.2. Sampling methods for Physio-chemical testing

➢ All physical parameters and free residual chlorine must be tested on site (refer *Annex-5* for detailed instruction).

1.3. Sampling methods chemical testing

1.3.1. Sample container

High Density Polyethylene (HDPE), 2.5 ltrs.

1.3.2. Sample volume

2.5 Ltrs (up to the marking on the neck of the container) of water should be collected.

1.3.3. Preservation

Samples should be preserved by either refrigeration or using appropriate preservatives (Refer Table 7)

1.3.4. Regents:

Chemicals: Chromic acid/ Nitric Acid/ Sulphuric Acid

Distilled water

1.3.5. Consumables:

1. Sample container- 2.5 ltr bottle
2. Spirit swab
3. Marker pens
4. Cold box with ice packs

1.3.6. Preparation of sampling containers

1. Wash thoroughly with tap water and rinse with distilled water.
2. Carry out the following washing procedures according to analyte of interest.

Table 6: Preparation of sampling containers

Sl. No.	Analyte of interest	Wash Procedure
1.	Chemicals	Rinse with chromic acid solution (35 ml of saturated $Na_2Cr_2O_7$ in 1 Ltr of conc. H_2SO_4). Rinse again with tap water and then with distilled water. Invert them to dry.
2.	Metals	Rinse the container with 20% nitric acid followed by distilled water

1.4. Collection Procedure

1. Fill out the register with all the necessary details (*Annex 1*).
2. Label the sample container with sample ID No.

3. Allow water to flow from the tap for 5 minutes.
4. Collect around 2.5 ltrs of sample (up to the marking on the neck of the container).
5. Close the cap tightly and use appropriate preservation methodology as given in *Annex 3*.

Annex 3: Preservation and Transportation of samples for microbiological analysis

1. Preservation and Transportation of samples for microbiological analysis

1.1. Tightly cap the bottles containing samples and seal them with parafilm.

1.2. Place them serially in a specimen carrier box in an upright position.

1.3. If possible analyze samples as soon as possible (within 2 hours). However, if the samples are immediately placed in a lightproof insulated box containing ice-packs to ensure rapid cooling, the samples can then be processed within 8 hours (refer Table 7).

1.4. Place tissue paper/ cotton/ gauze between the containers if glass containers are used for sample collection.

1.5. Close the sample box properly. *Note: The box used to carry samples should be cleaned and disinfected after each use.*

1.6. If the samples do not meet these storage and transportation condition, it should be discarded.

2. Preservation and Transportation of samples for Physio-chemical and Chemical analysis

2.1. Close the caps tightly and seal with parafilm in order to prevent leakage.

2.2. Place bottles in upright position.

2.3. Place absorbent materials between the bottles.

2.4. Do not expose samples to direct sunlight.

2.5. Always maintain appropriate temperature during transportation (refer Table 7)

2.6. If the samples do not meet these storage and transportation condition, it should be discarded.

Table 7: Sample preservation

Sl. No.	Parameter	Preservation	Maximum storage recommended
1	Microbiological testing	Sodium Thiosulfate if sample is chlorinated; 2-8◦C (if transportation exceeds 2 hours)	8hrs
2	Temperature	Analyze immediately	0.25hrs
3	Colour (TCU)	Refrigerate	48 Hrs
4	Odour	Analyze as soon as possible; refrigerate	6hrs
5	pH	Analyze immediately	0.25hrs
6	Taste	Analyze immediately	
7	Turbidity	Analyze same day; store in dark up to 24hrs; refrigerate	24hrs
8	Free Residual Chlorine	Analyze immediately	0.25hrs
9	Metals (general)	With preservatives (HNO3 to ph<2)	6 months
10	Sulfate	Refrigerate	28 days
11	Fluoride	None	28 days
12	Nitrate	Analyze as soon as possible; Refrigerate	48 hours
13	Mercury	With preservatives, Preservatives HNO3, Refrigerate	28 days

Annex 4: Membrane filtration technique for Thermotolerant coliform

1. Membrane filtration technique for Thermotolerant coliform

- ✓ Use appropriate PPE such as a lab coat, and disposable gloves while handling reagents and chemicals and performing the procedure.
- ✓ Fill necessary details in *Annex 1*
- ✓ Sterilize the filtration apparatus using alcohol.

2. Preparation of Culture Medium

2.1. Reagents required:

2.1.1. Sodium Hydroxide (NaOH)

2.1.2. Rosolic Acid

2.1.3. mFC Broth

2.1.4. Distilled Water

2.2. Preparation of 0.2N NaOH

Weigh 0.2g of Sodium Hydroxide (NaOH) and dissolve in 25mL of Distilled water. This gives a 25mL of 0.2N NaOH.

2.3. Preparation of 1% Rosolic Acid:

2.3.1. Dissolve 0.25g of Rosolic acid powder in 25mL of 0.2N Sodium Hydroxide (NaOH)

2.3.2. Mix thoroughly and store at 2-10^{o}C

2.4. Preparation of mFC Broth

2.4.1. Dissolve 3.71g of dehydrated mFC media in 100mL distilled water

2.4.2. Add 1mL of 1% Rosolic acid

2.4.3. Heat the broth until it just begins to boil, then immediately cool the broth to room temperature. DO NOT STERILIZE BY AUTOCLAVING!

2.4.4. Cover the container and store the mFC broth in a refrigerator (2-10 ^{o}C) until ready for use.

2.4.5. Discard any unused broth after 96hours[6].

2.5. **Sample Filtration**

2.5.1. Sterilize the funnel assembly by flaming using 96% alcohol.

2.5.2. Using sterile forceps, place a sterile membrane filter on the filter support assembly.

2.5.3. Place the funnel portion of the assembly over the filter, making sure the filter is properly aligned during this step.

2.5.4. Clamp or lock the assembly in place.

2.5.5. Mix the sample thoroughly by shaking gently.

2.5.6. Pour the 100mL sample into the funnel and apply vacuum.

2.5.7. Filter the entire volume of sample through the membrane filter.

2.5.8. Remove the membrane filter, using sterile forceps (**See incubation procedure for the remaining steps**)

2.5.9. Sterilize the funnel assembly using alcohol before the next sample is processed

Note: Filtration units should be sterile at the start of each filtration series and should be sterilized again if the series is interrupted for 30 minutes or more.

[6] Water Quality Monitoring - A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes

3. Incubation

3.1. Using sterile forceps or pad dispenser carefully place a sterile absorbent pad in the bottom portion of a sterile culture dish.

3.2. Transfer 2.0mL of MFC broth with a sterile Pasteur pipette onto the pad.

3.3. Using sterile forceps carefully place the filter (processed sample filter) on the absorbent pad using a rolling motion to avoid catching air bubbles under the filter.

3.4. Cover the culture dish and mark the top of the cover to identify the sample.

3.5. Place the culture dish (upside down position) in the incubator and incubate at 44.5° (±0.2°) C.

3.6. Incubate the culture dishes for 18 to 24 hours.

3.7. At the end of the incubation period, remove the culture dishes from the incubator.

4. Result Interpretation and Reporting

4.1. Upon completion of the incubation period, the surface of the filter may have growths of both Thermotolerant coliform and non-fecal coliform colonies.

4.2. The Thermotolerant coliform colonies will appear blue in color, while non-fecal coliform colonies will appear gray or cream colored (*Figure 3*).

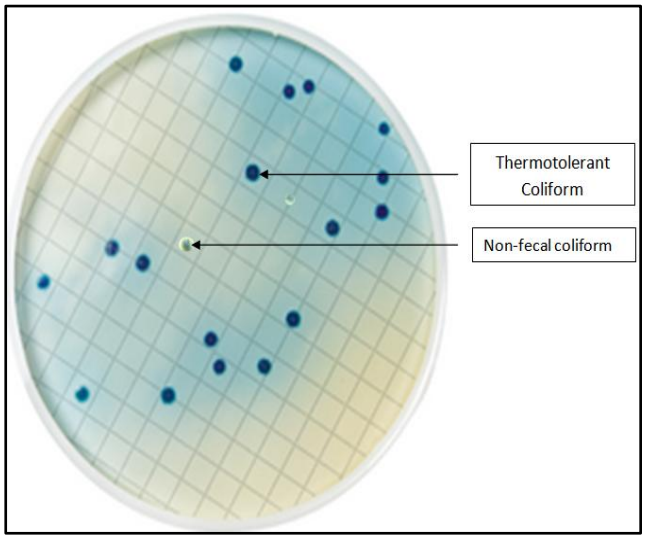

Figure 3: Colonies formed in mFC Media

4.3. When counting the colonies, the entire surface of the filter should be scanned thoroughly.

4.4. Colonies should be counted by scanning across one row and back across the next, etc. This should ensure that all areas of the filter are observed.

4.5. Note down the colonies counted as CFU/100mL of sample in *Annex 1*.

NOTE: *Discard the membrane filters and absorbent pads using the appropriate safety precautions*

Annex-5: Physio-Chemical Analysis

Physio-chemical test parameters that are carried out on routine basis are:-

1. **Free Chlorine Residual and pH**
2. **Turbidity**
3. **Color and Odor**
4. **Total Dissolved Solids and Conductivity**

1. Analysis of Free Chlorine Residual and pH

- ✓ Use appropriate PPE such as a lab coat, and disposable gloves while handling reagents and chemicals and performing the procedure.
- ✓ The test must be carried out immediately.
- ✓ Reject samples that have been kept standing for more than 15mins.

1.1. MATERIALS REQUIRED

1.1.1. Color comparator

1.1.2. DPD-1 tablet

1.1.3. Phenol red tablet

1.1.4. Tablet crusher

1.2. PROCEDURE

1.2.1. Fill the necessary details in *Annex 1*

1.2.2. Wash the comparator cells with the water that is to be analyzed and fill both cells with the sample.

1.2.3. Pour the sample into the color comparator.

1.2.4. Add one DPD-1 tablet into the chlorine compartment of the comparator (for residual chlorine) and one Phenol Red tablet into the pH compartment of the comparator (for pH).

1.2.5. Close the cover of the comparator.

1.2.6. Invert the comparator several times until the 2 tablets have dissolved completely. If the tablets are slow to dissolve use crusher to crush the tablets and allow them to dissolve completely.

1.2.7. Compare the color of the solution with the color bar on the comparator.

1.2.8. Note down reading of the matching color in *Annex 1*.

2. Analysis of Turbidity

- ✓ Use appropriate PPE such as a lab coat, and disposable gloves while handling reagents and chemicals and performing the procedure.
- ✓ The test must be carried out immediately.
- ✓ Follow manufacturer's instructions for preparing meter if the instrument is used for the first time.
- ✓ Conduct full inspection of the instrument (sample cells, battery, display, calibration etc.) before taking instrument to the field for testing.

2.1. MATERIALS AND REAGENTS

2.1.1. Turbidity meter

2.1.2. Water sample

2.1.3. Cuvette

2.1.4. Lint free cloth

2.1.5. Standard solutions (for calibration)

2.2. MEASURING PROCEDURE

Refer user manual of the instrument to carry out the testing. General instruction for common turbidity meter is given below:

2.2.1. Turn the meter.

2.2.2. Fill the sample into the cuvette.

2.2.3. Allow sufficient time for bubbles to escape before securing the cap.

2.2.4. Wipe the cuvette thoroughly with a lint-free tissue before inserting into the measurement cell.

2.2.5. The cuvette must be completely free of fingerprints and other oil or dirt, particularly in the area where the light goes.

2.2.6. Place the cuvette into the cell and check that the notch on the cap is positioned securely into the groove.

2.2.7. Press the READ/TEST key.

2.2.8. After 10 seconds, turbidity value will be displayed along with NTU unit.

NOTE:

- ✓ *The process here explains the procedure of general turbidity meter however the process may vary for different types of turbidity meter.*
- ✓ *For maintenance and calibration of the equipment refer to equipment user manual.*

3. Analysis of Color and Odor

Pure water is odor-free. Some organic and inorganic chemicals (wastes, decomposition of matters, microbial activity, disinfectants or their products etc) may contribute odor in the water and provides the first warning of potential hazard in the environment.

Use appropriate PPE such as a lab coat, and disposable gloves while handling reagents and chemicals and performing the procedure.

The test must be carried out immediately.

3.1. Shake the bottle well.

3.2. Place sample to be tested in a beaker.

3.3. Gently waft air over the beaker toward the nose, noting the odor.

3.4. Note: Do not smell the sample directly as sensitivity or injury to respiratory passages could occur.

3.5. The results of the test are very dependent upon the observers, since the sensitivity of individuals to odor is highly variable and changes from day to day therefore obtain other opinions if others are available and note whether or not odor is acceptable or unacceptable (acceptable if there is no odor and unacceptable if sample has any uncharacteristic odor).

4. Analysis of Total Dissolved Solids and Conductivity

This instruction describes the procedure for testing Conductivity, Total Dissolved Solids and Temperature of drinking water using Hach conductivity/ TDS meter.

4.1. Materials and reagents

4.1.1. Hach conductivity/ TDS meter

4.1.2. Glass beaker

4.1.3. Personal Protective Equipments

4.2. Procedure

4.2.1. **Conductivity Measurement**

NOTE: *If the probe has been in storage, soaking may be necessary prior to use to ensure the probe is thoroughly wetted.*

4.2.1.1. Press the power key and CND key. Verify that the LO BAT indication does not appear.

4.2.1.2. Select the appropriate range. If the range is unknown, begin with the highest range.

4.2.1.3. Insert the probe into the sample solution. Immerse the tip to or beyond the vent holes and agitate the probe vertically to be sure air bubbles are not entrapped. Allow time for the reading to stabilize. If the reading falls within the lowest 10% of the range, select the next lower range and again allow the reading to stabilize before recording the measurement. An over range condition causes a 1 display followed by blank digits.

4.2.1.4. Rinse the probe thoroughly with demineralized water after each measurement.

4.3. Measuring conductivity of diluted samples

If the conductivity of the sample solution exceeds the range of the instrument, the sample can be diluted and conductivity calculated. The effects of the dilution water must be considered; however, when calculating the results of low conductivity deionized water is not used as the dilution water.

$$\text{Conductivity of sample} = \frac{(100\ x\ A) - [B\ x\ (100 - C)]}{C}$$

Where;

A=>indicated conductivity

B=> conductivity of dilution water

C=> sample volume

NOTE: *when preparing sample dilutions, use a pipette, graduated cylinder or volumetric flask for volume measurements. Accuracy is necessary to obtain reliable test results.*

4.4. TDS Measurement

4.4.1. Press the power key and TDS key. Verify that the LO BAT indication does not appear.

4.4.2. Select the appropriate range. If the range is unknown, begin with the highest range.

4.4.3. Insert the probe into the sample solution. Immerse the tip to or beyond the vent holes and agitate the probe vertically to be sure air bubbles are not entrapped. Allow time for the reading to stabilize. If the reading falls within the lowest 10% of the range, select the next lower range and again allow the reading to stabilize before recording the measurement.

Annex 6: 3M Petrifilm technique for detecting Escherichia Coli in water

3M Petrifilm technique for detecting Escherichia Coli in water

- ✓ Use appropriate PPE such as a lab coat, and disposable gloves while handling reagents and performing the procedure.
- ✓ Fill necessary details in *Annex 1*
- ✓ Sterilize the working area using alcohol.

1. **PRINCIPLE**

   3M Petrifilm *E. coli*/Coliform Count Plates contain Violet Red Bile (VRB) nutrients, a cold-water-soluble gelling agent, an indicator of glucuronidase activity, and an indicator that facilitates colony enumeration. Most *E. coli* (about 97%) produce beta-glucuronidase which produces a blue precipitate associated with the colony. The top film traps gas produced by the lactose fermenting coliforms and *E. coli*. About 95% of *E. coli* produce gas, indicated by blue to red-blue colonies associated with entrapped gas on the 3M Petrifilm EC Plate (within approximately one colony diameter)

2. **SAMPLE REQUIREMENTS**

   2.1. **Sample type**

   - ✓ Water sample collected in a sterile collection container

   2.2. **Sample Handling**

   - ✓ Aseptically place the sample (or samples) sequentially (as per sample number) on the plain working bench.

3. **Reagents required:**

   3.1. 3M Petrifilm *E. coli*/Coliform count plate

   3.2. Sterile Pasteur Pipette

Inoculation

- ✓ Place 3M Petrifilm*E. coli*/Coliform Count Plate on level surface. Lift top film.
- ✓ With Pipette equivalent held perpendicular to plate, place 1mL of sample or diluted sample onto center of bottom film.
- ✓ Roll top film down onto sample gently to prevent pushing sample off film and to avoid entrapping air bubbles. Do not let top film drop.
- ✓ With flat side down, place 3M Petrifilm Spreader on top film over inoculum.
- ✓ Gently apply pressure on 3M Petrifilm Spreader to distribute inoculum over circular area before gel is formed. Do not twist or slide the spreader.
- ✓ Lift 3M Petrifilm Spreader. Wait a minimum of 1 minute for gel to solidify.

Figure 4: 3M Petrifilm E. Coli Technique

Incubation

1. Health facilities equipped with incubator can incubate plates with clear side up in stacks of up to 20 at 35°C±1°C for 24±2 hours.
2. Health facilities with no incubator can incubate using body temperature.
   - ✓ Wrap the plates in a transparent zip lock plastic/ transparent plastics.
   - ✓ Place inside the pocket(Pant/shirt)
   - ✓ Make sure the plates receive adequate body heat.
   - ✓ Keep for over night

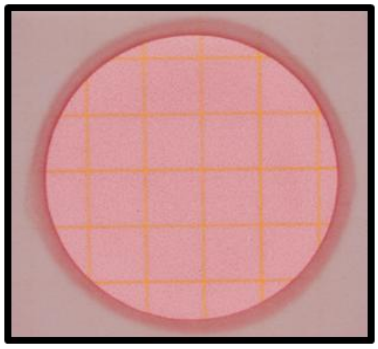

Figure 5:No growth

Interpretation

1. No growth = 0

   Background bubbles are a characteristic of the gel and are not a result of *E. coli* or coliform growth (figure. 5)

   Do not count colonies that appear on the foam barrier because they are removed from the selective influence of the medium (figure. 6)

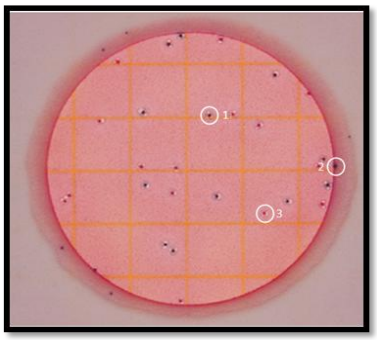

Figure 6:-1. Escherichia Coli, 2. Do not count colonies that appear on the foam barrier, 3. Other coliform

2. Any blue in a colony (blue to red-blue) indicates the presence of *E. coli*. Front lighting may enhance the detection of blue precipitate formed by a colony (figure. 6).

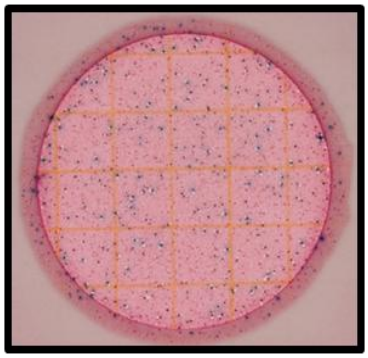

Figure 7: Plates containing more than 150 colonies

3. Estimates can be made on plates containing greater than 150 colonies by counting the number of colonies in one or more representative squares and determining the average number per square. Multiply the average number by 20 to determine the estimated count per plate (figure. 7).

4. 3M Petrifilm EC Plates with colonies that are too numerous to count (TNTC) have one or more of the following characteristics: many small colonies, many gas bubbles and a deepening of the gel color from red to purple-blue. High concentrations of *E. coli* may cause the growth area to turn purple-blue. To obtain a more accurate count, dilute the sample further
5. When high numbers of non-coliform organisms such as *Pseudomonas* are present on 3M Petrifilm EC Plates, the gel may turn yellow.
6. Colonies may be isolated for further identification. Lift top film and pick the colony from the gel.

Storage

- ✓ Store unopened pouches of plates at ≤8°C.
- ✓ Use before expiration date on package. In areas of high humidity where condensate may be an issue, it is best to allow pouches to reach room temperature before opening.
- ✓ To seal opened pouch, fold end over and tape shut.

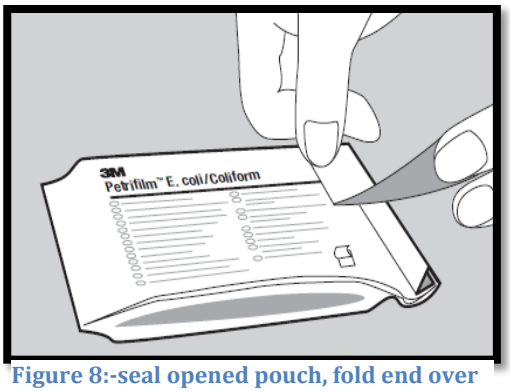

Figure 8:-seal opened pouch, fold end over and tape shut

- ✓ To prevent exposure to moisture, do not refrigerate opened pouches. Store resealed pouches in a cool, dry place. Use plates within one month after opening. Avoid exposure of plates to temperatures >25°C) and/or relative humidity >50%.

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List of Contributors

1. Chimmi Dorji, Dy. Chief Laboratory Officer, Royal Centre for Disease Control, MoH
2. Pema Chophel, Laboratory Officer, Centre for Disease Control, MoH
3. Nakphel Drukpa, Principal Engineer, Thimphu Thromde
4. Jigme Phuntsho, Dy. Executive Engineer, Ministry of Work and Human settlement
5. Tshewang Lhamo, Sr. Environment Officer, Water Resource Coordination Division, NECS
6. Karma, Principle Engineer, Public Health Engineering Division, MoH
7. Samten, District Health Officer, Haa Dzongkhag
8. Sonam Jamtsho, Laboratory Officer, Phuentsholing Hospital
9. Nima, Laboratory Officer, Bajo Hospital
10. Sonam Wangchuk, Laboratory Officer, Phuensholing Hospital
11. Pema Gyeltshen, Sr. Laboratory Technician
12. Rinzin Wangchuk, Sr. Laboratory Technician
13. Sangay Wangchuk, Sr. Laboratory Technician
14. Norbu Dukpa, HA, Genekha BHU
15. Karchung Dukpa HA, Paro CHU
16. Bhawani Shankar, Sr. HA, Kabesa BHU
17. Govind Ghimeray, ICT Associate II