Oxfam GB Drinking Water Quality Management System: For Tsunami Affected Districts

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1 Introduction

Oxfam GB (referred to as Oxfam hereafter in this document) has been involved in the relief efforts resulting from the Tsunamis that destroyed several coastal villages in Sri Lanka on 26 December 2004. The provision of water and sanitation services has been a primary focus for Oxfam since day one. The initial response involved providing adequate drinking water and sanitation facilities for the several hundred displaced people in temporary camps in 5 districts, Ampara, Mathara, Batticaloa, Trincomalee and Killinochi. Drinking water was provided in accordance to the Sphere Guidelines (2003), that stipulates…

‘ Until minimum standards for both quantity and quality are met, the priority should be to provide equitable access to an adequate quantity of water even if it is of intermediate quality, rather than to provide an inadequate quantity of water that meets the minimum quality standard.’

With the current shift from emergency relief to development, management of drinking water quality is becoming a priority. Furthermore, drinking water quality management is critical to safeguarding public health. Based on the World Health Organisation (WHO) Guidelines for Drinking Water Quality, ‘ safe drinking water does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages.’ (WHO, 2004). For Oxfam, the delivery of good quality and safe drinking water also ensures health promotion effectiveness, another significant program for Oxfam.

The implementation of this drinking water quality management system aims to minimise contamination to drinking water at all points in the delivery system and to ensure the supply of safe and good water quality to affected communities. This involves implementing appropriate management strategies within the delivery system to achieve a multiple barrier approach ranging from source water protection to household water protection.

In order to assess the effectiveness of the implemented drinking water quality management system, a water quality monitoring program is also implemented simultaneously. This will require regular water quality testing and analysis of selected parameters at various points in the supply system in accordance to the WHO Guidelines for Drinking Water Quality (2002).

Oxfam’s drinking water quality management system will be implemented and administered by both, public health engineers (PHE) and public health promoters (PHP) in Sri Lanka.

2 Drinking Water Quality in Sri Lanka

Since no baseline drinking water quality data was available for Oxfam’s drinking water supply systems in Sri Lanka an intensive water quality monitoring program was implemented in May 2005 in all 5 districts. Samples were collected from various points in the system and tested for the following parameters:

- Turbidity
- Total Dissolved Solids (TDS)/ Conductivity
- Temperature
- pH
- Chlorine residual
- Faecal coliforms (Thermotolerant coliforms (TTC))

These parameters were chosen based on existing resources available, such as water quality testing kits, consumables, human resources etc. Furthermore, these parameters were utilised as indicators to determine if there were major issues with the water quality. For example, high turbidity, presence of faecal coliforms and low chlorine residual would indicate that the water could be contaminated with pathogenic microorganisms. Likewise very high TDS/ conductivity will indicate the water is saline or could be contaminated with some chemicals. Low or high pH levels will indicate palatability of water and temperature can indicate potential growth of microorganisms.

Due to the limited resources available (testing kits, consumables, human resources etc.) certain conditions were developed for sampling and testing: - where chlorine residual levels were between 02 – 0.5 mg/L samples did not have to be collected and tested for TTC. Furthermore, due to several strikes (hartals) that occurred in May 2005, all water quality sampling and testing could not be completed. An average of results obtained in the month of May for all 5 districts are analysed and shown below.

2.1 Mathara

Drinking water is supplied by the National Water Supply & Drainage Board (NWSDB) to all camps and shelter sites managed by Oxfam in Mathara. Bowsers are utilised to truck water from the NWSDB water treatment plant to the various camps. Therefore samples were only collected within the camp level from random tanks in random camps. The table below shows the average water quality results for May 2005 in Mathara.

Table 1: May 2005 Mathara drinking water quality

Parameter	Monitoring Point	WHO Guideline Value	Results
Temperature	Distribution system	No guideline value °C	N/A
Turbidity	Distribution system	<5 NTU	<5
pH	Distribution system	6.5 – 8.5	7.2
TDS/ conductivity	Distribution system	1000 mg/L/ 1500μS	N/A*
Chlorine residual	Distribution system	0.2 – 0.5 mg/L	1.12
Faecal coliform	Distribution system	0 cfu/100ml	0**

N/A – not available

* Pocket tester calibrated in milli seimens (high range) therefore unable to detect low results

** Only one sample collected and tested for TTC. TTC absent

The general water quality supplied to Tsunami affected communities in Mathara is generally good with no evident faecal contamination in the water supply. However, chlorine residual levels are too high which can result in consumer complaints. A sample collected in a household at Tangalle showed presence of TTC colonies that were too numerous too count. This could indicate poor collection and storage practices within the household level.

2.2 Ampara

Water supplied to camps in Ampara where Oxfam manages water and sanitation activities comes from different sources. In Thirukovil division, drinking water comes from three filtration systems managed by the German Red Cross, FORUT and Polish Humanitarian Organisation. Oxfam bowsers collect water from these three plants and distribute it to the various camps and villages in that division. Oxfam operates and maintains a membrane filtration plant at

Sample analysis in Ampara

Illukuchenai. Here water is extracted from an irrigation tank, undergoes treatment via a series of membrane filters and chlorination in the storage tanks before it is distributed via bowsers to Akkaraipattu and Aliyadevemvu divisions.

Since the water source that supplies water for Akkaraipathu and Aiyadevemvu are the same a cumulative analysis is done for both divisions. No water quality data is available for Thirukovil district as no samples were collected.

Table 2: May 2005 Akkaraipattu & Aliyadevemu drinking water Quality

Parameter	Monitoring Point	WHO Guideline Value	Results
Temperature	Water source	No guideline value °C	34
	Filtration plant		33.4
	Distribution system		33.5
Turbidity	Water source	<5 NTU	30
	Filtration plant		<5
	Distribution system		<5
pH	Water source	6.5 – 8.5	7.6
	Filtration plant		7.2
	Distribution system		7.2
TDS/ conductivity	Water source	1000 mg/L/ 1500μS	124 mg/L
	Filtration plant		103 mg/L
	Distribution system		103 mg/L
Chlorine residual	Distribution system	0.2 – 0.5 mg/L	0.1
Faecal coliform	Water source	0 cfu/100ml	429
	Filtration plant		0
	Distribution system		2*

* Out of 3 samples that were collected and tested for TTC in May only one sample failed giving a result of 2 cfu/100ml.

The results above show that the Skhydrant filtration plant in Illukuchenai is effective in reducing turbidity levels, pH and TDS. Likewise, TTC results have also reduced significantly from water source during filtration indicating good performance of membrane filters. The failure of 1 sample collected and tested for TTC in the distribution system indicates issues with chlorine residual maintenance.

2.3 Batticaloa

Currently Oxfam is supplying water in Vakarai north and south in Batticaloa district. Water is extracted from the Verugal river, passed through a series of membrane filters, chlorinated and distributed to four major camps in Vakarai north. Water supplied to Vakarai south comes from a treatment facility (filtration) managed by a paper factory and a well managed by MoH. Water quality results from sampling conducted in May 2005 is shown in the table below. Due to a limited experience in using Delagua kits and understanding in water quality sampling and testing was not conducted to represent the entire water supply system in Batticaloa district.

Table 3: May 2005 Vakarai North Drinking Water Quality

Parameter	Monitoring Point	WHO Guideline Value	Results
Temperature	Water source	No guideline value °C	N/A
	Filtration plant		33
	Distribution system		34

Turbidity	Water source	<5 NTU	N/A
	Filtration plant		<5
	Distribution system		<5
pH	Water source	6.5 – 8.5	N/A
	Filtration plant		7.5
	Distribution system		7.5
TDS/ conductivity	Water source	1000 mg/L/ 1500μS	N/A
	Filtration plant		500μS
	Distribution system		400μS
Chlorine residual	Filtration Plant*	0.2 – 0.5 mg/L	0.5
	Distribution system		0.2
Faecal coliform	Water source	0 cfu/100ml	N/A
	Filtration plant		N/A
	Distribution system		N/A

N/A – not available

* Chlorine residual in storage tanks in the filtration plant at Verugal

Table 4: May 2005 Vakarai South Drinking Water Quality

Parameter	Monitoring Point	WHO Guideline Value	Results
Temperature	Water source*	No guideline value °C	36
	Water source**		37
	Distribution system		34
Turbidity	Water source*	<5 NTU	<5
	Water source**		<5
	Distribution system		<5
pH	Water source*	6.5 – 8.5	7.5
	Water source**		7.8
	Distribution system		7.6
TDS/ conductivity	Water source*	1000 mg/L/ 1500μS	400μS
	Water source**		200μS
	Distribution system		300
Chlorine residual	Water source**	0.2 – 0.5 mg/L	0.2
	Distribution system		0.2
Faecal coliform	Water source*	0 cfu/100ml	N/A
	Water source**		N/A
	Distribution system		N/A

* MoH well situated at Valachennai

**Treatment plant at paper factory (post-treatment)

The overall water quality supplied by Oxfam to several camps in the Batticaloa district is acceptable. Although there is no microbiological data available it can be assumed that certain failures could be evident due to the maintenance issues in the distribution system (tank cleaning etc). However, the maintenance of acceptable chlorine residual levels indicates possibilities of lesser microbiological failures emerging in the Batticaloa district.

2.4 *Trincomalee*

Oxfam is managing the delivery and supply of water to camps in Eachchalampathu, Kuchchaveli and Kinniya in the Trincomalee district. In Eachchalampathu, water is currently supplied to the camps from a well managed by the Pradeshya Sabah. Water is supplied to all camps by the NWSB in Kinniya and in Kuchchaveli water is extracted from two wells situated 2Km from the town and delivered to the camps via bowsers. The drinking water quality for Trincomalee district is shown below.

Table 5: May 2005 Eachchalampathu Drinking Water Quality

Parameter	Monitoring Point	WHO Guideline Value	Results
Temperature	Water source	No guideline value °C	32
	Distribution system		32
Turbidity	Water source	<5 NTU	<5
	Distribution system		<5
pH	Water source	6.5 – 8.5	8
	Distribution system		7.8
TDS/ conductivity	Water source	1000 mg/L/ 1500μS	800μS
	Distribution system		650μS
Chlorine residual	Distribution system	0.2 – 0.5 mg/L	0.5
Faecal coliform	Water source	0 cfu/100ml	6
	Distribution system		2*

*Out of 4 samples that were collected and tested for TTC only 1 sample failed giving a result of 2cfu/100ml

The water source at Eachchalampathu is slightly saline resulting in palatability issues. However, this will no longer be an issue as a Skyhydrant filtration plant has been installed and water will be extracted from the Verugal river and utilised for distribution instead of the wells. The sample that failed to comply with TTC guideline value was possibly due to the low chlorine residual in the tank (0.1mg/L).

Field testing in Trincomalee

Table 6: May 2005 Kinniya Drinking Water Quality

Parameter	Monitoring Point	WHO Guideline Value	Results
Temperature	Distribution system	No guideline value °C	33
Turbidity	Distribution system	<5 NTU	<5
pH	Distribution system	6.5 – 8.5	7.8
TDS/ conductivity	Distribution system	1000 mg/L/ 1500μS	300
Chlorine residual	Distribution system	0.2 – 0.5 mg/L	0.1
Faecal coliform	Distribution system	0 cfu/100ml	6 and 2*

* Out of 6 samples collected and tested for TTC in May 2005 2 samples failed giving a result of 6cfu/100ml and 2cfu/100ml

Since drinking water is supplied directly by the NWSDB to Oxfam camps in Kinniya, Oxfam is unable to directly monitor the water source. However, from the results above it can be determined that the overall water quality in Kinniya is acceptable with only some issues pertaining to chlorine residual maintenance within the tank.

Table 7: May 2005 Kuchchaveli Drinking Water Quality

Parameter	Monitoring Point	WHO Guideline Value	Results
Temperature	Water source*	No guideline value °C	32
	Water source**		31
	Distribution system		32
Turbidity	Water source*	<5 NTU	<5
	Water source**		<5
	Distribution system		<5
pH	Water source*	6.5 – 8.5	7.8
	Water source**		7.8
	Distribution system		7.8
TDS/ conductivity	Water source*	1000 mg/L/ 1500μS	850μS
	Water source**		700μS
	Distribution system		885μS
Chlorine residual	Distribution system	0.2 – 0.5 mg/L	0.2
Faecal coliform	Water source*	0 cfu/100ml	0
	Water source**		0
	Distribution system		8 and 6***

* Well source 1
** Well source 2
*** Out of 7 samples that were collected and tested for TTC in May 2005 2 samples failed giving a result of 8 cfu/100ml and 6 cfu/100ml

In Kuchchaveli the drinking water is slightly saline which can give rise to palatability issues. The water source is otherwise of good quality with currently no sign of microbiological contamination. Evidence of TTC within the distribution system is associated with the low chlorine residual maintained in particular tanks. Samples collected from bowsers also resulted in 0 cfu/100ml.

2.5 Killinochi

Several wells are utilised to supply drinking water at various camps. Generally water is extracted from a well within the camp site, stored in T11 or T45 tanks and supplied to the camp via a level 2 (communal tap stands) distribution system. Killinochi did not participate in the water quality monitoring programm. However regular monitoring for most parameters, except TTC and temperature have been conducted on a regular basis. This is shown below.

Table 8: Killinochi Drinking Water Quality

Parameter	Monitoring Point	WHO Guideline Value	Results
Temperature	Distribution system	No guideline value °C	N/A
Turbidity	Distribution system	<5 NTU	<5
pH	Distribution system	6.5 – 8.5	7.2
TDS/ conductivity	Distribution system	1000 mg/L/ 1500μS	600μS
Chlorine residual	Distribution system	0.2 – 0.5 mg/L	0.2
Faecal coliform	Distribution system	0 cfu/100ml	N/A

Drinking water supplied by Oxfam in Killinochi is generally good. Since majority of the water sources are deep wells, salinity is not a major issue. Furthermore, the maintenance of an appropriate chlorine residual level within the tanks and the distribution system can reduce the possibility of microbiological contamination. However, there could be isolated issues of TTC evident within the distribution system which can be associated to the cleaning and maintenance of tanks. Therefore it is important for continuous bacteriological monitoring.

2.6 Drinking water quality issues and management strategies

From the above analysis, it is evident that the overall water quality supplied by Oxfam in Mathara, Ampara, Batticaloa, Trincomalee and Killinochi is within the acceptable guideline values. Where results have exceeded the acceptable guideline value for TTC it has only been in isolated cases due to poor maintenance of the distribution system and chlorine residual maintenance. Even if TTC results exceeded the guideline value, the levels were not harmful (>10cfu/100ml). However its management is necessary as coliforms have a great potential to re grow and multiply in a medium that supports it. Where there have been issues with high turbidity filtration plants have been established and for salinity issues alternative sources have also been identified.

Since the water sources utilised for supplying drinking water by Oxfam is generally good (where issues are present additional treatment is established) it is evident that a distribution maintenance program is required to reduce contamination in the drinking water. This will involve a combination of activities such as regular tank cleaning, flushing of distribution system, hand dosing tanks with chlorine etc.

3 Oxfam Drinking Water Quality Management System

Drinking water quality management should be carried out from the water source right to the consumer end to ensure control and prevention of contamination. By implementing such an integrated approach it can be ensured that communities are consuming safe drinking water.

Oxfam's drinking water quality management system follows a similar approach to that of WHO's 'Framework for safe drinking water' (WHO, 2002). This framework adopts a proactive approach by implementing various strategies throughout the entire water supply system to ensure that barriers are in place to prevent contamination. These barriers range from source water protection to household water protection. The main components of Oxfam's drinking water quality management system are:

- Implementation of management plans and actions that need to be taken in normal operation and incident conditions, including upgrade and improvement, documentation and communication
- Implementation of a water quality monitoring program to verify that the above implementations are working properly

3.1 Integrated management system

3.1.1 Water source management

Water source management involves the implementation of large scale catchment management plans to immediate source water protection (e.g. well protection). Catchment management requires the involvement of all major stakeholders such as the government, communities living within the catchment, water authorities, water supply managers etc.

Protected well source in Killinochi

Within the current situation that Oxfam is working in Sri Lanka, water source management activities can only be limited to immediate source water protection activities. Therefore the following actions should be taken after surveillance for the 2 major water sources that are utilised for extracting water for drinking purposes by Oxfam:

Table 9: Well source management activities

Current Situation	Yes	No	Management Activities	
			If Yes	If No
Is the mouth of the well open?	☐	☐	Seal mouth of the well with appropriate materials to avoid contamination and to allow ease for extraction	No action required
Are animals grazing within 10m of the well?	☐	☐	Fence the area surrounding the well allowing area for access	Same action required
Is the community using the well for bathing purposes?	☐	☐	Restrict community access or find alternative source	Erect signs to restrict future access

Table 10: Surface water source management activities

Current Situation	Yes	No	Management Activities	
			If Yes	If No
Are animals or humans bathing or washing clothes within 10m of the extraction point?	☐	☐	Shift inlet pipe upstream or install a screen at the extraction point	Same action required
Is the extraction pipe placed in shallow waters?	☐	☐	Place inlet pipe in at least 1m depth to extract water	No action required

In addition to the above activities implemented, the following surveillance and management schedule should also be implemented.

Table 11: Water source surveillance and management schedule

Surveillance Program	Frequency	Required Action
Leak detection	Weekly	Replacement of valves, pipes
Inlet pipe cleaning	Monthly	Flush inlet pipes with chlorine solution
Equipment inspection	Monthly	General repairs or replacement of pump

3.1.2 Treatment management

For Oxfam, this is associated with the management and maintenance of the Skyhydrant filtration plants and disinfection with chlorine. The implementation of an operational and maintenance plan will ensure the control of contamination occurring at the treatment site. Refer to annex 1 for operational and maintenance plan of Skyhydrant filter plants.

Filtration Plant in Batticaloa District

Disinfection with chlorine is an important component of good water quality management. All drinking water supplied by Oxfam should be chlorinated to achieve a continuous chlorine residual between 0.2-0.5 mg/L in the distribution system. Disinfection with High Test Hypochlorite (HTH) should take place either in the storage tanks at the filtration plant, bowser or storage tanks (T11/ T45) connected to a level two distribution system (communal tap stands). No chlorine should be added directly to a well source or black tanks placed within the camps (unless for hand dosing during a water quality failure occurs). Refer to annex 2 for appropriate procedures for chlorination with HTH.

3.1.3 Distribution management

Distribution management involves the ongoing protection and maintenance of the distribution system. For Oxfam, the distribution system includes either one or a combination of the following depending on the type of system established in the particular district and camp sites:

- Bowser and black tanks (if Oxfam is trucking the water); and/ or
- Only black tanks in the camp (if water is being supplied by another organisation or government bowser); and/ or
- Storage tank (T11/ T45) and tap stands; and/ or
- Bowser, storage tank (T11/ T45) and tap stands (if water is being trucked by Oxfam and delivered to the T11/ T45)

To ensure that no contamination can occur within the distribution system the following operational and maintenance schedule should be implemented within each system.

Table 12: Distribution system surveillance and maintenance schedule

Surveillance Program	Frequency	Required Action
Leak detection	Weekly	Replacement of valves, pipes, taps
Pipe cleaning for level 2 distribution system	Monthly*	Flush pipes in the distribution system
Tank cleaning	Monthly*	Clean tank according to procedures refer to annex 3
Equipment inspection	Monthly	General repairs or replacement of tanks if damaged

* If turbidity levels are <5 clean tanks 6 monthly. If slime is evident then clean tanks monthly.

3.1.4 Consumer management

Consumer management activities target issues pertaining to collection, storage and usage practices within the household level. Activities will include training communities in appropriate management techniques to prevent contamination of drinking water within the household level. This component is very important in safeguarding public health. If no water quality management is in place at this level, then there is no guarantee that the consumer will be exposed to safe drinking water despite the delivery of safe drinking water within the supply chain.

This component should be implemented by the PHP team, however a collaboration with PHE teams is required to ensure drinking water quality management is conducted in an integrated manner.

3.2 Incidental Drinking water quality management matrix

Parameter	Guideline Value*	Water Source		Treatment Site		Distribution System		Consumer End	
		Issue	Action	Issue	Action	Issue	Action	Issue	Action
Temperature	No guideline value but should not exceed 40°C	Is it > 40°C Yes ☐	Extract water from source and store in tank in a cool place prior to filtration and chlorination	Is it > 40°C Yes ☐	Extract water from source and store in tank in a cool place prior to filtration and chlorination	Is it > 40°C Yes ☐	Place distribution tanks and pipes away from direct sunlight	Is it > 40°C Yes ☐	Store water pots, buckets, filters in a cool dry place away from direct sunlight
		No ☐	No action required	No ☐	No action required	No ☐	No action required	No ☐	No action required
Turbidity	<5 NTU	Is it >5 NTU Yes ☐	Install a filtration system or sedimentation tank to reduce levels to <5 NTU	Is it >200 NTU at extraction point Yes ☐	Install sedimentation tank to reduce levels to <200 NTU prior to entering the filters	Is it >5 NTU Yes ☐	Clean tanks and flush the distribution system	Is it >5 NTU Yes ☐	Clean storage utensils and household filters thoroughly.
		No ☐	No action required	No ☐	No action required	No ☐	No action required	No ☐	No action required
				Is it >5 NTU post treatment Yes ☐	Conduct backwash and sanclean for filters				

Parameter	Guideline Value*	Water Source		Treatment Site		Distribution System		Consumer End	
		Issue	Action	Issue	Action	Issue	Action	Issue	Action
				No ☐	No action required				
pH	6.5 – 8.5	Is it <6.5 Yes ☐	Aerate water prior to conducting treatment and sending it to the distribution system	Is it <6.5 Yes ☐	Aerate water prior to conducting treatment and sending it to the distribution system	Is it <6.5/ >8.5 Yes ☐	Clean tanks and flush the distribution system	Is it <6.5/ >8.5 Yes ☐	Clean storage utensils and household filters thoroughly.
		No ☐	No action required	No ☐	No action required	No ☐	No action required	No ☐	No action required
		Is it >8.5 Yes ☐	Find alternative source or other source to blend water to reduce pH	Is it >8.5 Yes ☐	Find alternative source or other source to blend water before treatment				
		No ☐	No action required	No ☐	No action required				
TDS/ conductivity	1000 mg/L or 1500µS	Is it >1000/ 1500 Yes ☐	Find alternative source. Treatment is too expensive	N/A**					
		No ☐	No action required						

Parameter	Guideline Value*	Water Source		Treatment Site		Distribution System		Consumer End	
		Issue	Action	Issue	Action	Issue	Action	Issue	Action
Chlorine residual	0.2 – 0.5 mg/L	N/A***		Is it <0.2/ >0.5 Yes ☐	Conduct chlorination as specified in procedures	Is it <0.2 Yes ☐	Hand dose in tanks with appropriate dose	N/A****	
				No ☐	No action required	No ☐	No action required		
						Is it >0.5 Yes ☐	Flush system and half empty tanks and dilute with water.		
						No ☐	No action required		
Faecal coliform	0 cfu/100ml	Is it >100 Yes ☐	Install a membrane filtration system or alternative treatment prior to chlorination	Is it >100 Yes ☐	Conduct sanclean procedure according to requirements	Is it >0 Yes ☐	Clean tanks and shock dose tanks/ bowsers with appropriate chlorine levels	Is it >0 Yes ☐	Empty all storage utensils and filters and clean. Train consumer on appropriate storage and use
		No ☐	No action required	No ☐	No action required	No ☐	No action required	No ☐	No action required
				Is it >0 Yes ☐	Chlorinate after treatment				

Parameter	Guideline Value*	Water Source		Treatment Site		Distribution System		Consumer End	
		Issue	Action	Issue	Action	Issue	Action	Issue	Action
				No ☐	Chlorinate after treatment				

* The required and acceptable level in the distribution system and consumer collection point.

**If water source exceeds limit, then the source should not be used, therefore issues should not arise in other areas.

*** No chlorine should be added directly to the water source body.

**** Generally chlorine residual will not remain in the household storage level, therefore water should be stored properly to avoid contamination.

3.3 Drinking Water Quality Monitoring Program

The drinking water quality monitoring program is a major part of the drinking water quality management system. It provides data to assess the effectiveness of the implemented management system and decisions for any changes.

Implementation of the drinking water quality program will require regular water quality testing at various points in the supply system. Selected indicator parameters will be tested and analysed based on the WHO Guidelines for Drinking Water Quality (2002).

3.3.1 Parameters to be monitored

It is difficult and too expensive to test for all parameters, therefore indicators are selected and tested based on the water quality assessments required within the system. For Oxfam's systems, a range of physical, chemical and bacteriological indicators have been selected to assess the following:

Table 13: Required water quality assessments for Oxfam's water supply systems

Assessment	Indicators
Water source management	Turbidity, pH, Conductivity, Temperature, TTC
Treatment management	Turbidity, pH, Conductivity, Temperature, TTC, Chlorine residual
Distribution management	Turbidity, pH, Conductivity, Temperature, TTC, Chlorine residual
Consumer management	Turbidity, TTC

Furthermore, since Oxfam's supply systems are small community supply systems (serving populations of <1000), a minimum of 4 parameters are only required to be tested - pH, turbidity, chlorine residual and faecal coliform (TTC) (NHMRC & NRMMC, 2004). Since the major sources of drinking water in Sri Lanka are from shallow wells and salinity being a major issue, conductivity/ total dissolved solids (TDS) is also tested. Temperature is an operational parameter.

3.3.1.1 Physical and chemical parameters

Turbidity: Turbidity is an aesthetic parameter which measures the amount of suspended matter (clay, silt etc) in the water. High turbidity results in the appearance of water being muddy or milky. High turbidity can interfere with disinfection effectiveness, therefore turbidity should ideally be 1NTU prior to disinfection. However, the WHO guidelines (1993) also stipulate that turbidity levels of 5NTU or less will not reduce the effectiveness of disinfection. High turbidity levels can also indicate presence of inorganic chemicals and organic compounds which can further react with chlorine to form carcinogenic byproducts such as Trihalomethanes.

pH: pH is an aesthetic parameter which measures the hydrogen ion concentration in the water to determine if it is acidic or alkaline. pH levels below 6.5 and above 8.5 can cause scaling and damage to pipes. High pH can also reduce chlorine disinfection effectiveness (above pH8.0).

Total dissolved solids (TDS)/ electrical conductivity (EC): TDS consists of inorganic salts and small amounts of organic matter. High TDS levels can result in scaling and corrosion of pipes and other fittings. Water should not contain more than 1000mg/L of TDS or 1500µs (EC). Furthermore high TDS levels can also result in poor tasting water. High salinity levels can be an issue in most of the areas where Oxfam manages the water supply in Sri Lanka, hence the need to test for this parameter.

Temperature: High temperatures can result in increased chemical reactions during chlorination and also influence the growth of some bacteria. Therefore testing of temperatures can be a general indicator to determine the presence/ absence of certain chemicals and bacteria. Generally high temperatures result in complaints from customers. There are no set guidelines for temperature, however when temperatures exceed 40°C precautions should in be in place to control bacterial growth and loss of chlorine residual.

Chlorine residual (free chlorine): After the disinfection of water with chlorine, a residual of 0.2mg/L to 0.5mg/L should be available in the distribution system. This allows the continuous deactivation of re-growth bacteria and biofilm formation within the system.

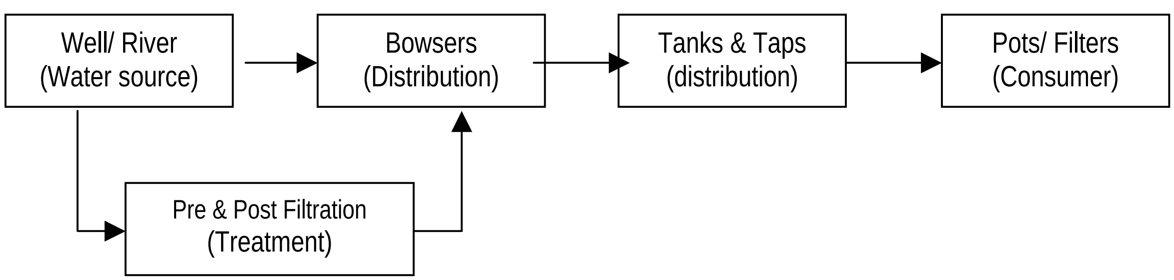
3.3.1.2 Bacteriological parameters

Thermotolerant coliform (TTC) Thermotolerant coliform is an indicator of faecal contamination in the water. TTC should not be detected in a 100ml sample at anytime.

3.3.2 Sampling location and frequency

3.3.2.1 Sampling location

To conduct the required water quality assessments for Oxfam's water supply systems as indicated in table 1, samples should be collected at the following points to get a good representation of the entire system. Where random samples are to be taken, between 1% and 5% of total bowsers, tanks, taps and household utensils/ filters should be tested. This sample size has been selected on the basis of availability of resources and size of the water supply system. When random bowsers, tanks and tap stands are selected for sampling the same ones should be sampled continuously unless they have been decommissioned. Random samples collected from the household level should be alternated to be able to get a better understanding of community practices. The figure below shows where samples should be collected in order to get a representation of the entire system.



3.3.2.2 Sampling frequency

Generally for small water supply systems water quality monitoring at various locations occurs on a weekly, monthly, quarterly or annual basis depending on the dynamics of the system. For example, if water being supplied to a community comes from a known and protected source, monthly sampling will be sufficient. The WHO Guidelines (2002) also stipulates that for water supplies serving a population of <5000 only 1 sample a month is sufficient to be collected and tested for faecal contamination in the distribution system. Based on these guidelines a water quality monitoring schedule for Sri Lanka is provided (refer to annex 4) and should be implemented in all 5 districts.

3.3.3 Sampling methods and equipment

The Oxfam Delagua water testing kits, HACH PathoScreen P/A reagents and the Palintest Pocket testers will be utilised simultaneously to conduct the monitoring. An Oxfam Water Laboratory (OWL) will be set up to house and maintain these equipments and conduct testing for bacteriological parameters.

3.3.3.1 Delagua water testing kit

The Delagua water testing kit contains the following equipments that allows for testing the following parameters

TTC Results

Turbidity tube – turbidity

- Pool tester with reagents – pH & chlorine residual
- Thermometer – temperature
- Filter apparatus, incubator, culture media and sterilisation equipment – faecal coliform (TTC)

Procedures for using these equipments are provided in annex 5.

3.3.3.2 HACH PathoScreen P/A test

The HACH PathoScreen Presence/ Absence test utilises the multiple tube fermentation process to give an indication whether any faecal coliforms are present or absent in the water. This test is highly sensitive unlike the membrane filtration method (Delagua kit), therefore should only be used for the purpose of operational monitoring. Since this test does not require any incubators and cumbersome processes to test for faecal coliforms, Oxfam is utilising them. However the HACH P/A test should only be utilised as indicated below:

Table 14: Using P/A and Delagua for testing faecal coliforms

Source	PathoScreen Test		Result	
	Yes	No	Action if Present	Action if Absent
Well	✔		Follow procedures from section 3.2. Also conduct test using Delagua	No action required
Surface water		✔ (use Delagua)		No action required
Treatment	✔		Follow procedures from section 3.2. Also conduct test using Delagua	No action required
Bowser	✔		Follow procedures from section 3.2. Also conduct test using Delagua	No action required
Tanks/ Taps	✔		Follow procedures from section 3.2. Also conduct test using Delagua	No action required

Household	✔		Follow procedures from section 3.2. Also conduct test using Delagua	No action required

Procedures for using PathoScreen P/A test is provided in annex 6.

3.3.3.3 Planitest pocket testers

Planitest or alternative pocket testers are utilised to test for TDS/ conductivity. It is very simple to utilise these testers, however they need to be calibrated at least on a 6 monthly basis. Sometimes this might have to be done more regularly depending on the usage of the testers. Each tester comes with instructions for use and calibration that are simple to follow.

3.3.4 Analysis and reporting of results

Results need to be recorded on field sheets (refer to annex 7) during testing and then entered onto an excel spread sheet on a monthly basis for simple analysis of results. An average (mean) of monthly results can then be recorded and reported on individual divisional levels in each district. A two-page report stipulating the management systems in place, results from sampling conducted for the particular month, water quality issues and actions taken should be reported on a monthly basis to the Water Quality Coordinator. Using these individual monthly reports, the Water Quality Coordinator will be able to provide an overall drinking water quality report on an annual basis.

4 Bibliography

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Annex 1: Management & Maintenance Plan of Skyhydrant (MEMCOR) Filter Plants

Oxfam monitoring requirements and schedule

To ensure that the Skyhydrant filters are undergoing optimal operation, continuous monitoring is required. Water quality monitoring allows for assessing operation of filters and provides information to make decisions on maintenance. This schedule is prepared in accordance to recommendations provided in the Skyhydrant operational and maintenance manual (Memcor Skyhydrant, 2005).

Samples should be collected from the following sites to enable appropriate assessment of the filtration system:

- Site 1- intake of source water (point of extraction of raw water)
- Site 2- after filtration (before chlorination)

Operational water quality monitoring schedule

Parameter	Frequency	Site	Acceptable Level	Required Level
			Site 1	Site 2
Turbidity	1 sample/ fortnight	Site 1 & 2	200 NTU	<5 NTU
pH	1 sample/ fortnight	Site 1 & 2	2 – 10 pH	6.5 – 8.0 pH
Temperature	1 sample/ month	Site 1 & 2	0 – 40 °C	0 - 40 °C
TTC	1 sample/ month	Site 1 & 2	<100 cfu/100ml	0 cfu/100ml *

* If >0 cfu/100ml is detected in site 2 then an additional sample needs to collected and tested for TTC at the storage tank after chlorination.

Operational surveillance and maintenance schedule

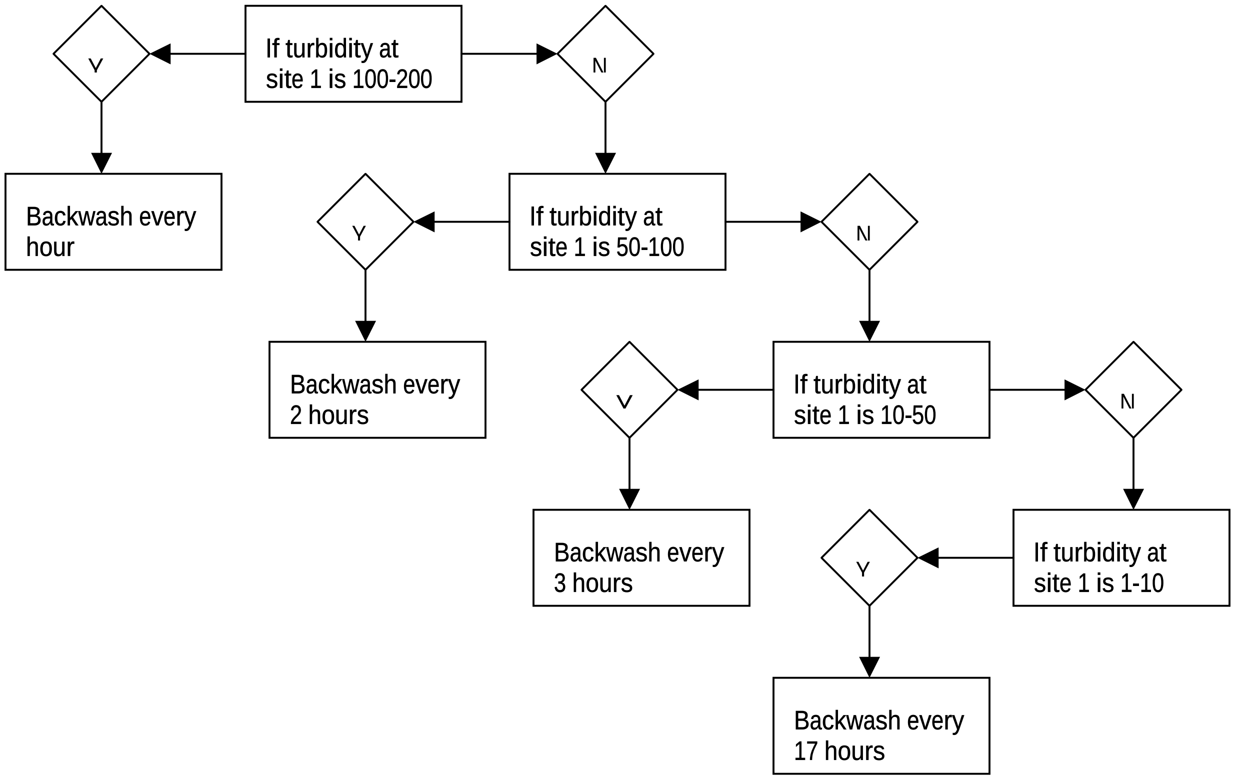
Surveillance Program	Frequency	Required Action
Leak detection	Weekly	Replacement of valves, pipes
Storage/ feed tank cleaning	6 monthly or annually*	Clean tanks/ replace if damaged
Equipment inspection	Weekly	General repairs/ replacements

* If turbidity of the water source is above 20 NTU clean feed tanks monthly.

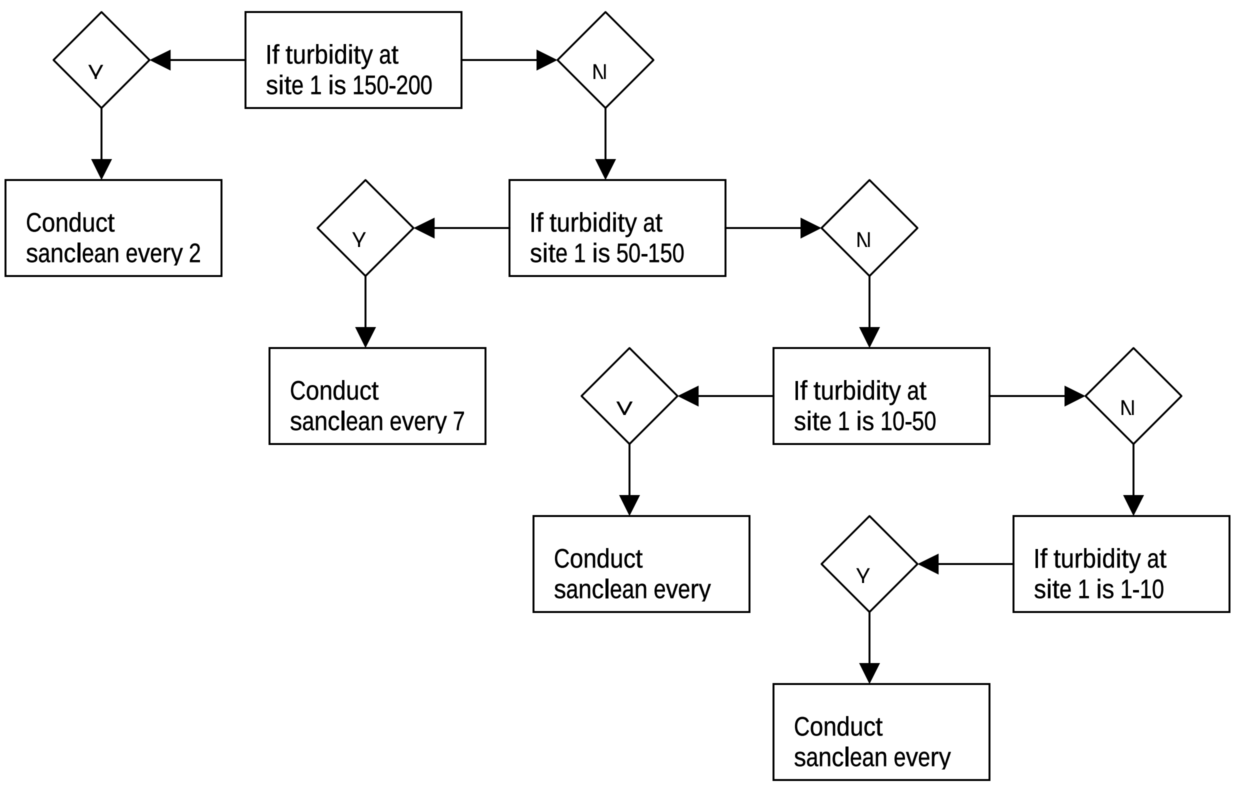
Decision for maintenance

Based on the results obtained from the water quality monitoring schedule, decisions can be made for maintenance of the filters

Frequency for backwash cycle



Frequency for sanclean cycle



Annex 2: Chlorinating Water Supply with High Test Hypochlorite (HTH)

Some water sources contain disease-causing microorganisms which need to be removed or killed before the water is safe to drink. If carefully undertaken and monitored, disinfection is an effective means of removing such organisms. Chlorine is the most widely used disinfectant, and is often the most readily available. The method of disinfecting water supplies with High Test Hypochlorite (HTH) is discussed in this section.

When chlorine is added to a water source, it purifies the water by damaging the cell structure of microbiological pollutants such as bacteria, viruses, protozoa etc., thereby destroying them. The amount of chlorine needed to do this is called the chlorine demand of the water. The chlorine demand varies with the amount of impurities in the water. It is important to realize that the chlorine demand of a water source will vary as the quality of the water varies. The aim of chlorination is to satisfy the chlorine demand of the water source. Once the demand has been satisfied, any excess chlorine above the level needed to satisfy the demand remains as a residual of chlorine (chlorine residual) in the supply. By maintaining chlorine residual in the supply, the water is continuously protected from subsequent bacterial contamination that occurs as a result of re-growth, biofilm production or external contamination. The chlorine residual should generally be in the range 0.2 to 0.5 mg/l of chlorine in treated water. Any more than this and the supply may taste bad and be harmful, and people may refuse to use it. Any less, and there is no guarantee that the supply is adequately protected.

Chlorination with HTH

To determine the appropriate chlorine dose required to disinfect a water supply, jar tests have to be carried out systematically for each supply system.

Jar test

A solution of 1% chlorine is required for chlorinating drinking water. This is prepared from HTH containing 70% active chlorine.

As a general rule 1% solution contains 10g of chlorine per litre. Therefore to prepare 1% solution of HTH

10g/L x (100/70) = 14.28g (which can be rounded up to 15g/L or 1 spoon/litre)

Since it is quite impossible to have an exact measurement of chlorine in the field a ‘standard solution’ can be prepared. Instead of using a spoon here, the plastic cap (internal) of a 1 litre plastic cup can be filled to the brim and added to 1liter of water. Make sure standard solution is prepared using the same water source that needs to be chlorinated.

Procedures for conducting Jar test

1. Fill 5 non-metallic containers/ jars of a known volume with water required to be disinfected (e.g. 20L)
2. Label each jar 1-5 and add the following amount of standard solution with a measuring cup/ syringe

   Jar 1 = 1ml

   Jar 2 = 1.5ml

   Jar 3 = 2ml

Jar 4 = 2.5ml and

Jar 5 = 3ml

3. Wait for 30 minutes and measure the chlorine residual in each jar using a comparator (30 minutes is the contact time required to effectively deactivate harmful bacteria in drinking water)
4. Choose the jar which shows a chlorine residual level between 0.2mg/L and 0.5mg/L. The amount of standard solution added to this jar will be the required chlorine dose for disinfecting the water.

Determining chlorine dose for disinfecting drinking water

After conducting the jar test, the chlorine dose required to disinfect a given drinking water supply is determined. For example, if the chlorine residual in each jar was; Jar 1 = 0mg/L, Jar 2 = 0.1mg/L, Jar 3 = 0.4mg/L, Jar 4 = 0.8mg/L and Jar 5 = 1.2mg/L then the dose rate (2ml) for Jar 3 is selected since the chlorine residual lies between 0.2 and 0.5mg/L.

Using the above example, if 2ml of standard solution is required to chlorinate 20L of water then chlorine dose rates for other quantities of water will be:

Bowzer/ Tank capacity (L)	Chlorine dosage of 1% solution (ml)
500	50
1000	100
2000	200
3000	300
4000	400
5000	500
6000	600
7000	700
8000	800
9000	900
10000	1000
10500	1050

Note:
Preperation of 1% solution (slug) of HTH = 15g/L (1 spoon/L)
As an example, if 2ml of 1% HTH solution is required to effectively dose 20L of water. Then for 1L chlorine dose = 0.1ml

Annex 3: Tank Cleaning Procedures

Procedures for black tanks

1. Stop all supply to the tank
2. Drain water from tank till ¼ full
3. Prepare a chlorine solution of 25g in a 20L bucket
4. Wash and scrub inside of tank using a soft nylon scourer
5. Drain the tank and then rinse it with the prepared chlorine solution
6. After 30 minutes repeat the above steps using a lesser chlorine solution (0.2-0.5mg/L chlorine residual solution).
7. Drain and rinse tank fully
8. Check tank fittings and change if required to avoid future contamination
9. Fill tank again and begin operation
10. Record tank cleaning completion in a log book

Procedures for T11 and T45

Employ the same procedures as of above. However ensure lining is not damaged.

Annex 4: Oxfam Water Quality Monitoring Schedule

Location	Parameters	Frequency	Site
Water Source	TDS (conductivity)	1 sample/ month	All water sources
	Turbidity, pH , Temperature, TTC	1 sample/ month	All water sources
Treatment (filtration)	As per the operational monitoring schedule for Skyhydrant filtration plant		
	Chlorine residual	1 sample/ week	1% of storage tanks on site (random)
Bowzer	TDS	1 sample/ month	Random bowzers (1 or 2 depending on how many bowzers operating)
	Turbidity, pH	1 sample/ month or fortnight if collected from filtration plant	Random bowzers (1 or 2 depending on how many bowzers operating)
	Temperature and TTC	1 sample/ month	Random bowzers (1 or 2 depending on how many bowzers operating)
	Chlorine residual	1 sample/ week	Random bowzers (1 or 2 depending on how many bowzers operating)
Tanks and tap stands	TDS	1 sample/ month	Random tanks and random tap stands (1% or 5% of total)
	Turbidity, pH,	1 sample/ month or fortnight if collected from filtration plant	Random tanks and random tap stands (1% or 5% of total)
	Temperature and TTC	1 sample/ month	Random tanks and random tap stands (1% or 5% of total)
	Chlorine residual	1 sample/ week	Random tanks and random tap stands (1% or 5% of total)
Household filters	Turbidity and TTC	1 sample/ month	Random samples from the top level and lower level of the filter. !% or 5%

Please Note:

- Once random tanks and tap stands in camps/ village and treatment plant have been selected for testing do not change selection.
- Test for chlorine residual before collecting samples for testing TTC from bowzer, tank and tap stand. If chlorine residual lies between 0.3-0.5 mg/L do not collect and test for TTC.
- Collect samples from 1% of household filters distributed in the district. For example, if 5000 filters have been distributed in Ampara test water quality for 50 household filters in the district.

Annex 5: Water Quality Sampling & Testing Procedures Using the Delagua Kit

Preparing Membrane Lauryl Sulphate Broth (MLSB) in the Laboratory

Procedure

1. Carefully wash 10 60ml plastic polypropylene bottles in clean, warm water before use
2. Measure 500ml of distilled water using a measuring cup and decant approximately half of the water into an empty container.
3. Add the 38.1g of MLSB powder to the distilled water in the container and stir until the powder has dissolved. Add the remaining volume of distilled water from the measuring cup and continue stirring to thoroughly mix the broth.

The culture medium will be a bright red colour when dissolved

4. Pour a suitable volume of culture medium (approximately 50ml, but no less than 40ml) into each of the 10 polypropylene bottles

This provides sufficient medium in each bottle to carry out 16 tests

5. Replace the screw caps on the polypropylene bottles. Make sure the caps are secure but do not tighten

Leaving the caps slightly loose prevents the bottles from collapsing during sterilization

6. Place the bottles of culture medium into the stainless steel pot of boiling water, taking care to ensure that the bottles do not come into contact with the base of the pan (use a rack or stand) or become submerged. If pressure cooker or autoclave is used refer to procedures in Delagua manual
7. Boil for 20 minutes.
8. Leave the medium to stand for 24 hours at room temperature (20-30degree C) in the dark.
9. On the following day heat the medium in boiling water for a further 20 minutes and once again, leave to stand for 24 hours.
10. On the third day repeat the heat treatment. The medium is now sterile and ready to use

Storage

1. Store the sterile MLSB in a refrigerator or in a cool dry place

If medium is stored in a refrigerator it can be used for 6 months, otherwise only for 3 months if stored in a cool dry place

Disposal

After conducting the tests do not discard non-sterile membranes and pads into the environment as it is a major public health risk. Therefore prior to disposing materials the following procedures need to be followed:

1. Plunge all used petri dishes, pads and membranes in boiling water for 30 minutes
2. Burn the sterilized pads and membranes
3. Wash petri dishes with detergent, rinse with clean water and allow to dry

Note: When ampoules are available need not prepare MLSB culture media

Sterilization of Laboratory/ Field Testing Equipment

Filter Apparatus

1. Carefully dry the Delagua sample cup and filtration assembly with a clean dry tissue

2. Using the plastic collar, secure the filtration funnel in a loose but not free position to allow the formaldehyde gas to penetrate all areas of the filter head

3. Pour about 1ml (approximately 20 drops) of methanol into the sample cup

4. Carefully ignite the methanol in the sample cup using a cigarette lighter. Place the cup on a flat surface, which will not be damaged by heat.

   Caution: Keep the mouth of the sample cup away from your face and the hole uppermost to prevent methanol running onto your hand.

5. Allow the methanol to burn for several seconds and when nearly burned out place the filtration head over the sample cup and push firmly into place to form a good seal.

6. Keep the filtration apparatus sealed for at least 15 minutes before use.

7. Carefully dry the Delagua sample cup with a clean dry tissue

Petri dishes

1. Plunge the bases and lids of the dishes into boiling water for 10 minutes. Pour away the water and assemble the dishes as they dry, but while they are still hot. Alternatively remove petri dishes from boiling water with stainless steel tongs and arrange them as they dry.

Field sample bottles

1. Immerse sample bottles (polypropylene) in the stainless steel pot containing boiling water for 10 minutes

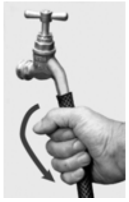
2. Remove bottles using tongs and allow them to dry completely on a clean surface

3. Once completely dried cover the bottles with lids. Place foil between lid and bottle to avoid contamination in the field

Water Sample Collection Procedures for Field & Laboratory Testing

Sampling from a tap

Collection of samples for field test



1. Remove any attachments from the tap such as nozzle, pipes, etc and check that the tap does not leak
2. Carefully clean the mouth of the tap with a clean tissue to remove any dirt or grease

3. Open the tap and leave water running for at least one minute before taking a sample. Do not adjust the flow of water during this time

4. Take a water sample with the delagua sample cup. Rinse the cup twice with the sample water before taking the sample
5. Conduct field test according to testing procedures

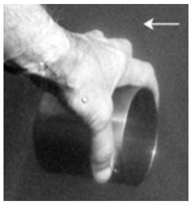
Collection of samples for laboratory test

1. Follow procedures 1-3 as above
2. Remove cap of sterile 60ml polypropylene bottle carefully without contaminating it and hold it with the other hand. Collect 2 samples
3. Fill the bottle completely to avoid any air bubbles to form. Replace the cap and close tightly
4. Store and transport bottles in a cool box (4°C-6°C)
5. Conduct test according to testing procedures in the laboratory

Sampling from a lake, reservoir or other surface water source

Collection of samples for Field test

1. Samples may be collected by hands, however use gloves if available
2. Grasp the delagua sample cup firmly keeping your fingers clear of the top of the cup to avoid contamination and dip the open mouth of the cup into the water



3. Submerge the cup about 30cm below the surface of the water and scoop up the water sample
4. Samples should be taken against the current flow of the water if there is a current flow (e.g. Rivers, streams)
5. In many cases it may be inconvenient or dangerous to enter the water. Then the sample cup can be lowered into the water by fastening the 2m sample cable to the hole in the lip of the sample cup
6. Conduct field test according to testing procedures

Collection of samples for laboratory test

1. Follow procedures 1-5 as above
2. Remove cap of sterile 60ml polypropylene bottle carefully without contaminating it and hold it with the other hand
3. Fill the bottle completely to avoid any air bubbles from forming, with water collected by the sample cup. Replace the cap and close tightly
4. Store and transport bottles in a cool box (4°C-6°C)
5. Conduct test according to testing procedures in the laboratory

Sampling from an open well

Collection of samples for field test

1. Fasten the sampling cable to the hole in the lip of the delagua sample cup. Make sure clip is closed and secure

2. If necessary, increase the length of the cable by attaching a rope or string to the sample cable Take care not to loose the sample cup

3. Lower the sample cup into the well, taking care not to allow the cup to touch the walls of the structure where it may pick up dirt. Submerge the cup to a depth of 30cm. If possible keep fingers clear of the cable or rope so as not to contaminate the water body
4. Lift the sample cup carefully
5. Conduct field test according to testing procedures

Collection of samples for laboratory test

1. Follow procedures 1-4 as above
2. Remove cap of sterile 60ml polypropylene bottle carefully without contaminating it and hold it with the other hand
3. Fill the bottle completely to avoid any air bubbles from forming, with water collected by the sample cup. Replace the cap and close tightly
4. Store and transport bottles in a cool box (4°C-6°C)
5. Conduct test according to testing procedures in the laboratory

Important Note:

1. When collecting samples for bacteriological testing (laboratory test) make sure that the delagua sample collection cup is sterilized using the methanol method. This should be done before collecting samples from different sources and sampling points.
2. Do not sterilize the delagua sampling cup whilst collecting samples to test for chlorine residual, TDS, turbidity, pH and temperature.

Total dissolved solids (TDS)

1. Use calibrated Palintest Pocket Tester to test for TDS using the following procedures
2. Remove the cap and press the On/Off button on the keypad
3. Immerse the electrode about 2cm into the sample collected in the delagua sample cup
4. Stir once and let the display stabilise
5. Record the value in the water quality sampling form
6. Press the hold button if you wish to hold the reading and press again to release the reading
7. Press the on/off button to switch the Pocket Tester off

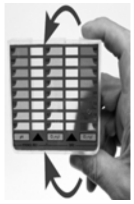
Rinse the electrodes with distilled water between samples to avoid cross contamination

Free chlorine residual and pH

1. Wash the delagua comparator cells three times with water that is to be analysed and finally fill both cells with the water sample collected in the non-sterile delagua sample cup

2. Drop one DPD No1 tablet into the right hand cell (Cl_2) and one Phenol Red tablet into the left hand cell (pH)

3. Replace the lid of the comparator and push down firmly to seal. Invert the comparator several times until the two tablets have dissolved completely



4. Immediately read the free chlorine residual (mg/l) and pH by holding the comparator up to daylight and matching the colour in the cells with standard colour scales

5. Record the result in the water quality sampling form

Turbidity

1. Push the upper tube (open at both ends) squarely into the lower tube and align the graduation marks up the side
2. Look through the open end of the tube at the black circle printed on the yellow base of the tube; this is the marker. Ensure that there is good illumination available
3. Hold the tube vertically and slowly pour the water sample from the delagua sample cup into the tube until the marker just disappears when viewed from the top of the tube
4. Avoid creating bubbles, as these may cause false reading. Do not strain to see the black circle as this can sometimes cause biased result.

5. Hold the tube vertically and read the turbidity using the graduations on the inside of the tube
6. The result is the value of the line nearest the water level. This permits a reasonable estimation of the turbidity of the water sample.
7. Record the result in the water quality sampling form

Temperature

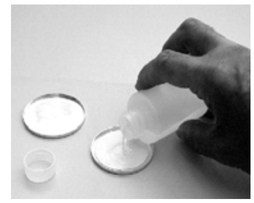
1. Wipe the delagua thermometer dry with a clean tissue
2. Immerse the thermometer in the sample
3. Allow to stand for 1 minute
4. Read the temperature of the sample in °Celcius
5. Record the temperature in the water quality sampling form

Testing for Thermotolerant Coliform (TTC) Using the Delagua Kit

Testing Procedures

1. Place absorbent pad in each petri dish using the dispenser or sterilised tweezers
2. Allow ampoules or prepared culture media to warm to room temperature before use

3. Pour sufficient amount of culture media from bottle or ampoules into the petri dish



4. Flame tips of tweezers with lighter for 5 seconds and place it in the test kit (hooked to the hinge) to keep it away from contamination
5. Remove filtration apparatus from sterile sample cup and fit it firmly onto the vacuum cup. Place the apparatus in an upright position
6. Unscrew plastic collar and filtration funnel so that it can be easily removed

7. Using the sterile tweezers remove a sterile membrane filter from the packet

8. With the other hand lift the filtration funnel and plastic collar, place the membrane filter (grid side facing upwards) into the bronze disc filter support

9. Replace the filter funnel and plastic collar immediately
10. Screw the plastic collar down tightly

11. Pour the sample (sample collected in the field) carefully into the filtration funnel up to the appropriate mark (10, 50 or 100mlaccording to source of water)

12. Insert plastic connector of the vacuum pump into the connection on the sample cup

13. Squeeze the pump several times to create a vacuum
14. Then squeeze as required to draw all the water through the membrane filter
15. When all the water has drained through, remove the pump from the apparatus

    Unscrew the collar and remove the funnel with hand

16. With the other hand lift the membrane using the sterilised tweezers

17. Place the membrane (grid side upwards) in the petri dish
18. Close the petri dish with the lid and mark the lid with the sample details using the marker pen

19. Place petri dish in the carrier and return to the incubator (all 16 petri dishes should be in the rack during incubation)
20. Re-sterilise filtration apparatus and run other samples
21. Once all samples have been filtered wait for a minimum of 60 minutes before switching on the incubator. This allows for resuscitation of bacteria
22. Incubate samples for 16 to 18 hours at 44°C. Keep case lid closed to avoid heat loss

Counting colonies & results

1. Remove the petri dishes from the incubator
2. Remove the lid of a petri dish and observe the surface of the membrane in good light
3. Count all the yellow colonies (if MLSB is used) or blue colonies (if M-FC broth in ampoules used) which have a diameter of between 1 to 3mm
4. Sometimes colonies will merge so count the sub-colonies. Do not count colonies that are red/pink or grey. They are not thermotolerant bacteria
5. If there are large sized yellow colonies count methodically using the horizontal grid lines. If there are more than 100 colonies on the membrane, the number can be estimated by dividing the membrane in sections.
6. Convert the count into number of TTC per 100ml by the following calculations

Volume filtered	TTC per 100ml
100 ml	Number of colonies x 1
50ml	Number of colonies x 2
10ml	Number of colonies x 10

7. Record result on the sampling form

Annex 6: HACH PathoScreen P/A Testing Procedures

Testing Procedures

1. Wash your hands thoroughly with soap and water.
2. Collect 100 mL of sample in a sterile sample container.
3. Swab the end of the PathoScreen Medium P/A Pillow with alcohol and aseptically cut it open with clippers. Add pillow contents to the 100 mL sample.
4. Place the bottle in a location with a constant temperature between 25–35 °C for 24–48 hours. No incubator required.
5. Note reaction after 24 hours
6. Record results.
7. Dispose of all completed tests appropriately. Use same sterilization process after conducting TTC test with Delagua.

Interpreting the Results

Test Results	Positive	Negative	Follow up
Color changes from yellow to black	Yes		
Black precipitate forms	Yes		
No colour change		No	Incubate for additional 24 hours if no colour change record as -ve

Annex 7: Water Quality Sampling & Testing Form

Village/ Camp:		Field Tester:	
District:		Local PHI:	
GPS Coordinates/ Location:		Laboratory Tester:	

Site Code	Date	Time	Temperature (°Celsius)	Turbidity (NTU)	pH (pH units)	TDS (mg/L)	Free chlorine (mg/L)	Thermotolerant coliform (TTC)		
								Volume filtered (ml)	No of colonies	TTC/ 100ml