RAIN

Rainwater Harvesting Implementation Network

RAIN Water Quality Guidelines

Guidelines and practical tools on rainwater quality

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Disclaimer

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1. Why this document?

1.1 Importance of water quality

As most public health problems are related to contaminated water and hygiene customs, access to good quality water is one of the most important factors to improve people's health. RAIN is an international network which aims to increase access to safe and sufficient water for vulnerable sections of the society in developing countries – women and children in particular – by collecting and storing of rainwater through different means. RAIN focuses on areas which experience a severe shortage of water due to quantity[1] or water quality[2] related issues. In these areas rainwater harvesting (RWH) is a valuable solution to water shortage and will lead to an improvement in livelihoods, starting with improved health. However, improved health can only be secured if water for drinking is of acceptable quality and at least better than the former source of water.

1.2 Objective of this document

This document will address RAINs guidelines towards water quality and will give practical guidelines to improve and maintain an acceptable water quality of harvested rainwater for drinking purpose. It will describe criteria for water quality of harvested rainwater, placed within the socio-economic and geographical context of RAINs target countries. The most practical approach of improving and maintaining the quality of harvested rainwater in rural water supply schemes is not to impose a set of unachievable targets, but to insist on adequate measures of quality protection which significantly improve the quality of water, compared with traditional sources (Morgan, 1990).

1.3 Scope of RAINs guidelines and guidelines towards water quality

This document summarizes the knowledge on how to protect harvested and stored rainwater from contamination. It focuses on simple and practical means to ensure good rainwater quality, reducing the incidence of water-borne diseases and can be used:

- by RAINs Rainwater Harvesting Capacity Centres (RHCCs) and implementing partners (ImOs) as a guideline for testing and analyzing water quality of RWH systems, for protecting rainwater from contamination by providing a range of measures to ensure or improve water quality and for comparing RAINs water quality standards with national standards for drinking water,
- to define RAINs water quality criteria for harvested rainwater towards donors, governments and other organisations,
- to define RAINs guidelines in ensuring water quality to donors, governments and other organisations.

The main document is describing RAINs guidelines towards water quality, while the annexes will provide practical guidelines and tools which can be used at a field level.

[1] No water sources within short reach or no accessible sources (too deep or to low-potential of groundwater).
[2] Contamination of water sources due to geology, for example Arsenic and Fluoride.

2. Water quality and contamination risks of harvested rainwater

2.1 Factors determining water quality of harvested rainwater

Water quality is determined by the composition of water as affected by natural processes and human activities. Water quality depends on the constituents dissolved or contained within the water. It is often presumed that the chemical composition of water is the only factor involved. However, especially (micro) biological factors are of main importance when considering water quality. Next to this there are also physical factors. This is illustrated in figure 1.

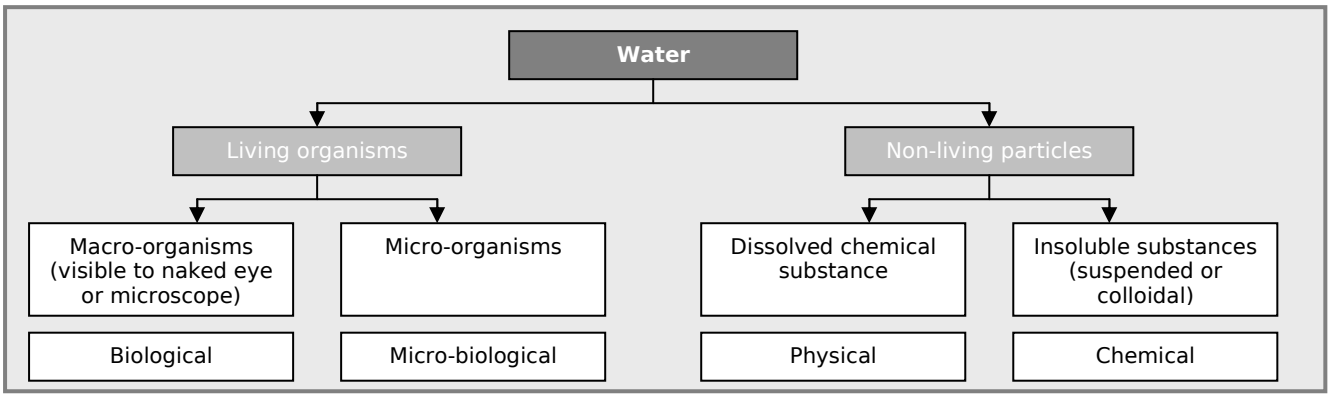

Figure 1: Factors determining water quality.

It is not possible to find completely pure water in nature, since water droplets already begin to dissolve a whole range of substances in the atmosphere, such as gases, airborne dust particles and salt from sea spray. Atmospheric pollution can have a major effect on the composition of rainwater. Water that reaches the earth as rain, acquires other substances from processes such as leaching, weathering, and dissolution. Living organisms may enter the water. All these processes affect the composition of the water. Depending on the source of the contamination, three types can be distinguished:

- <u>(Micro)biological contamination:</u>
  The most common hazard in water sources obtained from roof or surface catchments is microbial (biological and microbiological) contamination, especially enteric pathogens. Enteric pathogens are micro-organisms (bacteria, viruses, and protozoa) that cause gastrointestinal illness. These organisms are introduced into drinking water supplies by contamination with faecal material (from human or animal origin) or dead animals and insects (enHealth, 2004). The most important indicator is E-Coli.

- <u>Chemical contamination:</u>
  Chemical contamination results from air pollution (industrial and traffic emissions), runoff and leaching of chemical substances (agricultural and human activities) and toxic material use. All these factors can pose a serious a health threat. However, in rural areas of developing countries, these activities are mostly absent or very small-scale (for example: fireplaces near a roof or having a chimney can cause soot to settle on the roof), and are therefore unlikely to cause significant impacts on the quality of the collected rainwater (enHealth, 2004).

- <u>Physical contamination:</u>
  Physical contamination includes inorganic and organic sediments like sand, silt, clay, or plant material. Physical contamination affects the colour, odour or taste of the

water, but it poses no direct health risk. Users can however object to water if its colour, odour and taste are found less attractive.

Besides these contamination hazards, another significant health risk is the breeding of mosquitoes in or near RWH systems (see also annex 1). Mosquitoes can breed in a storage tank, but also in blocked rainwater collection gutters, drains, puddles and pools around a storage system, due to inappropriate operation of the RWH system or poor construction. Of particular concern are species of mosquitoes that can be a vector for viruses, for instance dengue virus (enHealth, 2004). malaria, yellow fever and filariasis diseases. A clear link exists between the presence of mosquito larvae and rainwater storage containers lacking secure covers or screens (Kolsky, 1997).

2.2 Risk assessment and control

2.2.1 Water Safety Plan

A Drinking Water Safety Plan, as described in the WHO Water Safety Plans, Managing drinking-water quality from catchment to consumer (2005), is a documented plan that identifies health risks from catchment to consumer of a water supply system. The plan prioritises those risks and puts in place controls to mitigate them. The effectiveness of the management control systems and the quality of the water provided has to be verified by clear indicators. For smaller water supply systems, like most RWH systems, the use of tool kit is found more appropriate. As shown in figure 2, three key stages can be defined in a Water Safety Plan: system assessment, monitoring and management. These are defined by health-based targets and the desired outcomes are verified using a surveillance system.

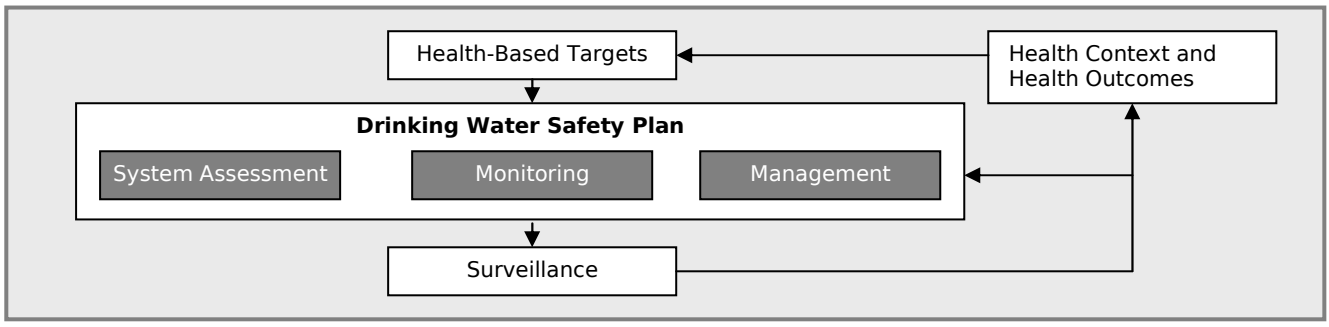

Figure 2: Framework for safe drinking water (The Bonn Charter for Safe Drinking Water, 2004).

RAIN has developed practical toolkits for each stage of the Water Safety Plan:

- Health-based targets:
  A direct measurable target is the quality of the water provided. This is defined in table 2. Improving the livelihoods of people by providing a reliable, safe and nearby source of water can be measured in different ways, like the annual number of diarrhoea episodes or the time spent on the collection of water. However, most health-based targets are difficult to measure since they are not only influenced by the source of water, but also depend on the living circumstances and customs of people.

- System assessment:
  The RWH system as a whole has to be assessed to verify if the water delivered is of a quality that meets the targets specified. Mapping the risks of contamination and taking proper measures to limit these risks as much as possible, is the main objective (see paragraph 2.2.2).

- Operational monitoring:
  By monitoring the control measures which influence the water quality as identified in the system assessment, safe drinking-water can be more ensured. RAIN has developed checklists which are given in annexes 2a, b and c.

- Management plans:
  By documenting the system assessment outcomes and describing actions to be taken in normal operation and incident conditions, management of the RWH system can be optimized. RAIN has developed checklists and actions plans given in annexes 3 a, b, c.

- Independent surveillance:
  The above can be verified by evaluating the operation, maintenance and management of the RWH system and the appropriateness and use of the checklists and actions plan provided by RAIN by an independent organisation (for example the Rainwater Harvesting Capacity Centre (RHCC) of a country).

2.2.2 System assessment: mapping the risks of contamination

Generally treating and filtering of water seems the obvious method for obtaining a certain water quality. This, however, is an end-of-pipe solution. If contamination resulted from for example use of toxic materials or by poor maintenance, re-contamination will certainly occur. By following a top-down method of preventing contamination, a more cost-effective approach can be reached (see figure 3).

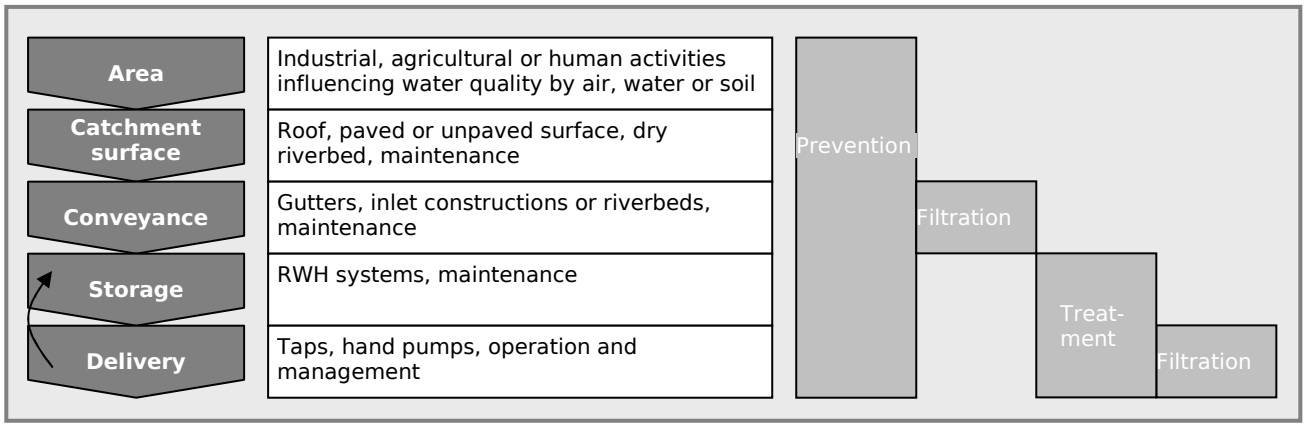

Figure 3: Mapping risks of contamination at RWH systems (based on www.eng.warwick.ac.uk/DTU/rwh/components1.html)

The number of people using a RWH system also influences the impact of a health hazard if contamination would occur. It is therefore important to link the impact of a health risk with the number of people. For household RWH systems the health hazard due to poor water quality is relatively small, since few people are using the water. For community managed systems, like for example school systems, this risk increases since more people can get sick from the water, but also carry this disease home.

2.2.2.1 Area

The area can be described as the external factors influencing the background or reference water quality in a RWH system and can be divided into physical and social factors:

- Physical factors:
  The air, water and soil pollution present within the area, resulting from industrial and agricultural activities and geology directly influences the water quality of the RWH system. Mostly these factors are difficult to influence, but should be taken into account when starting a RWH project. In rural areas their influence is relatively small and can often be excluded, but can reflect unexpected outcomes in water quality tests.

- Social factors:
  Human conduct and level of education, reflected in the level of awareness of the relation between water and health, hygiene and sanitation, management and

maintenance skills of RWH systems are social factors controlling water quality of a RWH system.

2.2.2.2 Catchment surface

The catchment surface can be described as the area on which the rainfall is collected. Depending on the type of RWH system, several catchment surfaces can be defined, i.e. roofs, paved or unpaved surfaces, dry sandy river beds. Contamination can be prevented by:

- Using non-toxic materials for roofing, like cement, corrugated and galvanised iron. Metal roofs subjected to atmospheric corrosion can act as a source of heavy metals[3];
- Frequently cleaning and clearing of the catchment surface (from human, animal and organic matter), removing overhanging branches and fencing off of the catchment area in the case of surface runoff.

Faecal contamination of water from rooftops can result from animal droppings on the roof surface. Water harvested from ground surfaces is vulnerable to contamination by animal or human faeces. The larger the catchment surface, the bigger the chance for contamination due to more complex management of the catchment.

2.2.2.3 Conveyance

The conveyance can be described as the means of transportation of the collected rainfall from the catchment surface to the storage system. Depending on the type of RWH systems, several conveyances can be defined: gutters, inlet pipes, and collection and inlet canals. Contamination can be prevented by:

- Using non-toxic materials;
- Frequently cleaning of the conveyances. Debris and pools should not remain in the gutters, since they can become pools of contamination.

Contamination might have occurred in the previous level (the catchment area). Therefore filters should be installed at the entrance or end of the gutters or inlet canals to prevent (small) animals, organic matter and debris from entering the RWH system. A first-flush device should be installed to divert the first (millimetres of) rainfall, which contains the main load of pollution.

2.2.2.4 Storage

The storage can be described as the structure or medium in which the rainwater is stored. In RAINs current programme three different types of RWH systems can be defined: above ground tanks, below ground tanks and sand dams. Contamination can be prevented by:

- Using non-toxic construction materials;
- Using adequate covering to prevent influence from direct sunlight, human, animal and organic matter from entering the storage system and mosquito breeding.

Contamination might have occurred in the previous levels. Treatment of the water can be applied when found necessary (see table 1 and annexes 3 a, b and c). Residence in the storage system itself provides opportunities for water purifying processes such as sedimentation, bacterial die-off and filtration (for sand dams), increasing the water quality over time.
Cleaning of the storage system should only be done if the previous water was found to be contaminated (see annex 6). Surface runoff storage systems will contain a lot of soil material which has to be removed every year when the tank is empty (before the rainy season) since it not only affects the water quality, but also decreases the tank capacity. Sand dams have no

[3] The presence of zinc, lead and cadmium in roof runoff is reported in studies, but its concentration was below the WHO guideline value for drinking water (Meera et al, 2006).

closed storage system which makes it even more important to limit contamination risks as much as possible in the previous levels.

Other possible risks of contamination at the storage level are:

- Frequent opening of the manhole.
  Although many people see opening of the manhole as necessary to investigate the water quality (by colour, odour, debris etc); it will pose a bigger risk to contamination since debris might fall into the tank. Children sometimes use the tank to bath in, which is not only dangerous, but will increase risks of contamination.
- Mixing of tank water or filling of a tank with water from other sources.
  If water from another source has been tested and found not contaminated (see table 2), the water can be mixed under well-controlled circumstances with the water in the RWH system. If the water is not tested, chlorination should always be applied after mixing with the water in the RWH system.

2.2.2.5 Delivery

The delivery can be described as delivery point to the user, hence the pump or tap by which the user fetches the water. Contamination can be prevented by:

- Proper management of the water distribution;
- Creating awareness on hygiene issues (hygiene education).
  People can contaminate the water by non-hygienic use of the taps or pumps, as well as use of unclean containers after extraction. This will be further discussed in paragraph 4.2.;
- Closing the area around the delivery point for animals,
  because they can infect the water by drinking from the (leaking) taps or pumps;

- Preventing water pools around the RWH systems which could enhance mosquito breeding for example by increasing the infiltration capacity of the soil at the delivery point (gravel). The picture on the right shows a good example of increasing the infiltration capacity near the tap of an above ground tank.

If the quality of the water is still in doubt, treatment at a household level can be applied (see table 2).

3. Recommended methods and measures for ensuring and improving water quality

3.1 Treatment and filtering

3.1.1 Treatment and the local context

For most small and remote settlements in developing countries, water treatment is both impractical and often unrealistically expensive. The main desired impact of water supply projects is to improve health, and therefore treatment of water should be applied if health is at risk. In contrast to most unprotected traditional water sources, drinking rainwater from well-maintained RWH catchments and storage facilities represent a considerable improvement: protection for possible health hazards is of more importance than applying treatment measures. Treatment of water harvested from rooftops is mostly not necessary (see box 1). In contrast, the quality of water collected from surface run-off catchments can contain high levels of suspended sediments which lead to higher contamination risks. However, water quality standards should always be seen within the local context and be adapted to the national standards, not impose a set of unrealistic (western) standards.

BOX 1: Fact sheet "The place of Domestic Roofwater Harvesting in water supply strategies" developed by Development Technology Unit of the University of Warwick, UK *[IRCSA website]*:

" In terms of organic and inorganic pollutants, untreated rainwater from roof runoff, withdrawn from well-maintained tanks fitted with inlet filters, is generally well within WHO standards and is superior to most groundwater. Microbiological contamination (indicated by levels of E.coli) is in the "low risk" category of WHO water quality standards, surpassing the quality of most traditional water sources and many improved sources. Such contamination is reduced further with storage. No additional treatment is usually needed. However, if higher quality water is required, standard household treatments such as boiling, chlorination or SODIS are effective on stored rainwater."

3.1.2 Recommended treatment and filtering methods

Water treatment only makes sense if it is done properly, and if hygienic collection, storage and use of water ensure prevention of recontamination. Due to the fact that RAIN works in remote areas, a selection has been made of practical and acknowledged treatment and filter techniques, presented in table 1. Until now RAIN only has had experience with chlorination.

RAINs recommended treatment and filtering methods for RWH systems				
Treatment method		**Roof runoff**	**Surface runoff**	**Sand dam**
Solutions or substances to be added to water:	Chlorination	tank	household[4]	household
	Silver coated ceramic balls	tank	household / tank	household
	Aluminium sulphate		household / tank	
	Moringa oleifera and stenopetala		household / tank	
Filters:	Ceramic pot filter	household	household	household
	Bio-sand filter	household	household	household
Heat and UV radiation:	Boiling	household	household[4]	household
	SODIS	household	household[4]	household

Table 1: RAINs recommended treatment and filtering techniques for RWH systems (grey = not appropriate or necessary for this type of system).

[4] water needs to be almost sediment-free, other treatment method to remove sediments should be applied first.

A more detailed description of these methods can be found in annexes 5 a – h. More information on these methods can also be found on www.who.int/water_sanitation_health/ and www.who.int/household_water/.

3.2 Hygienic practices

3.2.1 The importance of hygiene in water supply projects

In the absence of hygienic water practices, attempts to ensure high water quality will be futile. Safe rainwater can be easily contaminated after extraction from the system, for example by the use of contaminated jerry cans or by contamination present on the hands of users. Hygiene education and monitoring of the operation and maintenance of the system, along with sanitary practices, are essential if rainwater supplies are to provide clean water. Creating awareness on personal and system hygiene issues related to water is crucial. Local health organizations play an important role in educating consumers on water treatment methods, managing water supplies and giving specific guidance in managing, operating and maintaining RWH systems. Water supplies, sanitation facilities and hygiene behaviour work together as an integrated package: the quality of the approach in all components determines the outcome (Hygiene Promotion, Thematic Overview Paper 1, 2005).

3.2.2 The Hygiene Improvement Framework

Hygiene promotion works best when combined with improvements in water supply and sanitation services. The Environmental Health Project EHP therefore developed the Hygiene Improvement Framework (HIF), which combines the multiple fronts to fight water-related diseases and uses lessons learned from y ears of program experience. Three key elements can be defined: access to the necessary technologies, promotion of healthy behaviours, and support to ensure long-term sustainability. The HIF can be used as a framework to find the missing elements within a water supply and sanitation project. More information can be found in annex 7.

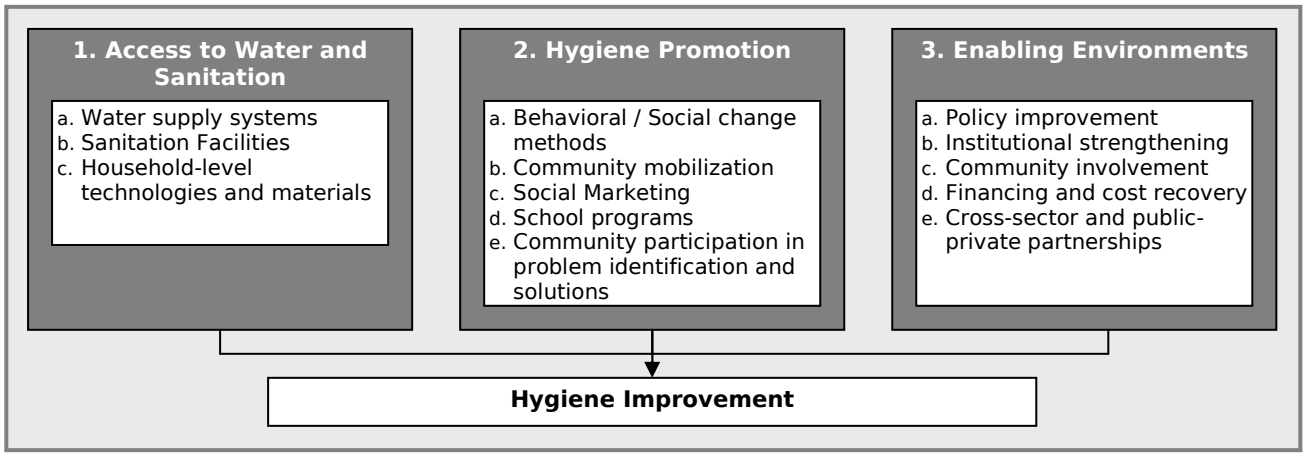

Figure 4: The Hygiene Improvement Framework (The Hygiene Improvement Framework, 2004).

Sanitation and hygiene play an important role in water supply projects. However RAIN will focus on providing sufficient and safe drinking water and will seek collaborations with national or international organisations with experience on sanitation and hygiene.

4. RAINs recommended methodology for water quality sampling and testing

4.1 Sampling and testing

There are two main parts within a water quality survey, which are:

- *Sampling* = taking a sample from a RWH system, collecting and storing it in a way which does not influence the water quality of the sample.

  Samples should be collected and stored with care: the accuracy of the results is primarily determined by the accuracy of the collection of the sample. Hygienic handling and full understanding of water quality sampling are required. The time of sampling is very important, since concentrations can change over time within a RWH storage system or is depended of runoff events. For instance, runoff of agricultural pesticides will only occur during rainfall events and will decrease in time after storage in a surface runoff tank due to settlement of clay particles. Also pathogens (and therefore E-coli) are known to decrease in time after entering a storage tank.

- *Testing* = taking measurements from the collected (and stored) samples. This can be done by field analysis or in field or official state laboratories.

  Laboratory testing is mostly done under very accurate conditions, but often laboratories are located in cities far away from the sampling locations and the methodology of laboratories can differ. Field testing can be done directly in the field and doesn't require (long) transportation, which can alter the results. Field testing needs to be done by a trained person who is capable of performing the required tests under field conditions.

Since all these factors can control the water quality of a sample, RAIN has developed guidelines for water quality sampling and testing, which can be found in annex 8.

4.2 RAINs water quality criteria

Based on the WHO Guidelines for Drinking Water Quality (2004), water quality analyses from RAINs water quality surveys in Burkina Faso, Ethiopia en Nepal in 2007, RAIN has set water quality criteria for potable water as listed in the table below. More information on these parameters and their risk to health can be found in annex 9.

RAINs water quality criteria based on WHO			
	Roofwater harvesting	**Surface Runoff**	**Sand dams**
E-Coli	< 10 cfu/100 ml	<10 cfu/100 ml	<10 cfu/100 ml
Ammonia	< 1.5 mg/l	< 1.5 mg/l	< 1.5 mg/l
Chlorine[5]	> 0.2 – 0.5 and < 5 mg/l	> 0.2 – 0.5 and < 5 mg/l	> 0.2 – 0.5 and < 5 mg/l
Aluminium[5]	Not relevant	< 0.2 mg /l	< 0.2 mg /l
pH	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5
Turbidity	Not relevant	< 15 NTU	< 5 NTU
Nitrate / Nitrite	Not relevant	< 50 mg/l and < 3 mg/l	< 50 mg/l and < 3 mg/l

Table 2: RAINs criteria for water quality based on WHO guidelines.

Water quality criteria depend on the political and social setting, which can differ from country to country but also within a country. National standards on water quality should always be

[5] Only to be tested in water that is or has been treated with Chlorine or Aluminium

followed if projects require national approval. However, RAINs water quality standards should always be tested next to national standards.

4.3 Baseline and long-term water quality survey

After the first rainy season after completion of a RWH system, a water quality survey should be done. This survey will also give a general idea of the performance of each system, the skills of construction of the implementing partner and the community operation and management. The results of this first survey will lead to fine-tuning of RWH system; identifying construction flaws, identifying operational, maintenance and management flaws and selecting most optimal treatment measures (see annexes 2 a, b and c).

RAINs methodology for water quality surveys			
	Baseline survey	**Long-term survey**	
Period	After 1st rainy season after construction	After rainy season	
Nr. of RWH systems	All RWH systems constructed that year	Random selection of 30% of all tanks (> 1 year old)	
Parameters	All parameters listed in table 2	Roofwater harvesting: • E-Coli, • Chlorine, if chlorination has been applied.	Surface runoff and sand dams: • E-Coli, • Turbidity, • Chlorine, if chlorination has been applied, • Aluminium, if it has been applied.
Period	November – December		

Table 3: RAINs methodology for baseline and long-term water quality surveys.

For the long-term survey a random selection of 30% of all RWH systems older than 1 year will be made. This survey should also be executed after the rainy season and the outcomes can be compared to the outcomes of the baseline survey in order to detect effects of improvements made, treatment measures applied or different operation and management of the RWH system.

4.4 RAIN water quality database

RHCCs can have access to the interactive interface of RAINs website, in which they can access the RAIN database. RAIN has already developed a project database, which will soon also be extended with a water quality database in which results of the water quality samples can be added, edited and exported for statistic analysis. This database will be living document, which will grow in time and can be updated to new insights. It will become a unique document in which long-term and cross-country water quality surveys will be collected. The data can be used to optimize RWH systems, operation and management, report to donors and provide data for policy advocacy and promotion. The RAIN database will be managed by trained country administrators.

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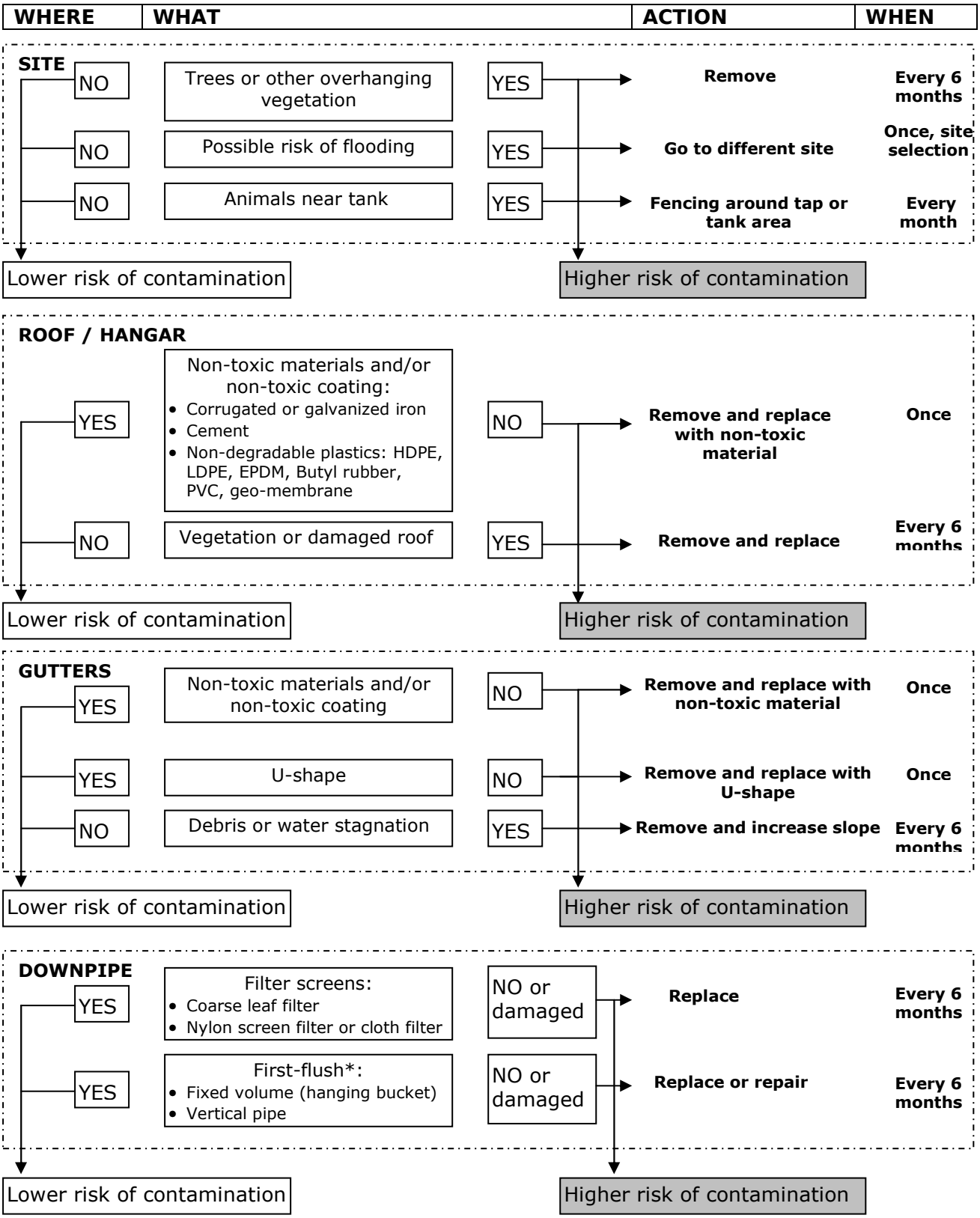
Relevant websites

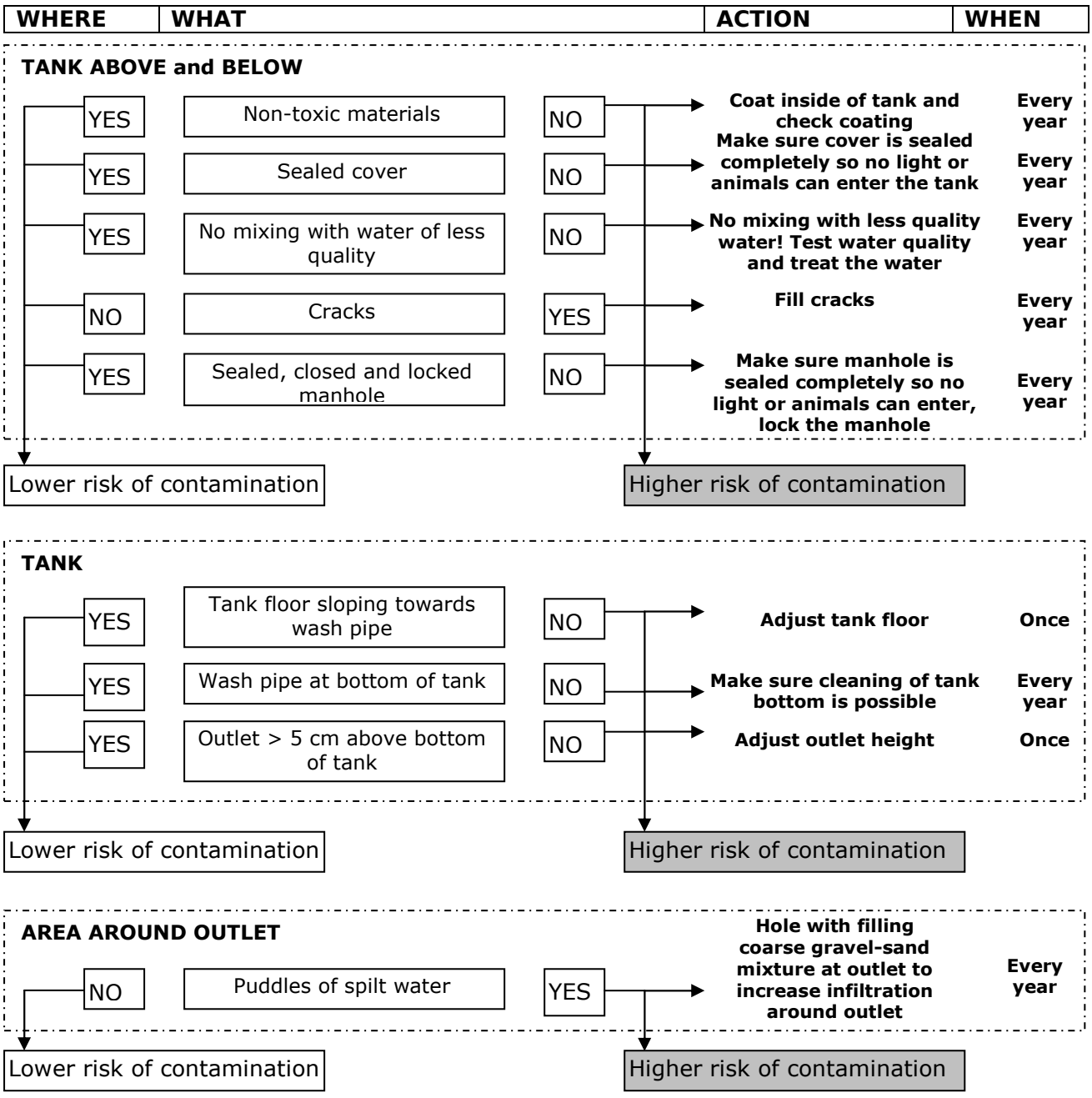
- www.aquaestinternational.com
- www.cawst.org
- www.delagua.co.uk
- www.eng.warwick.ac.uk
- www.enpho.org
- www.icrsa.org
- www.ideassonline.org
- www.pottersforpeace.org
- www.stason.org
- www.sodis.ch
- www.who.int

ANNEX 1: Summary of potential health hazards and preventive measures with roof water harvesting (enHealth, 2004)

HEALTH	CAUSE	PREVENTIVE MEASURES	MONITORING	CORRECTIVE ACTION
Faecal contamination	Overhanging branches on roof	Prune tree branches	Check tree growth every 6 months	Prune tree branches
	Animal access to tank	Protect all inlets, overflows and other openings to prevent entry by small animals and birds	Check inlets, overflows and other openings every 6 months	Repair gaps. Secure covers. If animal access suspected, disinfect tank using chlorine
		Maintain integrity of tank roof and body to prevent access points	Check structural integrity of tank	If a dead animal is found, empty and clean tank. Or remove remains and disinfect with chlorine
	Human access to tank	Prevent access. Ensure tank is roofed and access hatches are secured	Check access covers are secured, particularly in hot weather	Secure access cover
	Surface water ingress into tank (below ground tanks)	Ensure tank is protected from surface runoff flows and tank walls are intact.	Check structure annually to prevent surface water from entering during storm events	Repair or increase barrier to surface water flow. Repair or line inside tank
Mosquitoes	Access to stored water	Protect all inlets, overflows and other openings with mosquito proof mesh	Inspect water for presence of larvae at least every 6 months	Repair screening of inlets and openings to prevent access and if larvae are present, to prevent escape of mosquitoes.
Heavy metal contamination	Lead based paints and primers on roofs	Do not collect rainwater from roofs painted with products containing high lead concentrations (for example, pre-1970s paint).	Water quality has to be monitored for heavy metals from metals roofs if the harvested water is to be used for direct drinking purpose.	
	Lead flashing on roofs	Paint existing material with non-toxic coating	Inspect roof and gutters every 6 months.	Paint with non-toxic material if large amounts of uncoated flashing present
		Remove roof material which might contain toxic products and replace with non-toxic material	During construction	Remove roof material and replace
	Increased corrosion of metal (roof, gutters, piping)	Keep gutters clean. Install leaf protection devices on gutters.	Water quality has to be monitored for heavy metals from metals roofs if the harvested water is to be used for direct drinking purpose. Inspects gutters every 6 months.	Clean gutters and prune trees
Physical and chemical contamination	Re-suspension of accumulated sediment	Reduce amount of sediment by keeping roof catchments and gutters clean. Protect inlet to tank using a leaf filter. Install a first flush diverter.	Inspect roof and gutters and inlet filter every six months. Inspect tank every 2-3 years.	Clean roof, gutters and inlet filter as necessary. Ensure filter is in place. Clean tank if required using non-toxic products.
Other chemical contamination from roofs, tanks, piping etc.	Preservative-treated wood, or bitumen based materials	Do not collect rainwater from roofs covered with exposed treated wood orbitumen-based products.	Inspect roof before installing tank	If treated wood present it could be sealed or covered to prevent exposure to rainwater
	Inappropriate material that can cause health risk when in contact with	Use only approved (non-toxic) materials	Check suitability product	Remove or replace product
Dangerous plants	Overhanging branches of poisonous plants	Prune tree branches	Check tree growth every six months	Prune or remove plant

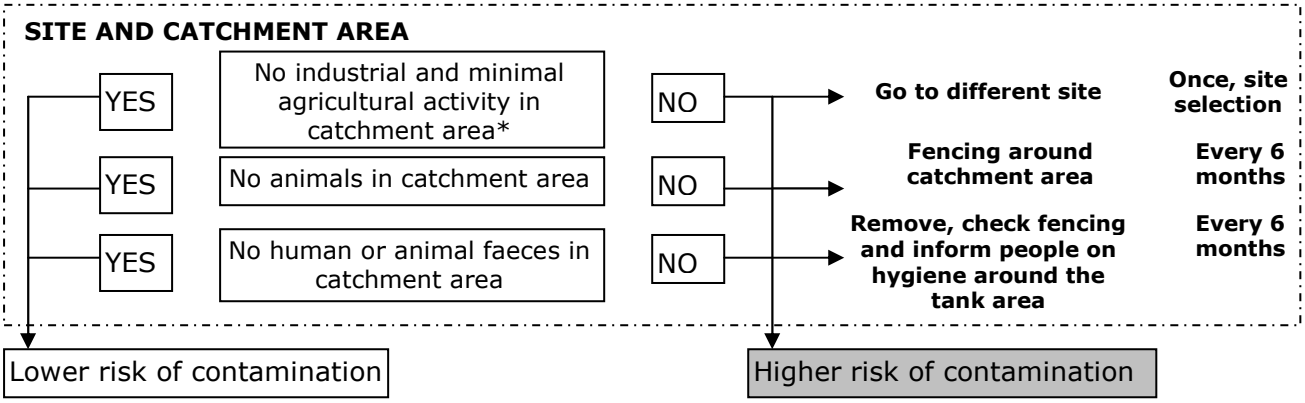
ANNEX 2a:
Water quality checklist for tanks storing roof water



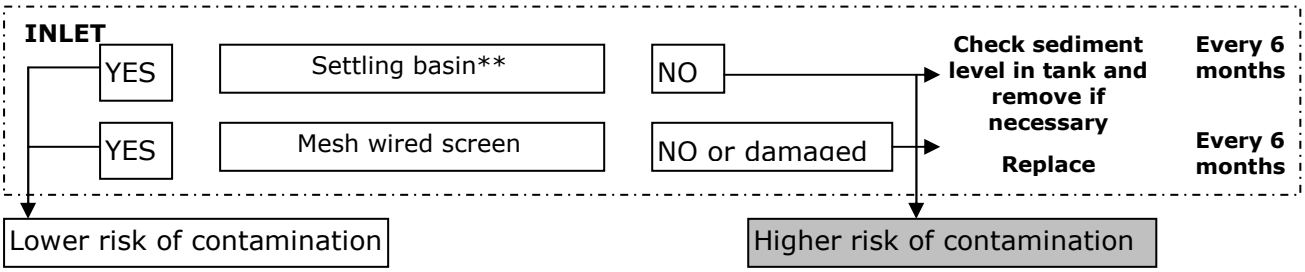

WHERE
WHAT
ACTION
WHEN
TANK ABOVE and BELOW
YES
Non-toxic materials
NO
Coat inside of tank and check coating
Every year
YES
Sealed cover
NO
Make sure cover is sealed completely so no light or animals can enter the tank
Every year
YES
No mixing with water of less quality
NO
No mixing with less quality water! Test water quality and treat the water
Every year
NO
Cracks
YES
Fill cracks
Every year
YES
Sealed, closed and locked manhole
NO
Make sure manhole is sealed completely so no light or animals can enter, lock the manhole
Every year
Lower risk of contamination
Higher risk of contamination
TANK
YES
Tank floor sloping towards wash pipe
NO
Adjust tank floor
Once
YES
Wash pipe at bottom of tank
NO
Make sure cleaning of tank bottom is possible
Every year
YES
Outlet > 5 cm above bottom of tank
NO
Adjust outlet height
Once
Lower risk of contamination
Higher risk of contamination
AREA AROUND OUTLET
NO
Puddles of spilt water
YES
Hole with filling coarse gravel-sand mixture at outlet to increase infiltration around outlet
Every year
Lower risk of contamination
Higher risk of contamination

ANNEX 2b:
Water quality checklist for below ground tanks storing surface runoff

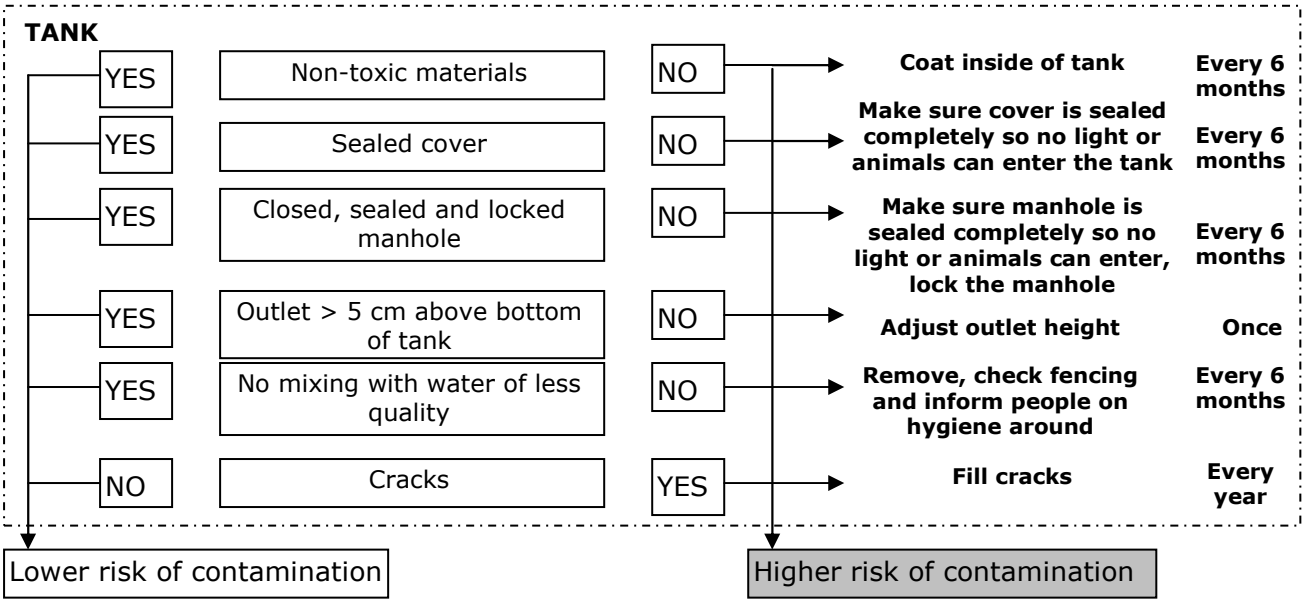
WHERE	WHAT	ACTION	WHEN

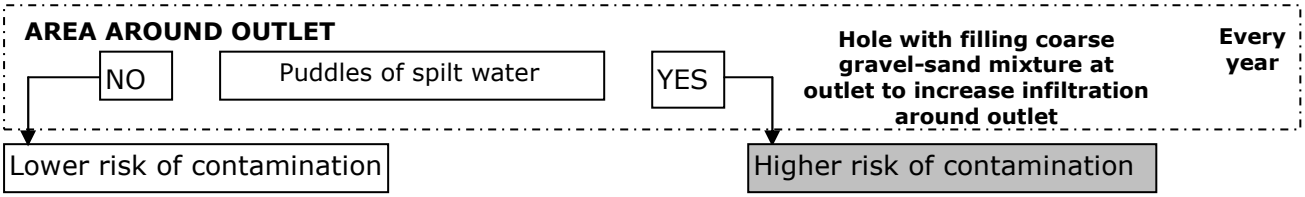


* If an elevation map or digital elevation model is available, it should be used to determine the borders of the catchment and hence the area which affects the water quality in the below ground tank.



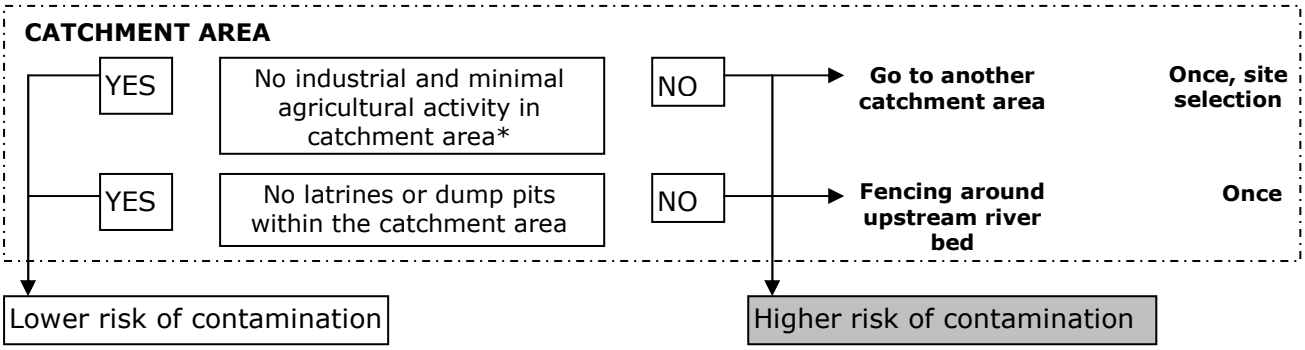
** An enormous settling basin would be needed to ensure settlement of the smallest particles. A smaller settling basin will have such a minimal effect, that the improvement in water quality can be neglected. The tank itself must be considered the main water processing appliance.	Course Sand	Sand/Silt	Silt/Clay
Required area fraction from the tank storage needed for settling basin	0.005%	0.2%	33%



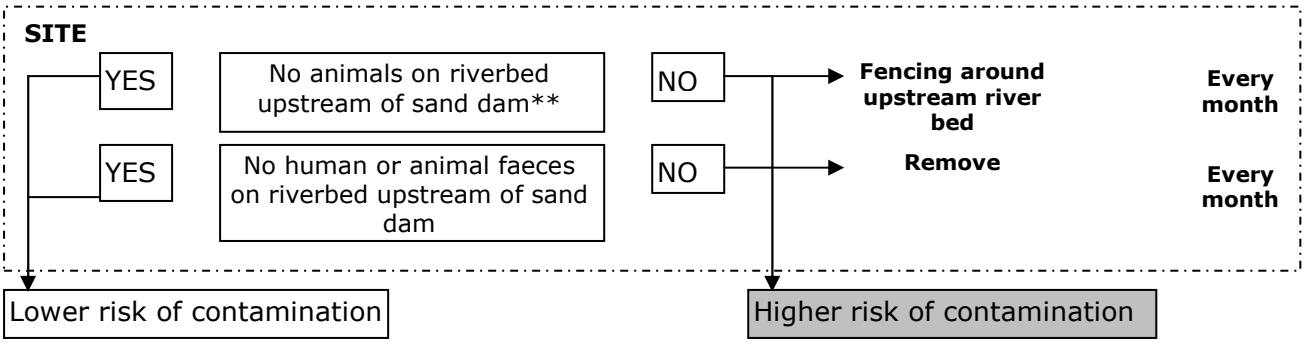


ANNEX 2c:
Water quality checklist for sand dams recharging ground water

WHERE	WHAT	ACTION	WHEN

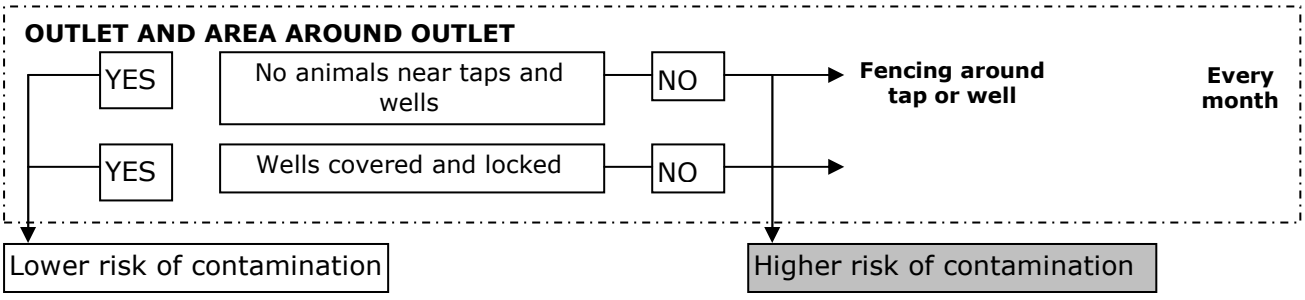


* If an elevation map or digital elevation model is available, it should be used to determine the borders of the catchment and hence the area which affects the water quality in the below ground tank. Other site selection criteria can be found in RAINs Sand dam Manual.

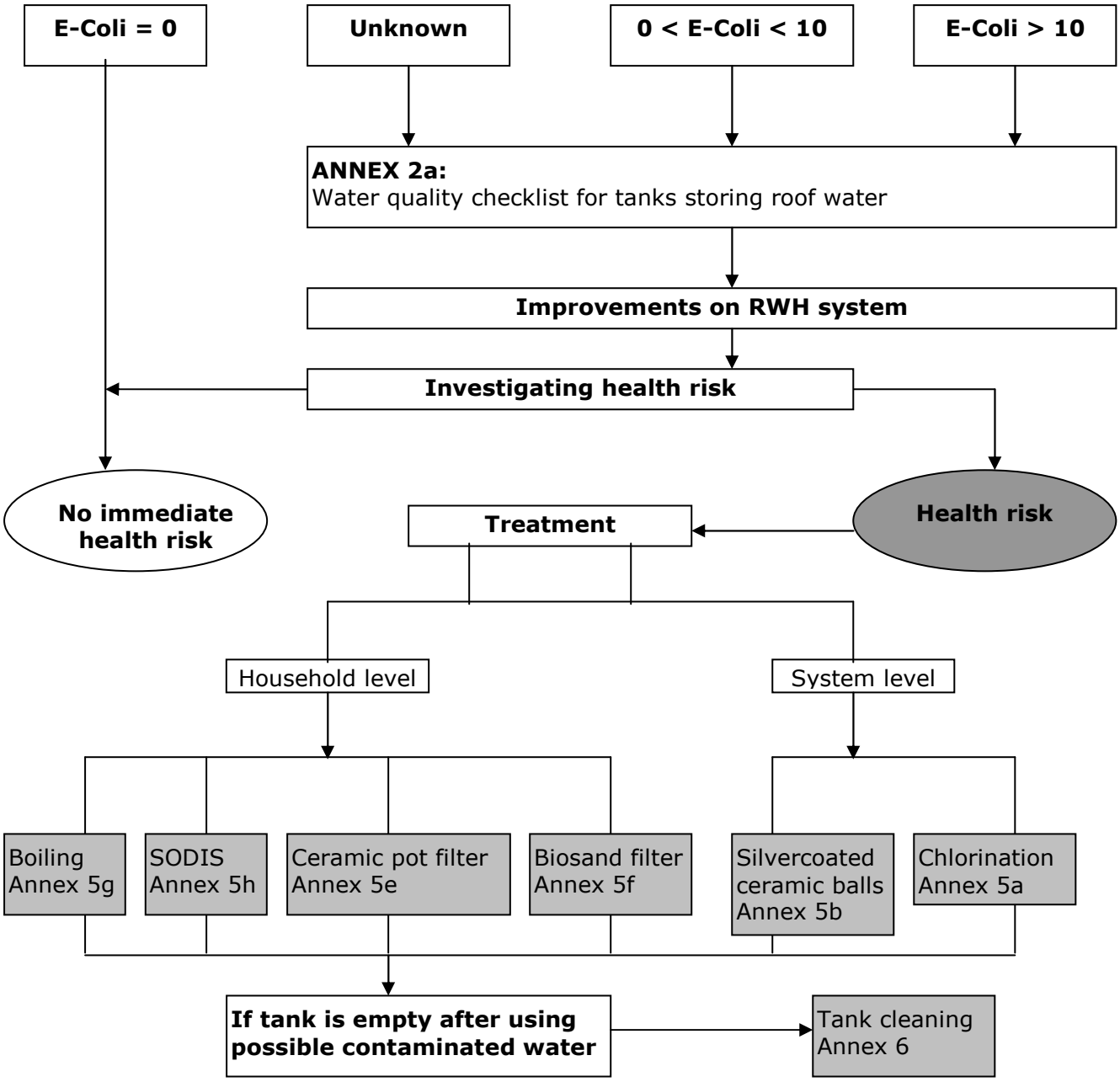


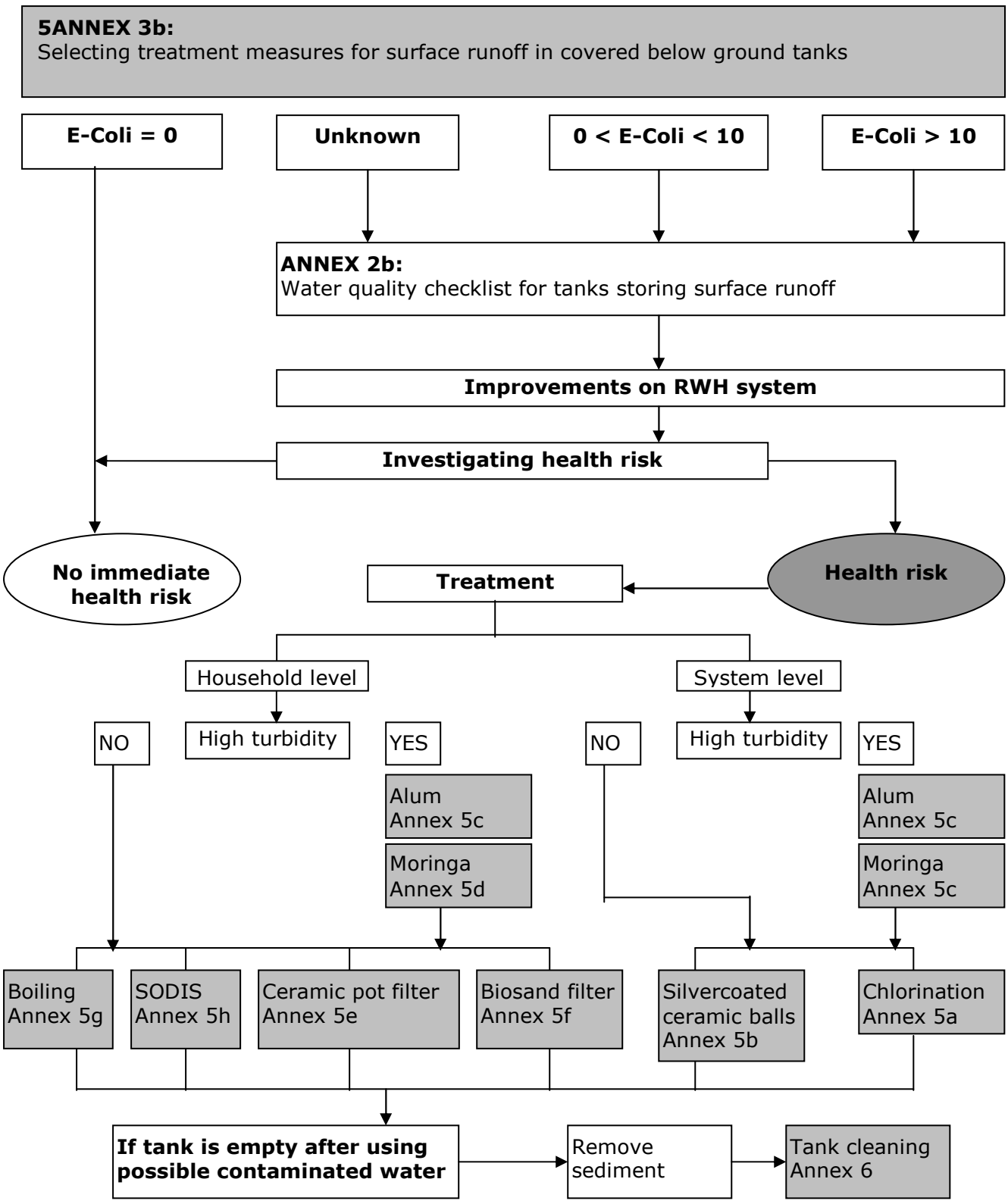
** Since it is difficult to see the whole catchment as a catchment area, it is advisable to focus on the riverbed upstream of a sand dam to the point where the dam affects the water table in the riverbed. This area should be fenced to avoid animals and people from entering this area.

STORAGE
Filtration will occur through the natural process of filtration through the soil. The soil can be seen as an interactive medium which can on one hand serves as a filter but can also be a medium for pollutants.

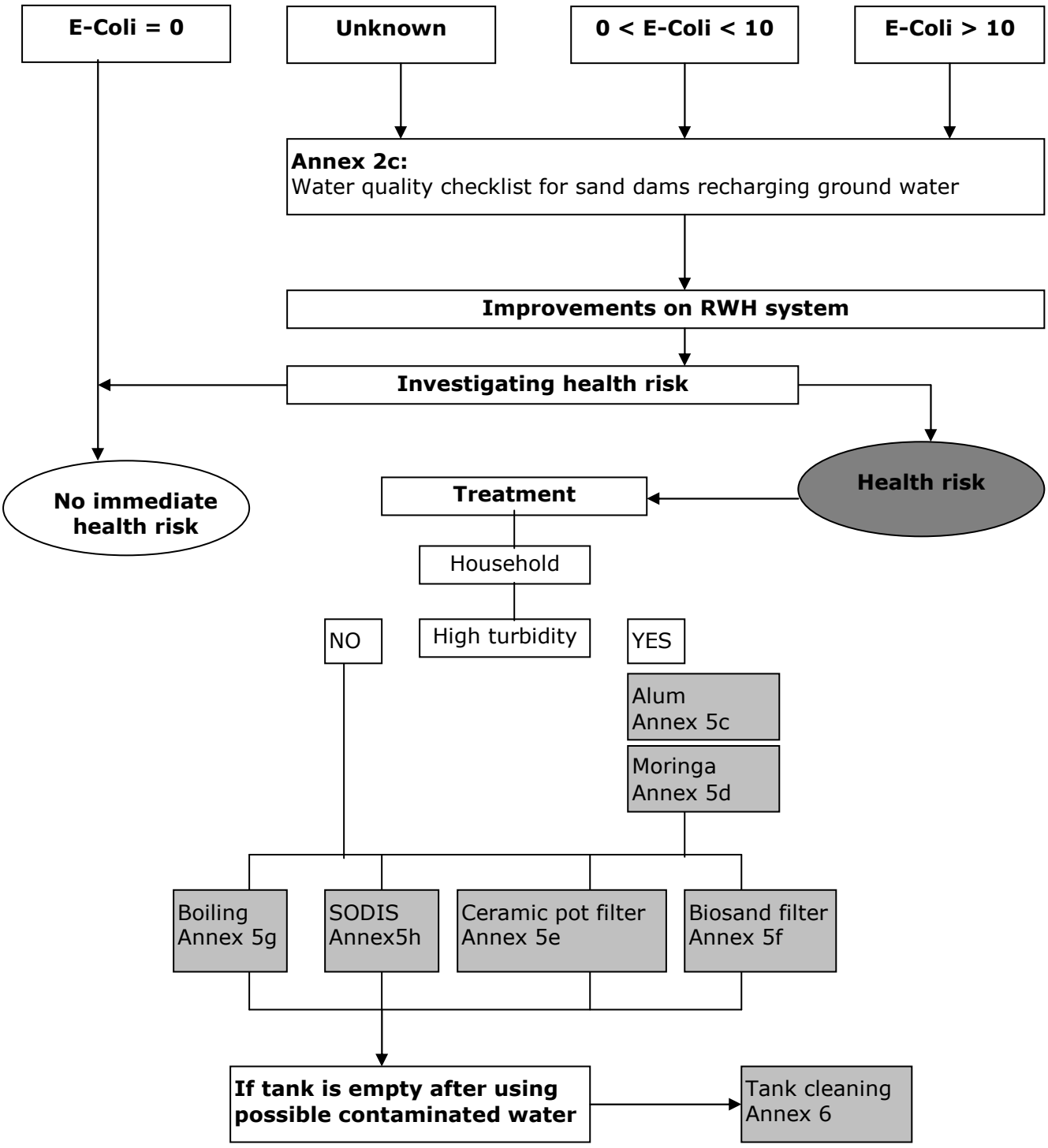


ANNEX 3a:
Selecting treatment measures for roofwater harvesting in covered above and below ground tanks




5ANNEX 3b:
Selecting treatment measures for surface runoff in covered below ground tanks
E-Coli = 0
Unknown
0 < E-Coli < 10
E-Coli > 10
ANNEX 2b:
Water quality checklist for tanks storing surface runoff
Improvements on RWH system
Investigating health risk
No immediate health risk
Health risk
Treatment
Household level
System level
NO
High turbidity
YES
NO
High turbidity
YES
Alum Annex 5c
Moringa Annex 5d
Alum Annex 5c
Moringa Annex 5c
Boiling Annex 5g
SODIS Annex 5h
Ceramic pot filter Annex 5e
Biosand filter Annex 5f
Silvercoated ceramic balls Annex 5b
Chlorination Annex 5a
If tank is empty after using possible contaminated water
Remove sediment
Tank cleaning Annex 6

ANNEX 3c:
Selecting treatment measures for sand dams with tap or covered wells



ANNEX 4:
Evaluation of water treatment methods and chemical coagulants (based on WHO)

Method	Bacteria removal efficiency	Virus removal efficiency	Affection of taste	Main purpose	Type of water
Chlorination	High	High	Yes	Disinfection	Clear
Silver coated ceramic balls	High	High	No	Disinfection	Clear
Aluminium sulphate	High	Moderate	No	Enhances flocculation and precipitation of flocks	Turbid
Moringa oleifera and stenopetala	High	High	No	Enhances flocculation and precipitation of flocks	Turbid
Ceramic pot filter	High	Moderate	No	Filtration and disinfection	Turbid and clear
Bio-sand filter	Moderate	Moderate	No	Filtration	Turbid and clear
Boiling	High	High		Killing bacteria with heat	Turbid and clear
SODIS	High	High	No	Killing bacteria using UV radiation	Clear

Coagulant	Community use	Household use	Advantages	Disadvantages	Cost*	Comments
Alum, alum potash	Yes	Rare-moderate	Community use common; simple technology	Difficult to optimize without training and equipment	Moderate?	Proper use requires skill
Iron salts (ferric chloride or sulfate)	Yes	Rare	Same as Alum	Same as Alum	Moderate?	Proper use requires skill
Lime, lime+soda ash, caustic soda	Yes	Rare-moderate	Same as Alum	Same as Alum; pH control and neutralization a problem; hazardous chemicals	Moderate to high?	Softeners; not applicable to many waters
Soluble synthetic organic polymers	Yes	No-rare	Improve coagulation with alum and iron salts	Same as Alum; hard to dose; need training & equipment; hazardous chemicals	High	Use with other coagulants; limited availability
Natural polymers from seeds, nuts, beans, etc.	Rare	Yes	Effective, available and culturally accepted in some places	May be toxic	Traditional use based on historical practices	Source plant required; training and skill required

*Estimated Annual Cost: low is 0.01 per liter (corresponds to about $100, respectively, assuming household use of about 25 liter per day)

(WHO, 2007, Managing water in the home: accelerated health gains from improved water supply, M. D. Sobsey, School of Public Health, University of North Carolina)

ANNEX 5a:
Practical guidelines for chlorination procedure

General description:
Chlorination is widely recommended to sterilise rainwater collection systems (Macomber, 2001), but generally chlorinated water is not liked by users and the chemicals used can be dangerous if misused. Chlorination is an effective way to disinfect the water, but it must be conducted with care. Chlorination of the water can be done either in the tank or after extraction. In order to ensure that disinfection is taking place and that there is enough chlorine in the system, a chlorine residual of at least 0.2 mg/l must be maintained. Because chlorine does not kill all bacteria, the use of a membrane filter or solar disinfection is recommended (Rainwater Committee Final Report, 2006).

Before getting started:
- Chlorine is available in different forms, it may be best to seek advice from a local Public Health or Water Office if the exact dosage or use is not clear.
- Always use proper safety precautions when working with chlorine, like proper ventilation, eye protection, respiratory mask, long sleeves, work clothing and gloves.
- Make sure the water is not turbid. If the water is too turbid (due to surface runoff), use alum, moringa or a filter to remove the sediments and then apply chlorination.

Household procedure:
1. Add and dissolve one teaspoon of granular calcium hypochlorite (approximately 7 grams) for each 7.5 litres of water. The mixture will produce a strong chlorine solution of approximately 500 milligrams per litre.
2. Add the chlorine solution in the ratio of one part of chlorine solution to each 100 parts of water to be treated. This is equal to adding 1 litre of the chlorine solution (step 1) to each 100 litres of water to be disinfected.
3. The water should be stirred and left to stand for at least 30 minutes to allow sufficient contact time.

Tank procedure: (Rural Community Water Supply and Sanitation Project, 2006)
1. Calculate the approximate volume of water in your tank.
   a. Calculate the tank diameter in metres by checking the dimensions on the design sheet or measuring the outer diameter and wall thickness. Calculate the internal diameter (ID) as follows: **ID (m) = DIA – (2 x WT/100)**
   b. Get a long, clean, dry stick and put the stick through manhole until it reaches the bottom of the tank. Make sure, the stick goes down straight rather than on an angle. Use a rule or tape to measure the length of the wet part of the stick in cm. This gives you the water depth in the tank (WD). Calculate the volume of water (V) in your tank as follows: **$V\ (Litres) = 0.79 \times (ID)^2 \times WD \times 10$**
   c. Dissolve sufficient bleaching powder (see table below) in water in a bucket and add to the tank. It is important to mix the chlorine in a plastic bucket in the open air before pouring it into the tank. Mix it thoroughly with the tank water. Do not pour water on to chlorine! Always add chlorine to a small amount of water and then add to the tank.

Volume of Water in Tank (Litres)	Amount of Bleaching Powder to Add	
	Grams	Teaspoons
1,000	7	1¾
5,000	35	8¾
10,000	70	17½

2. Wait 24 hours after putting in the bleaching powder to allow enough time to disinfect the water before using for drinking/cooking. Any chlorine smell and taste in the water will go away after a short time. If you find the taste of chlorine unacceptable, an alternative is to boil the water for at least five minutes before drinking it, or use SODIS.
3. The best way to know if you have added sufficient chlorine is to check the chlorine residual 30-60 minutes after adding chlorine. It should be in the range of 0.2-0.5mg/l.

ANNEX 5b:
Practical guidelines for use of silver-coated ceramic balls

General description:
Silver-coated ceramic balls are used to purify physically clean water. The use of silver, as a water purification technique, goes back millennia and is a proven method of eliminating bacteria and algae. The ceramic balls can be hanged inside of the tank and will release silver ions into the water which inhibit bacteria reproduction. It will hold its residual disinfectant value to water whilst in storage. This silver disinfection technology has been successfully tested by certified laboratories in Mexico and fully approved by the Mexican Ministry of Health and complies with the WHO Guidelines and requirements of the US Environmental Protection Agency (Aquaest website).

Tank and household procedure:
Hang required amount of ceramic balls inside a RWH storage system. Disinfection generally occurs within approximately 3 hours. More information can be found on www.aquaestinternational.com.

ANNEX 5c:
Practical guidelines for use of Aluminium sulphate

General description:
Adding coagulation chemicals such as aluminium sulphate (or alum) will increase the rate at which the suspended particles settle out by combining many smaller particles into larger flock which will settle out faster. Alum is also known to remove 80% of Arsine and Fluor present in water (Guidelines for Drinking Water Quality, WHO, 2004). Most of the flocculation agent is removed with the flock. Nevertheless some question the safety of using alum due to the toxicity of the Aluminium in it (Stason website).

Procedure:
- Add 10-30 mg Alum to each litre of water.
- Mix it rapidly with the water.
- Leave the water to agitate for at least 5 minutes to encourage the particles to form flocks. After this at least 30 minutes of settling time is needed for the flocks to fall to the bottom and the clear water above the flocks may be poured off.

ANNEX 5d:
Practical guidelines for use of Moringa_oleifera or stenopetala seeds

General description:
Moringa oleifera and stenopetala seeds treat water on two levels, acting both as a coagulant and an antimicrobial agent. Moringa works as a coagulant due to positively charged, water-soluble proteins, which bind with negatively charged particles (silt, clay, bacteria, toxins, etc) allowing the resulting "flocks" to settle to the bottom or be removed by filtration. Treatment with Moringa solutions will remove 90-99.9% of the impurities in water. It is acceptable for drinking only where people are currently drinking untreated, contaminated water (Doerr, 2005).

Procedure:
1. Collect mature Moringa oleifera seed pods and remove seeds from pods.
2. Shell seeds (remove seed coat) to obtain clean seed kernels; discard discoloured seeds.
3. Determine quantity of kernels needed based on amount and turbidity of water using the table above.
4. Crush appropriate number of seed kernels (using grinder, mortar & pestle, etc) to obtain a fine powder and sift the powder through a screen or small mesh.
5. Mix seed powder with a small amount of clean water to form a paste.
6. Mix the paste and 250 ml (1 cup) of clean water into a bottle and shake for 1 minute to activate the coagulant properties and form a solution.
7. Filter this solution through a muslin cloth or fine mesh screen (to remove insoluble materials) and into the water to be treated.
8. Stir treated water rapidly for at least 1 minute then slowly (15-20 rotations per minute) for 5-10 minutes.
9. Let the treated water sit without disturbing for at least 1-2 hours.
10. When the particles and contaminates have settled to the bottom, the clean water can be carefully poured off.

Dosage Rates	Turbidity (NTU)	n Seeds / n litre of water
Low	<50	1 seed / 4 litres
Medium	50 - 150	1 seed / 2 litres
High	150 – 250	1 seed / 1 litre
Extreme	> 250	2 seeds / 1 litre

Solutions of Moringa seeds for water treatment may be prepared from seed kernels or from the solid residue left over after oil extraction (press cake). Moringa seeds, seed kernels or dried press cake can be stored for long periods but Moringa solutions for treating water should be prepared fresh each time.

Points of attention (Vasedevan & Pathak, 1997):

- The process of shaking and stirring must be followed closely to activate the coagulant properties; if the flocculation process takes too long, there is a risk of secondary bacteria growth during flocculation.
- The process of settling is important. The sediment at the bottom contains the impurities so care must be taken to use only the clear water off the top and not allow the sediment to re-contaminate the cleared water.
- Moringa treatment does not remove 100% of water pathogens. It is acceptable for drinking only where people are currently drinking untreated, contaminated water. If not the following techniques can be used, SODIS, chlorination or boiling the water.

ANNEX 5e:
Practical guidelines for Ceramic pot filter

General description:
This filter consists of a pot-shaped ceramic filtering element that is treated with colloidal silver. Evaluations indicate that CSP filters remove turbidity and harmful waterborne microbes such as viruses, bacteria and parasites that cause diarrhoea, cholera and other waterborne diseases *[NWP et al., 2003]*. The filter can be made by local potters using local materials, with no need for electricity or advanced technology. The filter creates a membrane of tiny pores that stops bacteria from getting through. Next, the filter is soaked in a solution of colloidal silver to prevent bacterial growth (Ideass Nicaragua website). The filter (pot) it filled with water and covered with a lid. Standard filtration rate is between one and two litres an hour. Maintenance consists of cleaning the pot with a brush and changing the ceramic element every 2-3 years. A full detail description of the production of the Ceramic Pot filter can be downloaded on the Potters for Peace website: production-manual-iraq.pdf

Procedure (Potters for Peace website: ide-filter-user-guide.pdf)**:**

Before using the filter the first time:

Soak the ceramic pot in clear water (rain or tubewell water) for 12 hours

OR

Fill the ceramic pot three times, allow the water to seep through, and discard the filtered water.

Doing one of the above two steps will flush the clay smell and color from the ceramic pot. You only need to do one of the above steps, it is not necessary to do both.

Lastly, clean the receptacle tank and spigot with soapy water.

Daily use:

Put the filter in a safe place where it will not get knocked over and secure it to the wall or a post.

If the water source is very dirty, tie a piece of cloth over the top of the filter to strain out the dirt and debris.

The filter will flow faster when the ceramic pot is full, so fill it often.

Keep the lid closed to prevent dust and mosquitoes from entering.

Cleaning the filter:

The ceramic pot should be cleaned once per month or when the flow rate begins to slow down.

- Clean the inside surface of the lid with soapy water and let it dry. Place the lid on a level surface with the clean side facing up.

- Carefully lift the ceramic pot out of the receptacle and set it on the lid. Touch only the rim when lifting the ceramic pot. Do not touch the outside of the ceramic pot with dirty hands and do not set it on an unclean surface.

- Scrub the inside of the ceramic pot with a cloth or soft brush and rinse with clear water. Do not use soap to clean the ceramic pot.

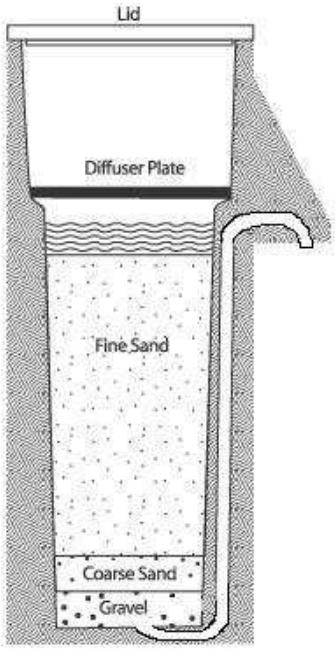
- Clean the receptacle tank and spigot with soapy water.

Put the ceramic pot back into the receptacle tank immediately after cleaning to prevent recontamination. The pot does not have to be dried after cleaning.

ANNEX 5f:
Practical guidelines for Bio-sand filter (CAWST website)

General description:
The Biosand filter is an innovation on traditional slow sand water filters, specifically designed for intermittent or household use. The filter can be produced locally, because it is built using materials that are readily available. It is simply a concrete or plastic container, enclosing layers of sand and gravel which trap and eliminate sediments, pathogens and other impurities from the water through a combination of biological and mechanical processes. Slow sand filters have been proven to almost entirely remove the disease-causing organisms found in water (CAWST websit). The filter has also been proven to remove 64 to 75 % of faecal coliforms and has a flow rate of 30 litres per hour (ENPHO website). There are several factors like quality of sand especially grain size, sanitary and hygienic practice of filter users play a crucial role in removal of pathogens. It can be recommended for one more treatment like SODIS after biosand filter treated water for complete reduction of pathogens.

Procedure:



- Operating the filter is very simple: remove the lid, pour a bucket of water into the filter, and immediately collect the treated water in a container. The filter can produce up to 36 litres / hour.
- Between uses, a layer of water (5cm deep) is maintained above the sand at all times. This distinguishes the Biosand filter from other slow sand filters. The layer of water is shallow enough for oxygen to diffuse through, providing the biological layer with enough oxygen to develop.
- The biological layer typically takes three weeks to develop to maturity in a new filter. Removal efficiency and the subsequent effectiveness of the filter increase throughout this period.

Maintenance:
Continued use of the filter causes the pore openings between the sand grains to become clogged with debris. As a result, the flow rate of water through the filter decreases.

- To clean the filter, the surface of the sand must be agitated, thereby suspending captured material in the standing layer of water.
- The dirty water can then be easily removed using a small container.
- The process can be repeated as many times as necessary to regain the desired flow rate.
- The need to do this depends on the amount and quality of water being put through the filter. If the water is relatively clean (turbidity less than 30 NTU), the filter can likely run for several months without this maintenance procedure. After cleaning, a re-establishment of the biological layer takes place, quickly returning removal efficiency to its previous level.

ANNEX 5g:
Practical guidelines for boiling procedure

General description:
Boiling water is probably the oldest and simplest method to remove pathogens from water. WHO (2004) considers that boiling is the most effective way to kill disease-causing pathogens, even at high altitudes and even for turbid waters. Although boiling water thoroughly ensures that it is free from any harmful bacteria or pathogens, it is not always a practical option. Boiling requires a lot of energy which, in areas where fuel is scarce or expensive, may be a problem. It also takes time before the water is cooled down.

Procedure:
Boil the water until it reaches a rolling point at let it boil for approximately 5 minutes. Leave the water the cool down before drinking.

ANNEX 5g:
Practical guidelines for SODIS procedure (SODIS website)

General description:
Direct sunlight can also be used to kill many of the harmful bacteria in water by exposing it in clear glass or plastic bottles for several hours. Solar disinfection method (SODIS) uses sun's ultra-violet (UV) radiation to improve the microbiological quality of drinking water. This process works in two ways; bacteria micro-organisms are killed both by exposure to direct UV-radiation and, if heated sufficiently, by water temperature exceeding 50 degrees Celsius. If the method is applied correctly, it can reduce coliform levels by 99.5%. Although SODIS cannot treat turbid water nor change the chemical quality of water, this method is ideal for disinfecting small quantities of water used for consumption (SODIS website). Always use a pre-treatment with alum, moringa or a filter to remove sediments.

Procedure (WHO Website: Household Water Treatment and Safe Storage Following Emergencies and Disasters, South Asia Earthquake and Tsunami):

Clean PET Bottles

Fill Bottles partly to 3/4

Aerate the Water through Shaking

Fill Bottles completely

Expose Bottles to Sunlight

Exposure on Roofs are adequate

Expose the Bottles for 6 Hours

Drink the Water from the Bottles

ANNEX 6:
Tank cleaning procedure (Rural Community Water Supply and Sanitation Project, 2006)

Requirements:

- Household bleaching powder.
- Bucket.
- Brush.
- Eye and hand protection (glasses, rubber gloves). Proper hand and eye protection should be worn when handling or preparing chlorine solutions to avoid burning skin and damaging eyes. Keep children away during disinfection procedures.
- A helper to watch the person inside the tank.

Procedure:

1. Drain any water in the tank to the level at the tap. Ideally, transfer water to a clean, contaminant free storage device or temporary container. If tanks are cleaned during a rainy period, any lost water will soon be replaced.
2. Dissolve 14g (about 3½ teaspoons) of bleach in water to make a bleach solution and add it to the remaining water in the tank. The ratio of bleach solution to water should be around 1 part bleach solution to 50 parts water.
3. Climb inside the tank. Using a soft brush, thoroughly scrub the bottom and sides of the tank. Make sure that ventilation is adequate for the person inside the tank and that a helper is watching.
4. Remove the water and bleach solution below the tap and any accumulated silt/sediment via the bottom drain outlet (if present) or using a bucket. The water and silt/sediment may be disposed of on in your home garden by spreading and digging into garden beds, or placed in your compost bin.
5. Refill the tank with water.
6. Leave the water to settle overnight before use.

ANNEX 7:
The Hygiene Improvement Framework (The Hygiene Improvement Framework, 2004)

1. Improving access to Water and Sanitation.	**a**	Addressing both the issue of water quality and water quantity to reduce the risk of contamination of food and water.
	b	Providing facilities to dispose of human excreta in ways that safeguard the environment and public health, typically in the form of various kinds of latrines, septic tanks, and water-borne toilets.
	c	Increasing the availability of hygiene supplies as soap (or local substitutes), chlorine, filters, water storage containers that have narrow necks and are covered, and potties for small children.
2. Promoting Hygiene. Advocating for, teaching, and supporting behaviours that are known to reduce diarrhoeal disease, namely: proper hand washing, proper disposal of faeces, and storing and using safe water, at least for drinking and preparing food	**a**	Raising awareness about hygiene facilities and practices, shares information, and promotes behaviour change by highlighting benefits that are important to the target audience.
	b	Obtaining and maintaining the involvement of various groups and sectors of the community in the control of disease.
	c	Introducing marketing principles and strategies to achieve social goals such as better hygiene and sanitation.
	d	Promoting community participation in activities as collective examination of barriers to practicing hygiene in the community, designing measures to use sanitation facilities and improve practices, or community-based monitoring of progress in achieving behaviour change.
	e	Policy advocacy of improved hygiene behaviours and interventions that support these behaviours to governmental and nongovernmental stakeholders.
3. Strengthening the Enabling Environment. Creating an environment, whether at the community, municipal, regional, or national level, that supports the technology and hygiene interventions envisioned in this framework. If these interventions are to be accepted and implemented, and especially if they are to be sustained, they must be built upon a firm foundation. Supporting the enabling environment typically takes the form of one or more of these activities.	**a**	Assessing the adequacy of national policies for hygiene improvement, determining where the gaps are, facilitating a process to reach consensus on a policy agenda, and developing more effective policies. There should be explicit policies for both water supply and sanitation.
	b	Strengthening national and implementing institutions. Capable institutions are an essential element of an effective hygiene improvement program.
	c	Developing local structures to take the responsibility for operating and maintaining local systems and increasing local commitment.
	d	Enhancing privately owned, operated public sanitary facilities and profit-making water and sanitation utilities run by local people to improve self-sustainable finance possibilities. The goal is for user fees to cover the recurrent costs of water supply and sanitation services.
	e	Establishing public-private collaboration. Water supply and sanitation agencies may have to work together with other ministries such as health, environment, rural development, agriculture, and planning. Establishing coordinating mechanisms such as interagency committees, steering committees, and task forces is key to effective partnerships, and successfully coordinating the activities of all the partners is likewise a key element of creating an effective enabling environment.

ANNEX 8:
RAINs guidelines for water quality sampling and testing (based on WHO guidelines for Drinking Water, 2004)

Before getting started:
The guidelines provided here take into account experience in surveillance programmes in remote, typically rural, areas and in peri-urban communities. The objective for performing a water quality survey can be:

- to assess the quality of the water of the former water source and of that of the rainwater harvesting system. Samples of both should be taken. Any significant difference between the two has important implications for remedial strategies.
- to asses a baseline research on the water quality from a specific rainwater harvesting system. A sample of each rainwater harvesting system should be taken.
- to asses a long-term research on the water quality from rainwater harvesting systems. A representative number of systems should be tested if any recommendations for remedial strategies or functioning of the system are to be developed.

Collection of samples for laboratory testing:
Results of physico-chemical analysis are of no value if the samples tested are not properly collected and stored. This has important consequences for sampling regimes, sampling procedures, and methods of sample preservation and storage (Guidelines for Drinking Water Quality, WHO, 2004).

- Time between sample collection and analysis should not exceed 6 hours! 24 hours is considered the absolute maximum.
- Storage in glass or polyethylene bottles. Sample bottles must be clean but need not be sterile.
- Residual chlorine, pH, and turbidity should be tested immediately after sampling as they will change during storage and transport!
- Samples should be immediately placed in a lightproof insulated box containing melting ice or ice-packs with water to ensure rapid cooling. If ice is not available, the transportation time must not exceed 2 hours. If these conditions are not met, the samples should be discarded.
- If the samples could contain chlorine (even traces), the chlorine must be inactivated. If it is not, microbes may be killed during transit and an erroneous result will be obtained. The bottles should therefore contain sodium thiosulfate to neutralize any chlorine present.
- The box used to carry samples should be cleaned and disinfected after each use to avoid contaminating the surfaces of the bottles and the sampler's hands.

Water quality sampling and testing:
The following forms should be filled out for each sample to ensure a standard methodology for sampling and testing:

- RAIN WATER QUALITY sample collection form: to be filled out in detail by trained field personnel.
- RAIN WATER QUALITY sample testing form: to be filled out in detail by laboratory or trained field personnel.

RAIN WATER QUALITY sample collection form

To be stuck on sample bottle

Sample data		
Name of organisation		
Name of person responsible		
Date of sampling		
Time of sampling		
Place		
Coordinates RWH system location	Longitude:	Latitude:
Sample number		

Sample data		
Name of organisation		
Name of person responsible		
Date of sampling		
Time of sampling		
Place		
Coordinates RWH system location	Longitude:	Latitude:
Sample number		

RAINWATER HARVESTING SYSTEM DESCRIPTION:

Source of water:

- O Roof water
- O Surface runoff
- O Ground water (sand dams)
- O Other:……

Type of rainwater harvesting system:

- O Ferrocement above ground tank
- O Reinforced cement above ground tank
- O Plastic lined above ground tank
- O Cement below ground tank
- O Plastic lined below ground tank
- O Sand dam
- O Other:……

RAINWATER HARVESTING SYSTEM DESCRIPTION (continued):

Total storage capacity (m^3):

O 4
O 8
O 10
O 12
O 60
O 90
O > 1000 (sand dam): …….
O Other: ……

Part of tank filled during sampling:

O empty
O 0 – 1/4
O 1/4 – 1/2
O 1/2 – 3/4
O 3/4 – 1
O full

Water quality improvement measures:

O first-flush
O coarse leaf filter
O filter screen
O settling basin
O Other: ……

Status of water quality improvement measures:

O	first-flush	connected? yes / no	cleaned? yes / no	
O	coarse leaf filter	in tact? yes / no	cleaned? yes / no	
O	filter screen	in tact? yes / no	cleaned? yes / no	
O	settling basin		cleaned? yes / no	
O	Other: ……			

Management and maintenance:

O	Has to catchment surface been cleaned before the rain?	yes / no	
O	Has the system been disinfected recently?	yes / no	when? ……
O	Are there trees overhanging the catchment roof?	yes / no	
O	Is the manhole locked?	yes / no	
O	Do people open the manhole frequently for inspection?	yes / no	how often? ……

Give a short description of the tank status which could not be answered with the above mentioned questions:

……

……

……

……

RAIN WATER QUALITY sample testing form

Sample data	
Name of Laboratory	
Place of Laboratory / field testing	
Name of person responsible	
Date of testing	
Sample number	

Type of testing:

O Field testing using DELAGUA test kit

O Laboratory testing

Transportation of sample:

O No transportation of sample (field testing using DELAGUA test kit at the system location)

O Transportation to field laboratory time of transportation: ……

O Transportation to laboratory time of transportation: ……

Means of transport of sample:

O Not applicable

O Cooled

O Not-cooled

O Other: ……

Parameter	**RAIN criteria**		**Sample**
	Roofwater harvesting	Other	
E-Coli (or faecal coliforms)	< 10 cfu/100 ml	<10 cfu/100 ml	
Ammonia	< 1.5 mg/l	< 1.5 mg/l	
Chlorine*	> 0.2 – 0.5 and < 5 mg/l	> 0.2 – 0.5 and < 5 mg/l	
Aluminium*	Not relevant	< 0.2 mg /l	
pH	6.5 – 8.5	6.5 – 8.5	
Turbidity	Not relevant	< 15 NTU	
Nitrate / Nitrite**	Not relevant	< 50 mg/l and < 3 mg/l	

Conclusion:

O Non-potable: …… (indicators out of RAIN range)
IMMEDIATE ACTING REQUIRED: see annexes IV for guidance on water quality measures

O Potable, but follow-up monitoring required:……(indicators which might pose a risk)

O Potable (all indicators within RAIN range)

ANNEX 9:
Risks to human health and aesthetic acceptance of RAIN water quality criteria

E-Coli or faecal coliforms
Examples of diseases which are waterborne (caused by contaminated drinking water) include cholera, typhoid, hepatitis, amoebiasis, and dracunculiasis. The causes of the high levels of contamination/pollution of surface water are often due to hanging latrines and direct sewage discharge (without any minimum treatment etc.) into surface waters and close proximity of latrines or drains (WaterAid, 2008).

Ammonia
Ammonia is an indicator of water pollution caused due to human activities and natural decay processed. Harvested rainwater may contain ammonia as a result of the decay process in the storage tank. Groundwater often contains some ammonia due to natural reduction of nitrate by bacteria, but sudden change in ammonia may be due to contamination of wastewater through seepage (WaterAid, 2008).

Chlorine
Free (or residual) chlorine in drinking water is only relevant where supplies are chlorinated, or where routine or emergency chlorination has taken place. The presence of free (residual) chlorine is an indication that removal of bacterial contamination is continuing within the supply. Exposure to extremely high levels of pure chlorine gas can cause lung collapse and death (WaterAid, 2008).

Aluminium
In humans, aluminium and its compounds appear to be poorly absorbed, although the rate and extent of absorption have not been adequately studied for all sectors of the population. There is little indication that orally ingested aluminium is acutely toxic to humans despite the widespread occurrence of the element in foods, drinking-water and many antacid preparations. It has been hypothesized that aluminium exposure is a risk factor for the development or acceleration of onset of Alzheimer disease (AD) in humans (Guidelines for Drinking Water Quality, WHO, 2004).

pH
According to the WHO guidelines, no health-based guideline value is proposed for pH, although eye irritation and exacerbation of skin disorders have been associated with pH values greater than 11. Although pH usually has no direct impact on consumers, it is one of the most important indicative water quality parameter for operational management, since pH determines the effectiveness of the treatment (WaterAid, 2008).

Turbidity
Turbidity which is a measure of extent to which light is either absorbed or scattered by suspended materials in water is an indicator of suspended solids present in water. These suspended solids can be in the form of silt, clay, sand, industrial wastes, sewage, organic matter, phytoplankton and other microbial organisms. Turbidity is an important parameter to be considered in drinking water supplies due to aesthetics, filterability and disinfection. Turbidity is also measured to determine what type and level of treatment are needed (WaterAid, 2008).

Nitrate and Nitrite
Nitrate is the most widespread agriculture contaminant but presence of nitrate/nitrite is considered to have minimal effect on the disease burden. The WHO guideline value for nitrate in drinking water of 50mg/litre (equivalent to 10mg/litre nitrate-nitrogen) and 3mg/l for nitrite (short-term exposure) is established solely to prevent Cyanosis (methaemoglobinaemia) in babies: bottle-fed infants of less than 3 months of age are most susceptible although occasional cases have been reported in some adult populations. The long term exposure to Nitrate/Nitrite is, however, a human health concern as it may increase stomach cancer. A recent study suggested that miscarriage might also be linked to high nitrate levels, although scientists have not confirmed this (WaterAid, 2008).