Aquarius
Technical Issue Paper 3

Home Water Treatment, Storage & Handling

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They aim at providing information to assist in funding decisions and monitoring of humanitarian projects and not at providing definitive answers.

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Last update: 3/08

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In many settings, both rural and urban, populations have access to sufficient quantities of water, but that water is unsafe. Treating drinking water at household level (point of use) can be a viable option to improve water quality and research shows that it is an effective way to reduce diarrhoeal disease.

Storage capacity at home and for transport is a key issue that can limit access to sufficient quantities of good quality water.

Overview of the technology

Summary of Household Based Treatment Systems and safe storage & handling

Drinking water may be contaminated at the source or during collection, transport and storage and drawing in the home. Strategies to reduce waterborne disease transmission must safeguard against all these events. Improving and preserving water quality at the point of use can result in a 35% reduction in diarrhoeal disease.

Household based treatment systems can be described in four main categories::

- Chemical Treatment
  - Disinfection using different products (e.g. liquid bleach, bleaching powder, liquid sodium hypochlorite, solid calcium hypochlorite, chloride tablets, iodine, colloidal silver, etc).
  - Coagulation – flocculation: Solid removal, decrease of turbidity and bacteria using chemicals (usually aluminium sulphate) or organic materials (e.g moringa seeds, shells etc).
- Physical removal of pathogens using filtration, adsorption and sedimentation:
  - Ceramic pot filters, candle filters, rapid sand filters, carbon filters, cloths, 3 pots system, etc.
- Pasteurisation (heat) and Ultraviolet action: Boiling and plastic bottles exposed to sun (SODIS)
- Combination systems
  - Sachets (flocculation + disinfection): "PUR" (ferric sulphate & calcium hypochlorite), "Chlorofloc", etc.
  - Lifestraw: filtration & disinfection (iodine)
  - Biofilters (sand filters with organic layer as filter) using both mechanical filtration and biological processes.
  - Pre-treatment systems to reduce turbidity combined with disinfection systems & filtration & chlorination.

A brief description of the different treatment systems is included in Annex 1.

Implementation of home water treatment strategies must be carefully evaluated:

The choice of the system must take into account both the context and the resources available. Table 1 explains the main factors to consider in assessing home water treatment strategies.

Household based treatment systems can be a solution for both acute emergency and stable contexts. The main challenges are faced in acute emergencies where the beneficiaries' acceptance and proper use of the systems are required from the first stages of the response.

Table 1: Factors to be considered to assess home water treatment strategies

	Factors	Elements
MICROBIAL EFFECTIVENESS	Ability to remove pathogens	Precise composition of the microbiological threat Physical parameters that may affect performance (pH, turbidity, etc)
USE BY COMMUNITIES	Acceptability	Taste, cultural related issues.
	Access	Availability of product. Availability of systems and consumables costs Affordability
	Proper use	Capacity to properly use and accept technology Feasibility of behavioral change.
PERIOD OF USE & TIMING	Feasibility of use during the project implementation	Enough staff and resources. Feasibility for behavioral change. Plan for close monitoring.
	Scalability	Mechanisms to sustain the intervention (other projects local mechanisms, integration in local development plans, etc) Use by communities after the conclusion of the project (accessibility,

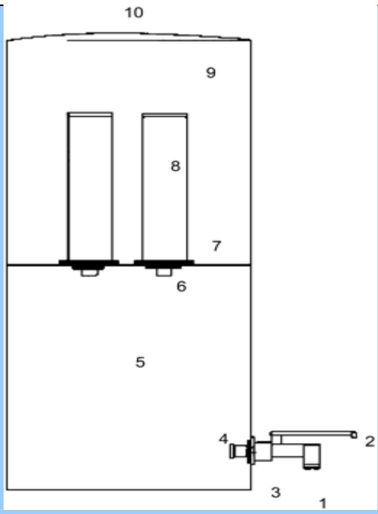

FIGURE 1.
***Schematic of ceramic filtration unit** used by Oxfam GB in pilot field trial, Colombia (not to scale). 1 = heavy-duty metal spigot; 2 = lever to operate ball-type valve; 3 = plastic collar (poly-vinyl chloride [PVC]); 4 = PVC nut and rubber gasket securing fitting to receiving/storage container; 5 = 18-liter transparent plastic receiving/storage container; 6 = plastic nut securing candle in place; 7 = barrier between containers, with a rubber gasket below candle and between containers; 8 = 12-cm ceramic filter candle; 9 = 18-liter transparent plastic top container; 10 = hinged top container lid.*

FIGURE 2
Sample of 500l Chemical Treatment distributed to households in Madagascar by CARE after the 2001 Cholera outbreak and by UNICEF & the Red Cross in Guinea Conakry in 2007..

FIGURE 3
Use of SODIS (Plastic bottles exposed to sun) in the urban slum in Vellore (Tamil Nadu,South India)

<u>Water containers for transport and storage</u>

Water containers are essential elements to preserve water quality at the point of use. Lack of containers can also limit the quantity of water used. Availability of enough containers, the choice of a proper model of container and good practices to safely transport, store and handle the water should be guaranteed in projects.

Main Advantages & Disadvantages

Annex 1 contains a table describing the main advantages and disadvantages of different household treatment systems in terms of effectiveness, cost and ease of use.

Lessons Learnt

- in general:

- Prevention of diarrhoeal disease must include an integrated water, sanitation and hygiene strategy where enhanced water quality should be considered. Water quality may be improved at the source but recent studies have shown a higher impact on reduction of diarrhoeas **where a proper water quality is guaranteed at the point of consumption** i.e. within the household.
- Community approaches are common in humanitarian interventions but they will not be effective enough without a household approach which includes water analysis, storage and/or treatment at household level. This is often missing in watsan projects.
- When adequate quantities of water are already available, household based water treatment is among the most cost effective approaches in preventing diarrhoea diseases.
- Water treatment and safe storage, like all other hardware, also requires appropriate software to be fully effective, (i.e. promotion and training support), actions must guarantee a behavioural change, interventions must assess the feasibility of these changes.

- on concrete experiences

- A comprehensive evaluation done on the use of household treatment systems during the first three months following the Indian Ocean tsunami (WHO 2005) had the following main findings for the first acute emergency responses: first priorities were focused on guaranteeing a minimum quantity of water in displaced settings not improving quality at households, choice of system were made without a proper understanding on how the system will be accepted by the communities, distribution of systems were made without the necessary software, projects were badly designed in terms of timing and means required and coordination between agencies was weak.
- UNICEF and the Red Cross have distributed a local made bleach (Sur'EAU) to improve the quality of the water in 100.000 households in Conakry city during two most critical months of the 2007 Cholera outbreak. The intervention targeted the most vulnerable families in the most risky areas as part of the Cholera response, so was more effective than a general distribution of disinfectant tablets.
- Oxfam GB has successfully used Candle filters in response to flooding in Dominican Republic (2003) and Tsunami in Sri Lanka (2005). Results from studies accompanying the response show up to 70% improvement in water quality.
- The appropriateness and effectiveness of some home treatment systems (such as bio-filters, ceramic filters and solar pasteurisation) have not been properly tested in emergency situations.
- While combined flocculent/chlorination systems such as "PUR" are easy to distribute and theoretically effective for treating all water types, they are relatively difficult to use (correct dosage requires a fixed quantity of water and clean water must be poured off after treatment because "flocs" produced by the treatment process will make the water dangerous to drink after approximately 1 day). Use of PUR in emergency intervention can therefore only be effective if combined with comprehensive usage training, hygiene education & monitoring.
- Evaluations on the use of ceramic pot filters in Cambodia have shown this to be an effective solution in improving water quality and health. However, education and behavioural change must accompany efforts to implement the filters, as recontamination through improper use is a major risk and potential barrier to effectiveness. Also, availability and accessibility of spare parts, particularly replacement of ceramic filter elements, will greatly enhance the sustainability of interventions.
- SODIS (plastic bottles exposed to sun) is one of the most promising house water treatment technologies. Many experiences have proven to be an effective solution when the system has been well accepted by the communities.
- Water containers specially designed for emergencies (light and flexible) have not been well accepted in some areas in Africa due to the difficulties to be transported on top of the head.

Recommendations for Use in ECHO Funded Operations

IN GENERAL

1. Both water quality and quantity assessed AT HOUSEHOLD LEVEL are recommended indicators for needs assessments, project design and monitoring of WASH interventions.
2. Household strategies must be assessed as an option in ALL CONTEXTS but in many situations they can not completely replace the protection of the sources or the community systems, in these cases both strategies must be considered as complementary. Home water treatment should specially be considered in cases where water sources are difficult to protect (e.g. post flooding) or when community water supplies are difficult to construct, e.g.: dispersed communities, places with problems of access, floods, emergency responses in urban settings before the reestablishment of permanent supplies, places where surface water is the only/main source, etc.
3. Home water treatment can be an option for both emergency and post emergency situations. However the option of using home water treatment strategies must always be carefully analysed before taking the decision to undertake the action. Main factors to consider are the feasibility of systems to decrease the risk of disease transmission, the acceptability of the technology by the communities and the capacity of families to properly use the systems to guarantee the quality of the water before consumption. The likelihood of the necessary behavioural change must also be assessed carefully.
4. Projects must be designed with enough means and staff to ensure a proper implementation of the activities with a full user education programme. CLOSE MONITORING of the actions is imperative during the implementation phase in all the cases.
5. Inadequate water containers can limit quality and access to sufficient quantities of water. Habits and hardware for proper collection, transport, storage and drawing of water should be promoted in all projects: (a) Having enough containers for transport and storage; (b)Choosing a proper model of container in order to avoid contamination (narrow neck jars, jerry cans, covered pots with a tap), to facilitate transport (assess shape and look at the volume to be transported), to be durable (quality of material) and to facilitate cleaning; (c) Following good practices (to cover the container after use, drawing the water with long-handled instrument, cleaning before refilling etc).

IN ACUTE EMERGENCIES

1. Projects based on home water treatment and safe storage must be carefully analysed in emergency responses. Victims of a disaster may not be open to any new intervention offered to them and timing is a big concern for introducing a new habit. It is not recommended to promote systems which will require an important change of behaviour. Methods that could present a health risk if incorrectly used must be avoided.
2. Sustainability issues may not be a priority during emergency responses. Systems are normally provided for free and the main objective is to act during the period of crisis.
3. The most tested and recommended technologies during emergencies are: (a) Household chlorination by supply of chlorine (usually tablets) bleach to beneficiaries or by chlorination done by trained staff; visiting each home (b) Candle filters (OXFAM has developed the use of this filter which can be stored in a proper manner to optimise the transport for emergencies). (c) PUR (coagulation + chlorination) which is also effective with turbid water but implementing partners must be sure that beneficiaries will use the technology correctly because there is a danger of contamination of water if it is not used correctly; (d) Boiling: Only after assessment of the availability of cooking fuel and the environmental impact & recommended for specific groups (pregnant women, children < 5, etc)
4. Working on preparedness (analysis of behaviour and tests of water quality) can help to assure the efficiency, acceptance and proper use of these systems during the emergency response.
5. Acceptability by the communities of specific containers specially designed for emergencies must be assessed (e.g. flexible containers can not easily be transported on top of the head).

IN POST EMERGENCY SCENARIOS AND CHRONIC SITUATIONS

1. Efficiency & acceptability of the systems are key issues but sustainability must also be considered: (a) Access to systems, spares and consumables must be guaranteed for communities, locally made alternatives must be encouraged; (b) Systems, spares and consumables must be affordable to communities; (c) Awareness should be continued after the "disaster" to encourage continued use of the systems; (d) Consistency with local policies and plans is important.

References::

- Combating Waterborne diseases at the household level. WHO 2007.
- Water Quality Interventions to Prevent Diarrhea: Cost and Cost-Effectiveness, WHO 2007.
- Intervention to improve water quality for preventing diarrhea (Review). The Cochrane collaboration. Clasen et all. 2006.
- Well Fact Sheet. Household Water Treatment, Storage and Handling. Clasen 2005.
- Well Fact Sheet. Household Water Treatment. Clasen 2005.
- Managing Water in the Home: Accelerated Health Gains from improved Water Supply. WHO 2002.
- The Drinking Water Response to the Indian Ocean Tsunami Including the Role of the Household Water treatment (Clasen, Smith). WHO 2005.
- Safe Water Systems for the Developing World: A Handbook for implementing Household based Water Treatment and Safe Storage Projects. CARE – CDC.
- Safe water treatment and storage in the home: A practical new strategy to prevent waterborne diseases (Mintz et all), CDC 2005.
- Household-based Ceramic Water Filters for the treatment of Drinking Water in Disaster Response: An assessment of a pilot programme in Dominican Republic (Clasen & Boisson)

Web sites:

- WHO: http://www.who.int/household_water
- WELL Resource C. Network: http//www.lboro.ac.uk/well
- Biofilters: http//www.biosandfilters.org
- Ceramic filters: http://www.purifier.com.np http://www.pottersforpeace.org
- Solar disinfection (SODIS): http://www.sodis.ch
- PUR sachets : http://www.psi.org/our_programs/products/pur.html
- Lifestraw : http://www.lifestraw.com

Recommendations (cont)

2. If the technology is not well known by the community, a pilot project is recommended before going to a larger scale. Successful experiences can be used as models for development projects to address problems of water access for the most vulnerable.
3. Most tested and recommended technologies during post emergencies and chronic situations are the household chlorination, the use of ceramic pot systems and the SODIS.

ANNEX 1 – Household Treatment Systems: Brief Description, Characteristics and Advantages and Disadvantages.

HOUSEHOLD TREATMENT SYSTEM	PROCESS & PRODUCTS	QUALITY of water to be treated	MICROBIAL Effectiveness	COST* & ACCESS to product / spares	EASY TO USE & maintenance	RECOMMENDED SCENARIOS		General recommendations
						Acute emergencies	Post Acute & Chronic Situations	
HOUSEHOLD CHLORINATION (leach, chlorine tablets)	**DISINFECTION** Employ of free chlorine derived from liquid or solid products (calcium hypochlorite, tablets formed from chlorinated isocyanurates, chlorine dioxide, etc) as oxidant for killing pathogens. Free chlorine continue active in the water during a certain period as protection against further contamination.	**Only clear water** (< 10 NTU). Effectiveness depends also on PH, temperature and chemical composition.	**HIGH** Removal of 99, 99 % of enteric bacteria. Not effective for Encysted protozoa (Giardia duodenal & cryptosporidium)	**LOW COST** (10 – 25 cents USD/family /month). But tablets are more expensive. Easy to find in local markets (leach, HTH) Easy transport for granulated products and tablets. Possible to produce by communities: electrolysis.	**EASY USE** with training & adequate materials. No maintenance required.	**Yes** **A good option in urban settings during Cholera outbreaks**	**Yes**	Take care with taste acceptability A good promotion is essential to introduce the behaviour Turbid waters must be pre-treated to leave water clear.
COLLOIDAL SILVER & Silver Salts	**DISINFECTION** Liquid solution poured into the water. Products: Solutions with *Colloidal Silver, Silver salts(silver chloride, silver iodide)* Colloidal silver is also used coated in filter with bacteriostatic purposes.	**Only clear water**	**MEDIUM - LOW** Slow acting and limited activity against virus, protozoan cyst, oocyst and bacterial spores) . Some bacteria may develop silver resistance	**LOW – MEDIUM COST** But more expensive than chlorination Difficult to find in many places	**VERY EASY USE** No maintenance required	Effectiveness depends on nature of pathogens, **so chlorination is more recommended.**	To assess affordability and access in markets	Filters impregnated with colloidal silver increase efficiency.
IODINE	**DISINFECTION** Iodine dissolved in water (tablets) or in the form of an iodinated exchange resin	**Only clear water**	**HIGH**	**HIGH COST** Difficult to find in many places	**EASY USE** No maintenance required	Chlorination is more currently used because residual chlorine and facility for access.	WHO does not recommend for routine uses on long term bases because there are indications of possible adverse health effects with usage for more than 10 years. High cost and difficult access limited availability in markets are constraints for sustainability.	Filters impregnated with iodine increase efficiency.
LIME JUICE	**DISINFECTION** Some drops of lime juice poured in water. Used to decrease the pH of water to inactivate *V. cholerae*	Clear water	**LOW** But 99,99 % effective for *V: cholerae*	**LOW COST** **EASY ACCESS**	**EASY USE** No maintenance required	Not recommended as unique strategy due to low microbial effectiveness. It can be recommended as good practice during **Cholera epidemics** but not as unique strategy	Good practice complemented with other strategies	**Take care during Cholera outbreaks this is not trusted as an effective, stand-alone strategy.**

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						Acute emergencies	Post Acute & Chronic Situations	
BIO FLOCS	**FLOCCULATION** Seeds (as *Moringa*) and crashed shells added to the water to be treated.	Not very turbid waters	**LOW**	**LOW COST** **EASY ACCESS** (in areas where it is available)	**MEDIUM DIFFICULTY OF USE** No maintenance required	**No**	Good practice complemented with other strategies	Local solutions recommended as good practices
Combination of coagulation, flocculation & disinfection (CFC SACHETS)	**FLOCCULATION & DISINFECTION** Individual sachets with flocculants and disinfection granulated products to be poured in the water. **"PUR"** (ferric sulphate & calcium hypochlorite) "Chlorofloc" (formula not expressed)	**All the waters** Effectiveness depends also on PH, temperature and chemical composition.	**HIGH** Also effective against pesticides & heavy metals	**HIGH COST** Difficult to find in many places	**MEDIUM DIFFICULTY OF USE** No maintenance required	**Mainly in Floods or with turbid waters** Only if proper use by the beneficiaries can be ensured, CLOSE MONITORING REQUIRED	High cost and difficult access in markets are common handicaps for sustainability.	To evaluate composition of the product Health risks if not correctly used Flocs must be properly removed.
CERAMIC CANDLE FILTERS	**FILTRATION** A two compartment container communicated by ceramic filters <1 micrometer (pore size depends on type). Some filters are impregnated with silver and some contains carbon. Products: *Katadyn, , Pelikan, Stefani*, Doulton, Aquamaster, Pozzani, etc	**Better with clear water** (if not problems with maintenance and flow rate filtration)	**HIGH – MEDIUM** (depending on type: pore size and ceramic quality) All bacteria and protozoan and oocyst < 3 micrometers) Not effective against virus (20 – 100 nanometres)	**MIDDLE COST** Cost depends on the type and country *Using "Katadyn"candles* - 30 USD / system - 10 USD/candle/ 3 years Using "Pelikan" candles - 2USD/candle/6months **DIFFICULT ACCESS IN MANY PLACES** (imported spares).	**VERY EASY USE** **MAINTENANCE** Systems must be maintained clean, roughing & replacement of candles	**Yes** It can be a solution for floods but a pre-treatment is recommended	Spares must be available in the market and spare's cost affordable by families Possible **continuity of use** from the emergency to the post emergency phase	Promotion is essential for maintenance If the water is not clear, pre-treatment of water is recommended to decrease turbidity in order to increase efficiency and life of the candles.
CERAMIC POT FILTERS (coated with silver)	**FILTRATION** The ceramic is made porous by mixing the clay with a material burnt away during firing (sawdust or rice husk) The filter is impregnated with colloidal silver which act as a magnet on the bacteria.	High turbidity will increase the blockages	**HIGH** But not totally effective against virus. Colloidal silver acts as bacteriostatic.	**LOW COST** (around 10 USD/pc/ 1 – 2 years life)) **Easy access**, it can be locally made	**EASY USE** Easy maintenance: to keep the filter clean & replace de filter when needed.	Not tested during emergency responses It can be fragile for transport	**Yes** Good experiences if is done with promotion of local manufacture.	**:** Prospect local manufacture feasibility and/or access in markets
CLOTHS	**FILTRATION** Filtration with cloths (saris, etc)	All waters	**VARIES** depending nature & condition of the cloths (pore size, dirty, etc)	**LOW COST** **Easy access**	**EASY USE** Easy maintenance: to keep the cloths clean	**as pre-treatment and combined with other systems**	**Yes as good practice**	**FOR ALL SCENARIOS:** **A**s pre-treatment or as good practice to promote, but accompanied with other systems if there are risks on health.

HOUSEHOLD TREATMENT SYSTEM	PROCESS & PRODUCTS	QUALITY of water to be treated	MICROBIAL Effectiveness	COST* & ACCESS to product / spares	EASY TO USE & maintenance	RECOMMENDED SCENARIOS		General recommendations
						Acute emergencies	Post Acute & Chronic Situations	
CARBON FILTERS	**FILTRATION & ABSORPTION** Carbon filters are normally a part of other filters & they serve mainly to remove odours & tastes.	Depends of the nature of the entire system.	**LOW** (carbon filters alone)	**LOW COST** ACCESS depending on the type of the entire system.	**USE & maintenance** depending of the entire system	**No if it is alone** Depends of the entire system if it is only a part of it	**Yes** Normally makes part of other filters	Maintenance is a key issue
SAND FILTERS (rapid filtration)	**FILTRATION** Rapid sand filter.	All waters	**LOW**	**LOW COST** **Easy access (locally made)**	**EASY USE** Proper maintenance if not can increase bacteria growth	**Only as** pre-treatment	**Better as** pre-treatment	Maintenance is a key issue if it is done as unique treatment
SETTLEMENT OF WATER 3 pots system	**SETTLEMENT & OVERTIME** Rotation process when each time the water is poured from one pot to another in order to leave the water to be settled a period of time for the die-off of the bacteria and solid removal.	**All the waters** But some suspended materials can be not removed by settlement	**LOW**	**LOW COST** **Easy access** Pots can be locally produced	**MEDIUM DIFFICULTY OF USE** (to follow the all process) **Maintenance: Cleaning of pots**	**No** Low microbial effectiveness & it requires a long sensitization to be effectively used	High level of sensitization required. Not recommended in environments of high risk of diseases.	Introduction of habits and proper manipulation as key issues
BOILING	**PASTEURISATION**	**ALL the waters** but better to do a pre-filtration	**HIGH** 100 °C / 10 minutes will kill most of pathogens	**HIGH COST** 1 Kg firewood / 1 litre / 1 minute Access depends on fuel availability	**EASY USE** No maintenance required	**Yes** See General recommendations	**Yes** See General recommendations	Problems with altitude. **FOR ALL SCENARIOS:** Recommended practice for specific target groups such as pregnant women, children < 5 & sick persons. For a broader use, good assessment of environmental impact and availability of fuel is required.
SODIS	**PASTEURISATION & UV ACTION** Clear plastic bottles (or not coloured glass bottles) filled with water and exposed to the sunlight (at least for 6 hours)	**Only clear water**	**HIGH**	**LOW COST** Access depends on availability of containers.	**EASY USE** To maintain the bottles clean and to drink the water within 1 day after treatment	Not used in emergency responses	**Yes** Good results when beneficiaries acquire the habits, it is a very promising method	Exposure must be adjusted to climatic conditions and altitude (6 – 48 hours). NOT suitable in all climatic regions. Key issues: Introduction of habits and proper manipulation Length on time to treat water can be an handicap for acceptability by beneficiaries.

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						Acute emergencies	Post Acute & Chronic Situations	
BIOFILTERS	**COMBINED FILTRATION & BIOLOGICAL ACTION** Special conditions in sand filters (fine sand, to be always under water and slow flow) will allow the development of organisms in the first few centimetres of the sand layer, this organisms form a biological membrane which will trap and kill the pathogens.	High turbidity will increase the blockages	**HIGH** But not totally effective against virus. Low if it is bad maintained.	**MIDDLE COST** (as first investment, 15 – 75 USD family) **LOW COST** after 1st year **Easy access**, it can be locally made	**EASY USE** Maintenance is a key issue for effectiveness of the system To maintain active the biological layer.	**No** Long period of sensitization is required to achieve proper maintenance.	High sensitisation & close monitoring required	If it not well maintain, it can increase bacteria growth in water .
"LIFESTRAW"	**COMBINED FILTRATION & DISINFECTION** It is a plastic straw (flute shape) where you must suck the water before drinking. It contains synthetic filters with activate carbon, colloidal silver and iodine resin.	**Low turbidity**	**HIGH**	**LOW COST** 3,5 USD/person/year Difficult to find in many places	**Difficult use for children** (difficulties to suck) After 6 months – 1 year must be replaced.	The difficulty for the children and the fact that it is only for drinking purposes are constraints	Difficult to guarantee availability in markets.	Only for drinking purposes Acceptability by beneficiaries is a key issue. Lack of field research.
Combined Filtration & Chlorination	**COMBINED FILTRATION & DISINFECTION** A two chambers container including a set of different filters (synthetic & carbon activated) and a chlorine dispenser. *Product: PUREIT filter*	All waters high turbidity provokes blockages spite the existence of a pre filter	**HIGH**	**MIDDLE COST** (if accessible in market & as first investment) **LOW COST** after 1st year Difficult to find the system in many places.	**EASY USE** To maintain the system clean, replacement of filters & check the chlorine dispenser.	Not tested during emergency responses	Need to carefully assess sustainability issues.	Proper use and maintenance are key issues.

*Cost: (for 25 litres per household per day, 5 litres / person / day), the ranking is based on the perceived affordability for beneficiary households:
High (>100 USD / household/year) or >0,01 USD / l. - **Middle** (10 - 100 USD/ household/year) – 0,001 - 0,01 USD / l. - **Low** (<10 USD / household/year) – <0,001 USD / l.