Smart Disinfection Solutions

Examples of small-scale disinfection products for safe drinking water

The first edition of this booklet was prepared as a contribution to the IWA conference on Sustainable Solutions for Small Water and Wastewater Treatment Systems (S2Small2010) which was held in Girona, Spain, april 2010. It is the result of a successful cooperation between the Netherlands Water Partnership (NWP) and all other organisations indicated under Collaboration and Acknowledgment.

Collaboration

This publication is the result of a collaborative effort by a number of organisations:

NWP, the Netherlands Water Partnership, an independent organisation formed by government bodies, NGOs, research institutes and businesses involved in the water sector. The main aim of the NWP is to harmonise initiatives of the Dutch water sector and to promote Dutch water expertise worldwide. www.nwp.nl

Aqua for All (A4A) aims to create a link between the Dutch public and private water sector and actors in water and sanitation projects in developing countries. A4A sponsors socially responsible entrepreneurship by acting as a "broker" between all parties involved. A4A claims to tackle the scarcity of drinking water and sanitation in developing countries in a structural way. www.aquaforall.nl

Witteveen+Bos (W+B) is a consultancy company, providing consultancy and engineering services for projects in the following areas: water, infrastructure, environment and economics. A multidisciplinary project approach characterises our way of working. The clients are governmental, commercial, and industrial, including various types of joint ventures and public private partnerships. W+B serves them from eight offices in the Netherlands and five offices abroad. www.witteveenbos.nl

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Foreword

In 2000, 189 heads of state declared their full commitment to achieving eight Millennium Development Goals (MDGs). This booklet aims to help achieve the drinking water targets as stated in MDG 7: halving the proportion of people who don't have sustainable access to safe drinking water and basic sanitation. In 2009 some 884 million people still did not have access to an improved water facility.

Experience shows that access to "improved" water supply facilities is no guarantee for safe and reliable water. Especially in developing countries tap water can be unsafe, because of inadequate treatment, recontamination during transport or storage or at home. "Point of use" and small-scale treatment is a promising strategy to improve access to safe drinking water, in particular for the poor. Recent studies show that PoU reduces diarrhea morbidity for children under 5 by 29 % and is more effective than source water treatment, piped water on premises and improved public water supply. All the more reason to provide those who advise on systems for home water treatment in rural areas with current information on simple methods to improve drinking water for households. This booklet, part of the Smart Water Solutions series, can help them decide which method is best for a specific situation and what effect can be expected with respect to reduction of harmful micro-organisms. It also gives some price indications and refers to specific websites for further information.

KWR Watercycle Research Institute views water and sanitation problems as closely connected. Water supply and sanitation are both parts of the same worldwide watercycle. Improving available technologies and adding new and better ones is our core business. At the same time we whole-heartedly support this initiative by NWP, Aqua for All and Witteveen+Bos to help consultants and people in small settlements all over the world to make optimal use of available technologies. We hope this will lead to a strong improvement in living conditions for many of the underprivileged people worldwide.

Prof. dr. Wim van Vierssen
CEO of KWR Watercycle Research Institute
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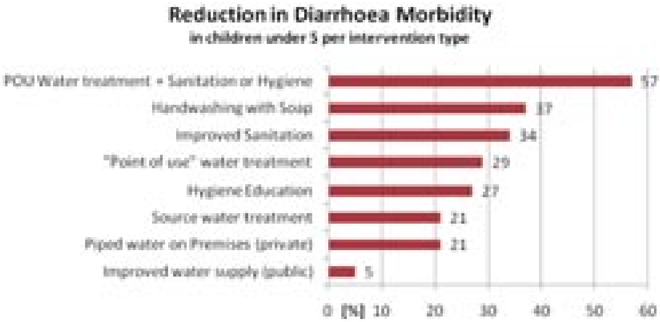
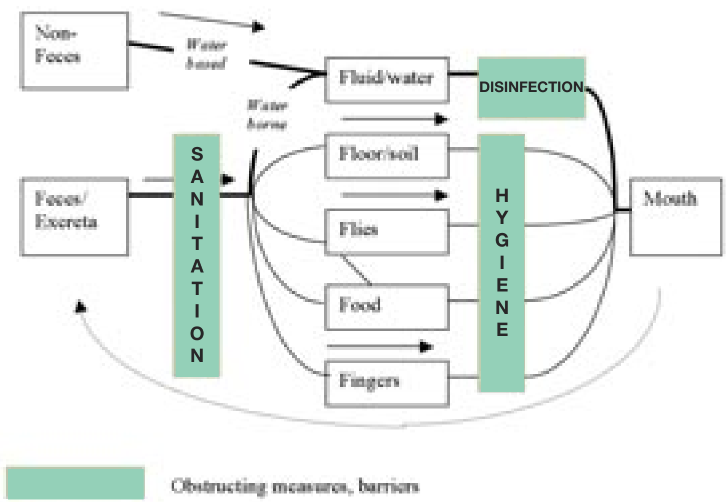
Water contaminated with harmful micro-organisms (pathogens) is one of the main causes of illness and death, especially among children. Each year diarrhea is still killing millions of children. Improved quality and quantity of drinking water, hygienic practices and sanitation are among the most effective measures in reducing the under five mortality rate and in increasing life expectancy, well being and economic wealth (UN summerschool 2008). It is estimated that improved water quality at home will reduce the occurrence of diarrhea by 29% (3IE 2009).



Effectiveness [%] of WASH Interventions in reducing diarrhea morbidity in children under 5
(Source: 3IE 2009)

More than one third of the world's population cannot safely drink their water from the nearby water source or tap, without further treatment. Almost 1 billion people lack access to an 'improved' water source. And many of the so-called improved sources can still be unsafe, or the water is contaminated when carried home from the tap or stored at home. Home Water Treatment methods and products provide an accessible alternative for people who want to take responsibility for the health of themselves and their children, instead of depending on often unreliable services.

Disinfection is only one of the measures employed to ensure better health as is shown in the above figure. Sanitation and hygiene are important measures as well. Better sanitation will lead to less contaminated water, soil, food and fingers. Flies will transmit fewer organisms or be less abundant. Hygiene helps to prevent recontamination of the food that is eaten and the water that is drunk.



Transmission of harmful micro-organisms through the oral/ingestion route and their prevention.
Water borne means part of the fecal-oral route; water based means that micro-organisms are from non excreta origin, mostly helminths.

Smart Solutions for disinfection
Presently, chlorination of water in urban schemes and boiling of water at home are the most common methods of disinfection. But chlorination has an impact on taste and can be harmful in the longer term. Boiling requires a lot of scarce energy (wood, charcoal, gas, electricity) and brings about a high number of incidents. This booklet provides a number of alternative methods, which can be used at family, community or village scale. We call them SMART solutions, as they are challenging, ingenious, attractive, simple to use and affordable for many.

This booklet is not a manual, but tries to challenge the reader to think beyond the common framework. It provides a wide range of methods and products. The list could easily be extended (equivalents or real alternatives). Some products might get out of production. In our selection, we used several criteria: globally recognized or related to a Dutch initiative; proven technology; at least 100 fold reduction of micro-organisms; generally appropriate for the rural setting in the Least Developed Countries; challenging. We did not apply the "price" criterion, as some methods might become cheaper when applied on a larger scale. “Traditional" options, which provide limited reduction, are not included, such as the application of flocculation media (e.g. grounded moringa olifera seeds), or the three pot storage system. But also very sophisticated methods such as reversed osmosis are not considered, because of damage risk and requirement of highly skilled staff.

The scope of this booklet is limited. Much more information on the methods and products can be found at the website www.akvo.org. This website also provides a Decision Support Tool to select the method which might be the best or the most economic option for a specific situation and additional treatment needs (such as removal of arsenic, iron, salts, fluoride). The fundament for this booklet was laid by the research of two international BSc students, W. Novalia and N. Wacka Tchetkoua, who, in 2009, received two Dutch awards for their challenging approach.

Considerations
Home Water Treatment methods and products are rarely recognized by official organizations as a serious alternative. One of the reasons is, that they are not considered in the water supply indicator under the 7th Millennium Goal, as defined by UNICEF and the WHO.

A major constraint is that the continuity and impact of the use of small sized treatment systems may not be guaranteed (Hutton 2009). Users might lose their interest, forget maintenance/cleaning or stop using it when a replacement is required. This is especially true where products were provided free of charge, when the performance is less than expected or when a lot of time is required. Spare parts may not be available or not affordable. This means that marketing, business wise approach, repeated education and a massive introduction are conditional. Local manufacturing might assist to create emotional connectivity.

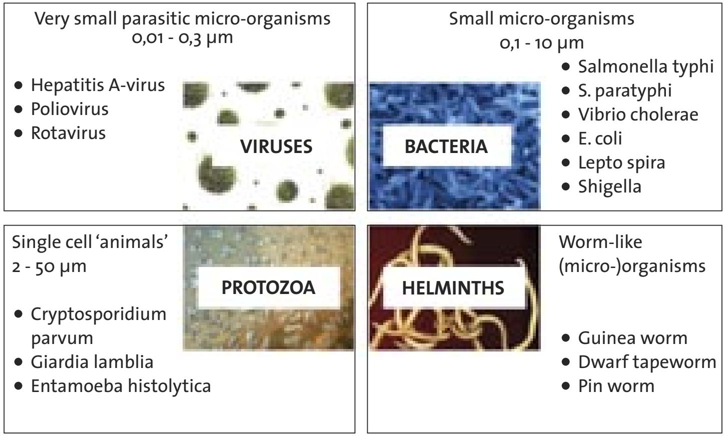
In the first period, health impact may improve considerably. But in many cases, the impact reduces to minor levels within one year. One of the possible reasons is that the human body might get used to another level of contamination and become more vulnerable to occasional deteriorations.

Further reading

As mentioned before, hygiene education and sanitation have an important impact on health, too, and should be considered in parallel with water treatment. Therefore the booklets Smart Sanitation Solutions and Smart Hygiene Solutions in the same Smart Solutions Series are recommended. For increased water availability the booklet Smart Water Harvesting Solutions might provide valuable notes, whereas the booklet Smart Financial Solutions might be of interest for the start of a businesswise introduction of a water treatment product.

In this booklet we will use the word disinfection for the reduction of the number of harmful micro-organisms in drinking water. This is a wider definition than that applied by specialists as they limit disinfection to inactivation by chemical or radiation processes.

Harmful micro-organisms are called pathogens. They are known as viruses, bacteria, protozoa and helminthes, according to size, appearance and biological characteristics. The consumption of pathogens may lead to severe diseases and has been proven to cause high mortality under adults and children in developing countries. Next figure shows some of the organisms and the diseases they cause.



Some water borne and water based infectious micro-organisms causing fever, cholera, dysentery, diarrhea or other diseases.

The reduction of numbers of harmful micro-organisms entails both methods to kill or to inactivate these organisms, to prevent their expansion or to remove them by filtration (see box).

Disinfection in this booklet is the reduction of the number of harmful micro-organisms (bacteria, viruses, protozoa and parasites) in drinking water. Disinfection can be done by different methods or a combination of them:

- Physical destruction: heating/boiling and Ultra Violet light (UV)
- Physical filtering: membranes, ceramic filters, slow sand filters, coagulation/precipitation+sedimentation, bank infiltration
- Biological destruction: in the top layer, "Schmutzdecke" of a slow sand filter
- Chemical destruction and prevention of multiplication: use of chlorine, chlorine dioxide, monochloramine or other halogens (like iodine), ozone, hydrogen peroxide, silver or copper

Not all of these methods are convenient in rural areas of developing countries, because many of them require skilled staff, permanent presence of electricity or fuel and the reliable supply of spares and consumables. This means for instance that methods like membrane filtration (microfiltration, ultrafiltration, nanofiltration) are not considered in this booklet as these technologies permanently require electricity or fuel and quite regular servicing.

Nevertheless the Perfector-E is included because it can be applied in the case of large scale emergencies (like 2004 tsunami Sumatra, 2010 earthquake Haiti). Chemicals which entail considerable risk if not handled properly (ozone, hydrogenperoxide) are also out of scope.

Another restriction is that we only consider methods that are used for small-scale treatment in rural communities and home treatment. Large investments, e.g. for bank infiltration, are therefore not included, though it can be appropriate to withdraw the water to be treated from some protected well, natural or dug, not far away from a river or stream.

Where to start?

Disinfection is only one part in a long chain from water source to drinking cup. Prevention of contamination at the source might be more economic than treatment afterwards. If possible and available: the best choice is a water source that contains little or no particles at all. Spring water is most suitable, or groundwater, preferably from depths > 5 m. Streams high up in mountains are better than rivers flowing through densely populated regions.
From the source, water is to be transported. Leaking pipes, interrupted flow and low pressure might provoke contamination. Water may be stored in tanks, accessible to dirt, animals and insects.

Pre-treatment might be required, such as sedimentation, coagulation and filtration in case of turbid water. Chlorination is not very effective in turbid water containing organic matter and ammonium because these consume chlorine as well. Membranes and filters may clog easily when the water to be treated contains a lot of particles.
During treatment, other substances might need to be reduced/removed as well. And after treatment recontamination should be prevented by using clean containers and avoidance of contact with dirty hands and other dirt.

Removal efficiencies

Removal efficiencies of treatment methods differ considerably when looking at organisms like worms or larvae of worms, protozoa, bacteria and viruses.
The WHO Guidelines for drinking water quality provide an elaborate scheme of reductions of different types of organisms. Next table summarizes the baseline removal efficiencies of household water treatment technologies (after WHO, 2006, table 7.6a).

Treatment method (log removal)	bacteria 0	1	2	3	4	viruses 0	1	2	3	4	protozoa 0	1	2	3	4
Chemical desinfection															
Free chlorine				•					•					•	
Membrane filtration															
Ceramic or carbon block			•				•								•
Micro-membrane			•			•							•		
Ultra-, Nano-, Reversed Osmosis				•					•					•	
Fibre and fabric, textile		•				•					•				
Sand and granular filtration															
Rapid granular (diatomaceous earth, biomass etc)		•					•					•			
Intermittent slow sand filter (household)		•				0.5							•		
Ultra-violet															
Solar (including some heat effects)				•				•					•		
UV-lamp				•				•						•	
Thermal heat															
Boiling etc					6					6					6
Coagulation, precipitation/sedimentation															
Combi flocculation, disinfection (sachets)					7					4.5				•	

Baseline removal (log units) by different treatment methods
from: WHO Guidelines, table 7.6a
logunits: 1 = 10% left = 1/10 = 10^{-1}; 2 = 1% left = 1/100 = 10^{-2}; 3 = 0.1% left = 1/1000 = 10^{-3}

Removal efficiencies may be higher but this requires adequate operation by skilled persons, quite regular maintenance and quality checking. Higher efficiencies have to be checked by laboratory methods on a frequent scale. Usually these laboratory methods are not available in rural areas.

Some more considerations on disinfection

a. The level of contamination and the cause of the contamination (bacteria, viruses, protozoa, or helminthes) will influence the choice of a disinfection method or product.

b. Most ceramic filters will have a 3-log (or more) disinfection efficiency, and will disinfect a sample with 1.000 E. coli per 100 ml to a barely acceptable level of 1 per 100 ml.

c. Keep in mind that boiling of the water is not a full guarantee for disinfection when conditions are not standardized like in laboratories.

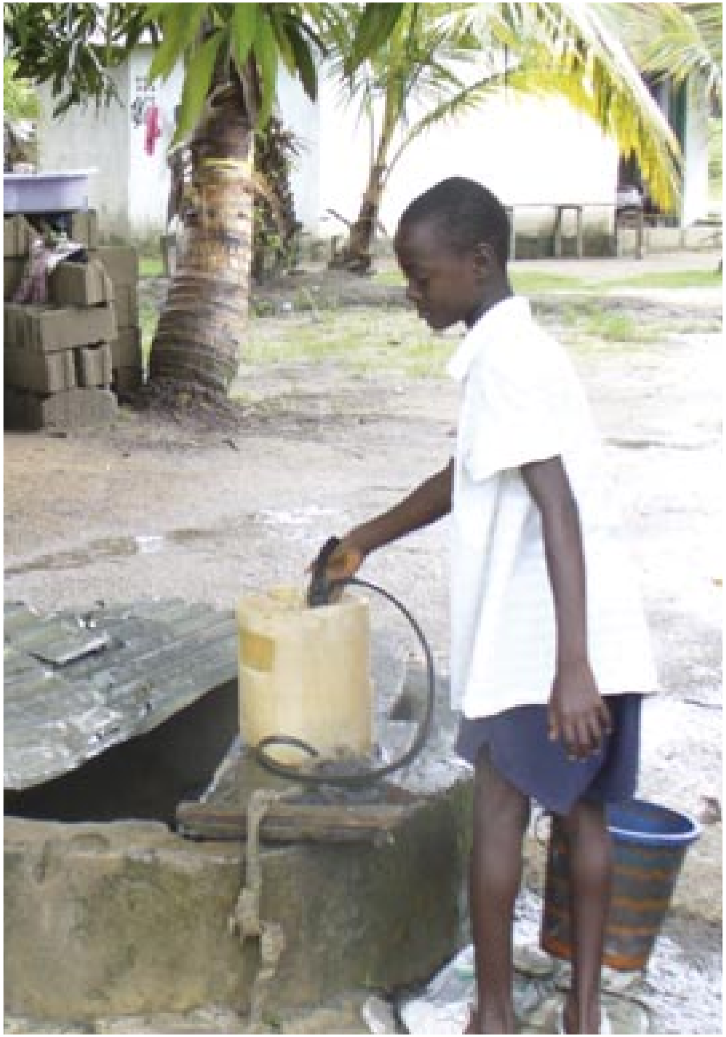
d. If water was chlorinated before, a check can be made by smell, indicator strip or DPD test to determine the presence of residual chlorine, this being an indication that re-contamination is not likely. The most common test for measuring residual chlorine is the DPD (N,N-diethyl-p-phenylene-diamine) indicator test, using a comparator. This test is the quickest and simplest method. The comparator compares the intensity of the purple red colour of the sample with reagent with a set of predefined concentrations.

Safe storage

After treatment the water should be safely stored to avoid recontamination. This means that the water container should meet the following requirements:

- a strong and tightly fitting lid or cover
- tap or narrow opening
- stable base
- durable
- easy to handle
- not translucent.

Sometimes the water to be stored may require some additional disinfectant in order to prevent regrowth of pathogenic bacteria. Chlorine is a good option but there are other means like silver. Some of them are mentioned later in this booklet.



Preface

There is no simple and smart method that provides a guarantee that a water sample is 100% free of pathogens. The main reason is the difficult distinction between pathogens and harmless micro-organisms. The other reason is that most tests need sterile handling (under laboratory conditions) and a long 'incubation' period.

Most common methods use indicators. One of the indicators is the presence of H_2S, which may be produced by pathogens. The other main indicator is the presence of E. coli (*Escherichia coli*), a bacteria associated with excreta.

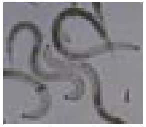
This highlights the great need for rapid, simple, inexpensive tests for the microbial quality of drinking water. This need is especially great for small community and household water supplies that lack access to and cannot afford conventional bacteriological testing of drinking water. On-site testing using portable equipment and use of simplified tests, such as the H_2S tests, may contribute to overcoming these constraints.

Testing

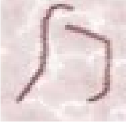
The verification of contamination with micro-organisms "in the field" can be executed by different methods. A first analysis can be done by smell or visually, e.g. by using a magnifying glass or stereomicroscope which might show helminthes and other parasites.

Stereomicroscope

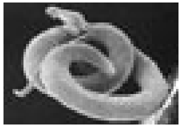
Loupe



Nematode



Leptospira



Helminth

Even if micro-organisms are not observed, the water can still be contaminated and a more sophisticated field-test is always required.

Most common in such field-tests is the detection of H_2S (hydrogensulphide) producing micro-organisms among which, but not exclusively, bacteria of fecal origin and other anaerobic bacteria. This principle is applied in 'Presence/absence' methods, like 'test-strips' (Fluka) or liquid media (Hach Pathogen Screen). The results can be obtained within 18-48 hours depending on incubation temperature. If H_2S producing bacteria are present there will be black precipitate. Because the test is sensitive to false positives (other bacteria than the fecal indicators) and the presence of H_2S in the water itself, the method is more suited for treated water than for raw water.

Another qualitative method uses 'ready cult sachets' with cult powder, which is added to a water sample. Also these tests need 24 hours at body temperature. Unfortunately these methods rarely show the level of contamination or whether the bacteria are harmful or not. If bacteria are found, further investigation is required.

Quantitative methods
If contamination cannot be excluded, a more sophisticated test is required. Most common tests stimulate the growth of bacteria in a culture medium under 'body' temperature (37 °C), sometimes using a color indication. In laboratory, the most common methods are 'membrane filtration' or 'Most Probable Number', the latter one using bottles with different dilutions. Only one method does not require 'body temperature', using 'Coliscan Easygel' of Micrology Laboratories.

For field use, there are different types of 'paddle testers' (e.g. Hach-Lange and Millipore swaps) and the more sophisticated Field Kit of Oxfam-DelAgua and the Intertek MPT Field test kit, imitating a small field lab. Another quantitative method is the Petrifilm (3M).

Some high-tech institutes are developing 'rapid tests', but these are required for quick evaluation of fecal pollution in well-designed drinking water systems and not suitable for field conditions. Furthermore these are still in the R&D stage.

More information about field tests can be found at the website of *Akvo*.

Appropriateness
The appropriateness of the methods for disinfection in this booklet is evaluated by expert panels on drinking water production. This is by no means 100% objective nor should it be regarded as a single determining factor in selecting a solution. The evaluation is also based on the information provided by the manufacturer. Scores are given on a relative scale towards other methods.

All methods have a considerable level of disinfection capacity for bacteria and fulfil certain appropriateness criteria on performance, people and planet. Each fact sheet in this booklet shows a scorecard (1-10) for overall appropriateness, broken down in Performance and People/Planet. The score is determined by 13 different criteria: 7 for performance, 4 for people and 2 for planet (see box).

Selected appropriateness criteria and weight

Performance

1 Continuity of water quality and quantity (high weight)
2 Adaptability to part time operations (high weight)
3 High potential of local production (high weight)
4 Robustness (medium weight)
5 User safety during operation (medium weight)
6 Possibility of water quality checking by user (medium weight)
7 Amount of experience in technology application (low weight)

People

8 Operated and maintained at local level (high weight)
9 Accessible spare parts (medium weight)
10 Social benefits to user (medium weight)
11 Acceptable intensity and frequency of operation and maintenance (low weight)

Planet

12 Low dependency on fuels and chemicals (high weight)
13 Isolation or reuse of the waste product (low weight)

For each criterion, an objective rating system is created to define standard assessment for the scores: 1 (poor), 4 (reasonable), 7 (good) and 10 (excellent). An example of such standard assessment is as follows:

- Criterion 2: Adaptability to part time operations
  Score 1, not suitable for part time operation (running continuously)
  Score 4, system can be started up and shut down at any given time, but it will compromise water quality and/or system's well being
  Score 7, system can be started up and shut down at any given time, but certain O&M procedures must be adhered to
  Score 10, system can be started up and shut down at any given time, without compromising water quality and system's well being

An extended explanation on the rating system can be found on www.akvo.org. Except for criterion 3, all criteria have relevance for consumers. Criterion 3 is more associated with the potential for local production and of relevance for organisations that intend to introduce a 'new' product in the area.

For the determination of the appropriateness score, a weighted average is used. The weighted average for overall category, Performance and People/Planet categories are defined as poor for scores less than 5.5, medium between 5.5 and 6.5, and good when higher than 6.5.

The result of this *Multi Criteria Analysis* is as follows.
Of all 21 products in this booklet, five score less than 5.5 in the overall appropriateness category. Nine products score medium and seven are evaluated as good. Nine products show medium performances, while seven are good. In the People/Planet category, six of them score between 5.5 and 6.5. Seven score more than 6.5.

Price

Price level has not been a scoring criterion, but it is shown in the scorecard as a comparison guide for the reader to decide. For the price evaluation, running costs are as relevant as the investment price. Methods with low initial cost, such as AquaPak, are expensive in the long run due to the low capacity. On the other hand, a slow sand filter system with high initial cost produces much cheaper water within its expected lifetime. Hence, the price comparison is based on the unit price of water per m^3 during the lifetime of the method.

For most methods, except for the addition of chemicals, the unit price is calculated as the Total cost (input) divided by the Total Volume during lifetime (output). The latter is derived from the length of the expected lifetime and the daily capacity (often lower than 24 times the hour capacity). For solar and wind driven devices without a long lasting battery, a reduction factor is to be applied for percentage of days with insufficient power.

The total cost is calculated from the investment cost (without depreciation), the cost of replacements during its lifetime, the running cost during lifetime (fuel, chemicals) and the salary cost for possible operator or services/repair. An annual salary is set at € 500 (fulltime). This is based on the average Gross National Income per capita in the third world countries (World Bank). Generally, it is assumed that an operator will only be working 1 day per week. Therefore an annual salary of € 100 is calculated. Time cost for the consumer is not included, as this is too site-specific.

For the chemical products (drops and powders), the price is based on the price of the chemical required for treating one m^3 of water.

Cost remains very location and situation specific. It can deviate from the assumed average, because of the use of local materials, operation by volunteers, expensive training, etc. Bear in mind also that the total cost of water may be much higher when costs for water abstraction, pre-treatment, storage and distribution have to be included! Local prices can also differ a lot from the assumed global price. The price of electricity in Nigeria, for example, is many times the price in Zambia or South Africa.

Products are defined as expensive when the price is above € 2,00/m^3, cheap when below € 0,50/m^3 and medium in between. As an illustration, the price of perfect tap water in the Netherlands is € 2/m^3. For a person on the poverty line (having € 0,80 per day), the amount of € 2/m^3 still represents 5% of the daily budget when he uses the required daily minimum of 20 litres. This is already above the generally accepted expense for water of 3% of the daily household basket, whereas the other components of the water chain are not yet included.

From all of the products presented in this booklet, six are within the cheap price range, nine in the medium range and six in the expensive range.

Disclaimer: The scorecard has to be regarded only as a second opinion in selecting the most suitable technology. Product appropriateness according to variables of local situations has to be considered by users. It is recommended that implementation of technology is preceded and followed by water quality testing.

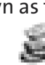
Reading guide

In this booklet some 21 disinfection technologies are presented that are based on various treatment techniques. They range from filtration by ceramic, sand, or membrane, to post-disinfection techniques such as chlorination, heat, UV or silver. Three categories are used to distinguish the technologies: 1) the removal efficiency of pathogens, 2) the capacity of the technology, and 3) the unit price of the water produced. These categories are illustrated by pictograms on the left-side page.

Each technology is presented in two pages. The first page contains images and pictograms. The first set of pictograms deals with removal efficiencies. These are represented as follows:

resp. for bacteria, viruses, and parasites
red, orange or green: resp. no or very little removal; some removal ; good removal
Furthermore there are pictograms for the level of user(s):

equipment feasible for resp. one person, a family, a (small) community

Cost per m^3 during lifetime is shown as follows:
 ≤ 0,50 €  0,51 - 2,00 €  > 2,00 €

The second page explains specific product characteristics. To start with, *Product description* explains general features such as treatment process, capacity, and manufacturer. *O&M and Lifespan* provides information about how the product should be operated and maintained (O&M), so that it will work properly throughout its effective lifetime. The lifespan may represent the total amount of safe drinking water produced or a time period, until when a complete/partial replacement has to take place.

Some of these technologies are able to treat various contaminants, such as suspended solids, microorganisms, or even dissolved anorganic chemicals (single stage system), provided the raw water input is acceptable. On the other hand, post-disinfection is only effective in removing pathogens. Thus, most of the time, they are applied in the very last step (multistage system), unless the raw water is contaminated only by micro-organisms. Under *Efficiency and Considerations*, you will find the efficiencies of contaminants removal and important recommendations regarding the application of a technology.

Next, the cost per m³ of water treated, overall appropriateness score, and sub-scores for performance and people/planet criteria are summarized in the *blue box*. The complete scoring table can be found in the extended fact sheet accessible in www.akvo.org. The Cost aspect is further elaborated in a separate table. The values presented under "evaluation" are pre-selected by authors to calculate the final "unit price". Cost ranges that depend on local conditions are provided in "remark". For instance, the cost of boiling is related to fuels or electricity prices, which are variable from one place to another. In such situations, cost ranges will give better reviews. Likewise, some technologies can be produced locally, which means the cost will be directly dependent on the local price of the raw materials.

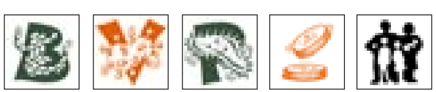
This booklet strives to provide the most relevant information concisely. If readers are interested in finding out more, they are advised to read the extended fact sheet or visit the websites presented under *More information*.

We sincerely hope that the following examples provide a solution for your situation or will provide inspiration for new developments. Any comments and experiences can be communicated through the akvo website.

Summary of products

(sequence of type and appropriateness score)

Product	Virus removal	Unit price (Euro/m3) **	Overall AT score *	Sub-score performance *	Sub-score people/planet *	see page
Filter						
Ceramic Water Purifier	Ltd	0,57	7,9	7,9	8,0	29
Biosand Filter	Ltd	0,11	6,4	5,7	8,0	33
Water4Life Filter	Ltd	0,42	6,3	5,7	5,5	31
Tulip Siphon Filter	Ltd	0,51	6,1	6,1	5,5	27
Kanchan Arsenic Filter	Ltd	0,11	6,1	5,3	7,0	35
Jal-TARA Water Filter (SSF)	Ltd	0,22	5,2	4,4	7,0	59
Disinfection						
Chlorine	Gd	0,24	7,0	8,3	4,6	57
Solar Disinfection	Gd	0,87	7,0	7,0	6,5	45
Boiling	Gd	17,85	6,8	7,9	4,0	43
AquaEst Plation Floats	Ltd	0,75	6,6	6,1	7,0	37
NaDCC	Gd	3,25	6,5	7,9	4,6	41
PUR Purifier of Water	Gd	7,14	6,5	7,9	4,6	55
Aquapak	Gd	3,13	6,4	6,1	6,0	47
WATA (mini)	Gd	0,02	4,9	5,3	5,8	67
Filter + Disinfection						
Lifestraw (individual)	Gd	4,08	6,4	6,1	6,3	49
Perfector-E	Gd	0,69	6,2	6,6	6,0	65
Naiade	Gd	0,59	5,8	5,7	6,5	61
WaterPurifier	Gd	1,21	5,7	6,1	5,0	63
Lifestraw Family	Gd	0,79	5,3	4,9	5,2	51
Pureit	Gd	4,36	5,1	5,3	5,0	53
Other						
AquaEst RainPC	Ltd	2,00	5,4	5,7	5,0	39



Tulip Siphon Filter

Product description: Tulip siphon filter is a candle-type water filter that uses siphon pressure to force water through a high-quality ceramic filter element. The innovative usage of the siphon results in a high flow rate of 4-6 l/hour. Very com-pact build consisting of a filter element, a plastic hose, a valve, a cleaning pad and a fleece pre-filter, while existing water containers can be used. The filter element is impregnated with silver to increase efficiency. A new type of filter element with activated carbon will go into production in March, 2010.

O&M and Lifespan: To start treatment, filter is put into a container filled with contaminated water that should be placed about 70 cm above a clean water container. The siphon action is initiated by squeezing the rubber bulb. The pressure forces water through the filter element, ensuring high flow. After some time, the flow rate may reduce due to clogging. It can be cleaned by backwashing, using the rubber bulb, or by using the cleaning pad. Backwashing increases the lifetime of the filter element. The filter element lasts between 6 months to 2 years depending on water quality (it produces at least 7.000 litres of water). Plastic parts could last 5 years.

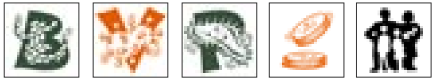
Efficiency and Considerations: Tulip filter has been tested using a certified method by Water Laboratory Noord, an independent laboratory based in the Netherlands. It was found that at the end of its lifetime, it still removed E. Coli by more than 99,99%. However, it is not effective for highly turbid water. The filter is small and easy to transport or store. Local production is only feasible for some plastic parts, if there is an existing industrial infrastructure.

Unit price (Euro/m³)	**0,51**	**Medium**
Overall AT score	**6,1**	**Good**
Sub-score performance	6,1	Good
Sub-score people/planet	5,5	Medium

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	5	
Capacity	l/day	50-80	
Volume in lifetime	m³	35	5 filters * 7 m³
Investment	€	8,00	€ 7 - 9
Replacement during lifetime	€	10,00	5 * € 2/year
O&M lifetime	€		none
Salary cost Lifetime	€		none
Unit price	€/m³	0,51	€ 0,49 - 0,54

More information:

- www.basicwaterneeds.com
- www.nulpuntenergie.net
- www.arrakis.nl
- www.akvo.org



Ceramic Water Purifier

Product description: There are many variants of ceramic pot filters. The one discussed in this booklet is by Potters for Peace (PFP) known as Ceramic Water Purifier (CWP). The filter element (local clay mixed with a combustible material like sawdust, rice husks or coffee husks) typically sits or hangs on top of the receptacle (plastic/ceramic container fitted with tap with a capacity of 20-30 litres). The mould provided by PFP is a cylindrical, flat-bottomed pot. Colloidal silver is added to the filter element after firing, to increase pathogen removal.

O&M and Lifespan: Contaminated water is poured into filter element and treated water can be collected from the bottom container. It has slow flow rate: 0,5-2,5 l/hour. Continued use of the filter causes the pore openings in the ceramic to become clogged with debris. To clean the filter, scrub the surface of the ceramic filter with a sturdy brush and flush with water. Additionally, if input water is highly turbid, pre-sedimentation is recommended. The estimated lifespan is up to 5 years, but normally partial replacement (cracks in filter element or bottom container, broken tap) of the system will occur within 1 or 2 years.

Efficiency and Considerations: CWP is effective in removing bacteria, protozoa and helminths and reasonably effective for virus removal and turbidity. Field experience and clinical test results have shown this filter to effectively eliminate approx. 99,88% of most waterborne disease agents. It also provides safe storage. Production quality shows variations. Clogging is partly irreversible, resulting in lower outputs. To prevent recontamination and breakage, it is recommended that filter element not be moved frequently. Transport and handling should be done carefully, since the filter is quite fragile. It is preferable to produce CWP locally; free press and kiln design are provided by PFP.

Unit price (Euro/m³)	**0,57**	**Medium**
Overall AT score	**7,9**	**Good**
Sub-score performance	7,9	Good
Sub-score people/planet	8,0	Good

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	5	
Capacity	l/day	24	16 hours-operation
Volume in lifetime	m^3	43,8	
Investment	€	14,00	€ 5,4 - 22
Replacement during lifetime	€	10,80	3 * € 3,6/replacement
O&M lifetime	€		none
Salary cost Lifetime	€		none
Unit price	€/m^3	0,57	€ 0,37 - 0,75

More information:
- www.akvo.org
- www.pottersforpeace.org
- www.cawst.org

Water4Life Filter

Product description: The gravity unit ceramic candle filters consist of two reservoirs. The top reservoir contains at least one candle filter (at most two) and the lower container works as safe storage for treated water. The first layer of the candle filter is made from clay with fine pore structures. It can stop any particles/ bacteria larger than 0,5 µm. The second layer is impregnated with colloidal silver that inactivates bacteria. Layer 3 is filled up with activated carbon that can absorb iron, chlorine, odour and colour. Gravity pushes the water gradually through the porous filter candle. Water4Life filter is available in metal or plastic container design. Extra carbon cartridge can be added.

O&M and Lifespan: The average flow rate of the water is limited to about 1-2 l/hour. When a new candle is used, do not consume the first 5 litres as drinking water. The filter needs to be cleaned when flow rate is very low. This can be done with some water and a piece of cloth to rub the dirt. When dirt has penetrated the outer layer, scraping off the layer is required. Avoid damage and do not use detergents in this procedure. One candle could normally produce 7.000 litres. Steel vessels are very robust and will easily last 10 years.

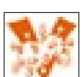
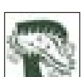
Efficiency and Considerations: This treatment provides 99,9-99,99% of bacteria removal. To prevent recontamination, proper O&M should be conducted, especially in handling the lower vessel. One of the drawbacks is lack of a reliable method to check water quality with regard to exhausted filter elements. Several hours of waiting time for clean water to be available is also necessary. The main advantages are the safe storage vessel and the support from Water4Life for training and education for both users and manufacturers.

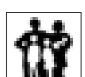
Unit price (Euro/m³)	**0,42**	**Good**
Overall AT score	**6,25**	**Good**
Sub-score performance	6,57	Good
Sub-score people/planet	5,50	Medium

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	10	metal design, one candle
Capacity	l/day	24	1/2 l/h (filled 3 times/day)
Volume in lifetime	m³	70	1 year candle life
Investment	€	15,00	€ 2,30 - 25,00
Replacement during lifetime	€	14,52	€ 1,16 per year
O&M lifetime	€		none
Salary cost Lifetime	€		none
Unit price	€/m³	0,42	€ 0,24 - 0,56

More information:

- www.water4life.eu



Biosand Filter

Product description: Biosand Filter (BSF) by CAWST (Centre for Affordable Water and Sanitation Technology, Canada) is an adaptation of the traditional slow sand filter, smaller in size and suitable for intermittent use in households. The filter container can be made of concrete, plastic or any other waterproof, rustproof and non-toxic material. The container is filled with layers of sieved and washed sand and gravel (filter media). There should be 5 cm of standing water above the sand layer to sustain the bio-layer or schmutzdecke that contributes to pathogens removal. Removal of contaminants is a combination of biological and mechanical processes. Another type of biosand filter with similar principle is the patented HydrAid® (see photo) which uses plastic containers.

O&M and Lifespan: Operating the filter is very simple: remove the lid, pour a bucket of water gently into the filter, and immediately collect the treated water in a container. In a new filter, the bio-layer typically takes at least three weeks to mature. Flow rate is 0,3-0,6 l/min. Depending on frequency of use, daily production is 24-72 litres. When the flow rate drops to a level that is inadequate, simple swirl and dump maintenance can be done. Filters are still performing satisfactorily after 10+ years, lids and diffusers may need replacement.

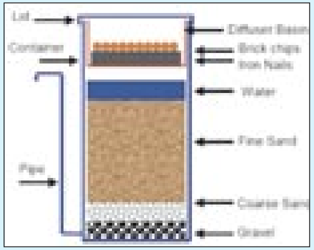
Efficiency and Considerations: Laboratory test shows >96,5% removal of bacteria, 70 to >99% viruses, >99,9% protozoa, up to 100% helminths, 95% to <1 NTU turbidity, and field test shows 90-95% additional iron removal. For optimum performance, filter should be used every day, preferably with a consistent water source. It is recommended to add final disinfection step (chlorine, SODIS, or boiling). CAWST facilitates local production as well as training and education for users.

Unit price (Euro/m³)	**0,11**	**Good**
Overall AT score	**6,4**	**Good**
Sub-score performance	5,7	Medium
Sub-score people/planet	8,0	Good

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	10	
Capacity	l/day	60	24 - 72
Volume in lifetime	m³	219	
Investment	€	18,30	€ 8,6 - 28
Replacement during lifetime	€	5,00	breakage repair
O&M lifetime	€		none
Salary cost Lifetime	€		none
Unit price	€/m³	0,11	€ 0,08 - 0,19

More information:

- www.cawst.org
- www.hydraid.org



Kanchan™ Arsenic Filter

Product description: Kanchan™ Arsenic Filter (KAF) is an adaptation of a BSF, developed by researchers at Massachusetts Institute of Technology, ENPHO (Environment and Public Health Organization of Nepal), and Rural Water Supply and Sanitation Support Programme of Nepal. It is designed to remove arsenic from drinking water, in addition to the contaminants removed by BSF. The filter container can be constructed out of concrete or plastic. Typical dimensions are 90x30x30 cm. Arsenic removal is achieved by incorporating a layer of rusty nails (iron) in the diffuser basin of the filter. KAF removes pathogens, iron and suspended material through a combination of biological (bio-layer) and physical (straining) processes.

O&M and Lifespan: Contaminated water is poured into the top of the filter on an intermittent basis. Water slowly passes through the diffuser, and percolates down through the bio-layer, sand and gravel. Treated water naturally flows from the outlet. The filters are still performing satisfactorily after 10+ years. Lids and diffusers may need replacement. Nails need to be replaced every 2-3 years to en-sure effective arsenic removal.

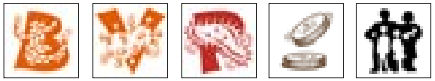
Efficiency and Considerations: KAF provides good flow rate (15-20 l/hour). Lab test showed removal of bacteria up to 96,5% (field 60-100%), viruses 70-99%, protozoa >99%, helminths up to 100%, iron and turbidity 90-99% (field 90-95%), and arsenic 85-95% (field). The treatment does not provide residual protection, thus post-disinfection may be necessary. Another concern is the waste isolation of the arsenic impregnated nails. Local production of the filters is recommended, with borrowed/rented/locally-produced mould.

Unit price (Euro/m³)	**0,11**	**Good**
Overall AT score	**6,1**	**Good**
Sub-score performance	5,3	Medium
Sub-score people/planet	7,0	Good

Cost	Unit	Evaluation	Remark
Lifetime	year	10	
Capacity	l/day	60	48 - 72 l/day
Volume in lifetime	m³	219	
Investment	€	15,30	€ 8,6 - 22
Replacement during lifetime	€	9,52	€ 2,85 per 3-year
O&M lifetime	€		none
Salary cost Lifetime	€		none
Unit price	€/m³	0,11	€ 0,08 - 0,14

More information:

- www.akvo.org
- www.cawst.org
- www.jalmandir.com



AquaEst Plation® Floats

Product description: Plation products inactivate (pathogenic) bacteria by silver ions. The silver ions are released by a natural ionization process from special ceramic balls with a coating of pure, high quality colloidal silver (microscopically small silver particles). Plation floats were originally developed for preservation of public drinking water in storage tanks and cisterns, but also work very well for Rooftop Harvested Rainwater and even in contaminated public water. The floats effectively prevent growth of pathogenic bacteria during storage, keeping stored water safe and fresh without electricity and maintenance. AquaEst has a wide product range for tanks from 10-20 litres (jerry cans) up to 5.000 litres or more.

O&M and Lifespan: No special O&M procedure is needed: put a Plation float into a drinking water tank and the water will be preserved during (long term) storage. In public water, the Plation floats have a lifetime of 2 years. In chlorinated public water, contaminated public water or rooftop harvested rainwater the lifetime may be less than 2 years. For rooftop harvested rainwater in schools therefore AquaEst supplies the RainPC, adding filtration, copper/silver and activated carbon, ensuring long lifetime.

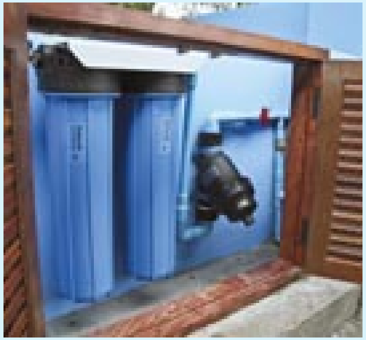
Efficiency and Considerations: Plation floats are effective in inactivating bacteria (tested by C-mark Waterconsultants and Vitens Water laboratory, the Netherlands and laboratories in Mexico and Thailand). In heavily bacterially contaminated drinking water, the Plation floats are still effective but need longer contact times, so for rapid disinfection, a preliminary disinfection step with chlorine is a possibility. Plation reduces or eliminates the possibility of recontamination and is a useful addition for storage, generally not offered by others.

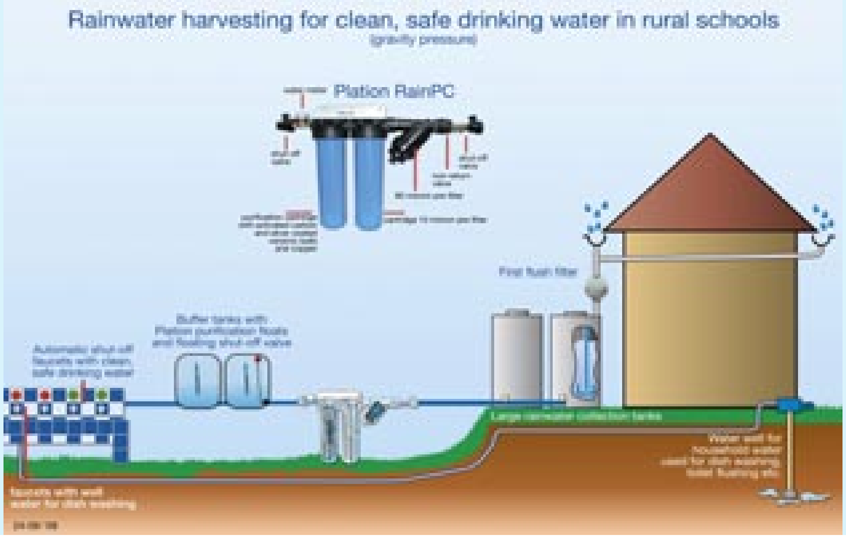
Unit price (Euro/m³)	**0,75**	**Medium**
Overall AT score	**6,6**	**Good**
Sub-score performance	6,1	Good
Sub-score people/planet	7,0	Good

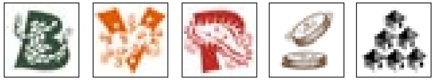
Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	2	
Capacity	l/day	50	
Volume in lifetime	m^3	37	Plation JC50
Investment	€	27,40	€ 27,40 - 337,80
Replacement during lifetime	€		none
O&M lifetime	€		none
Salary cost Lifetime	€		none
Unit price	€/m^3	0,75	bigger capacity cost less

More information:

- www.aquaesteurope.com







AquaEst RainPC®

Product description: The Plation RainPC (Rain Purification Centre) turns rainwater into pure, safe drinking water. Rooftop harvested rainwater is purified by means of multi-stage and multi-media filtration. It is a 3 stage filtration system using a 80 micron and a 10 micron pre-filter along with an activated carbon filter in which ceramic silver balls and copper are embedded. To ensure water to be safe from bacteria and create enough capacity, the filtered water is stored in storage tanks. Due to storage (contact time) the bacterial retention is > log 3. Combined with storage tanks the RainPC is suitable for households as well as small villages and schools. In Thailand the RainPC is successfully used in rural schools providing > 2000 children with safe drinking water. The RainPC operates at low gravity pressure as well as pump pressure, the maximum water flow is 8 litres/minute.

O&M and Lifespan: Regular operation and maintenance is required for the 80 micron filter, including inspection and cleaning. The 10 micron prefilter and the filter cartridge, in adequate systems, can achieve a capacity of up to 150 m³ without further maintenance. The service life of the system is at least 15 years, with respect to the complete project.

Efficiency and Considerations: The system is effective in eliminating bacteria (tested by C-mark Waterconsultants and Vitens Water laboratory, the Netherlands and The Ministry of Health in Thailand; meeting WHO Guidelines). Important issue is a suitable rainwater harvesting system and protected storage of the filtered water to ensure bacterially safe water and enough capacity. In Thailand the RainPC is integrated in complete new/revised rainwater harvesting systems (new gutters, new piping, reparation main storage tanks, first flush, etc.).

Unit price (Euro/m³)	**2,00**	**Medium**
Overall AT score	**5,4**	**Medium**
Sub-score performance	5,7	Medium
Sub-score people/planet	5,0	Medium

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	15	
Capacity	l/day	274	
Volume in lifetime	m³	1500	
Investment	€	1000,00	complete system
Replacement during lifetime	€	2000,00	€ 200 / 150 m³
O&M lifetime	€		none
Salary cost Lifetime	€		none
Unit price	€/m³	2,00	

More information:

- www.aquaesteurope.com

NaDCC

Product description: NaDCC, also known as sodium dichloroisocyanurate or so-dium troclosene, is a form of chlorine used for disinfection. It is often used to treat water in emergencies, and is now widely available for household water treatment. NaDCC tablets are available with different chlorine content (3,5 mg to 10 g) to treat from 1 to 3.000 litres of water. They are usually effervescent tablets. When added to water, NaDCC releases hypochlorous acidthat reacts through oxidization with micro-organisms and kills them.

O&M and Lifespan: User should add the correct sized tablet for the specific amount of water. Water is then agitated in a container, and wait for chlorine to take effect. Normally 30 minutes contact time is necessary before water is potable. The required dose and contact time vary according to water quality; it usually calls for low turbidity and pH between 5,5-9,0. The tablets should be protected from exposure to temperature extremes or high humidity. Five year shelf-life in strip packs and a three year shelf-life in tubs are common.

Efficiency and Considerations: NaDCC is highly effective against bacteria and viruses but not as effective against protozoa. Aquatabs by Medentech have gone through extensive lab and field testing, proving high reliability. It is part of the Safe Water System (SWS) approach by Centres for Disease Control and Prevention (CDC). For successful intervention, education is essential. Most users cannot determine the proper dosing quantity (although instructions are available). It also requires supply chain, market availability and regular purchase. NaDCC tablets cannot be produced locally, but they can be bought in bulk and packaged locally.

Unit price (Euro/m³)	**3,25**	**Poor**
Overall AT score	**6,5**	**Good**
Sub-score performance	7,9	Good
Sub-score people/planet	4,6	Medium

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	5	strip packs
Capacity	l/day		NA
Volume in lifetime	m^3	0,02	20-litre tablet
Investment	€		none
Replacement during lifetime	€		none
O&M lifetime	€	0,07	€ 0,02 - 0,11/tablet
Salary cost Lifetime	€		none
Unit price	€/m^3	3,25	bulk purchase cost much lower

More information:
- www.cawst.org
- www.aquatabs.com
- www.cdc.gov
- www.who.int

Boiling

Product description: Boiling is arguably the oldest and most commonly practiced household water treatment method, and it has been widely promoted for decades. Many organizations recommend boiling for disinfection in developing countries and in emergency situations throughout the world.

O&M: Water should be placed in a clean container and brought to a full boil for at least 3 minutes. If more than 1.500 m above sea level, the boiling time must increase to at least 5 minutes (plus ± 1 minute for every additional 300 m). Water should be stored in the same container in which it was boiled, handled carefully, and consumed within 24 hours to prevent recontamination. Safety measures are required to avoid injuries and skin burning.

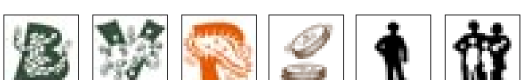
Efficiency and Considerations: When boiling point is reached, it is effective at in-activating all bacteria, viruses (up to 100%), protozoa and helminths (up to 100%) that cause diarrhoeal disease. Some studies in developing countries have documented incomplete inactivation of bacteria in boiled water (97-100% removal). This disparity between the laboratory and field results is attributed to users not heating the water to the boiling point and/or recontamination of boiled water in storage. The major drawback of boiling is its dependency on fuels that can be expensive and difficult to obtain in rural areas of developing countries. It is estimated that 1 kg of wood or 0,1-0,2 kWh is needed to boil 1 litre of water. Therefore, it is most applicable in areas with a good fuel supply, a cultural tradition of boiling, and where water is stored safely after boiling. The cost consideration is highly dependent on prices of fuels/electricity.

Unit price (Euro/m³)	**17,85**	**Poor**
Overall AT score	**6,8**	**Good**
Sub-score performance	7,9	Good
Sub-score people/planet	4,0	Medium

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year		NA
Capacity	l/day		NA
Volume in lifetime	m^3		NA
Investment	€	2,00	container; boiler
Replacement during lifetime	€		none
O&M lifetime	€		fuels; electricity
Salary cost Lifetime	€		none
Unit price	€/m^3	17,85	€ 7,1 - 28,6

More information:

- www.who.int
- www.cawst.org



Solar Disinfection

Product description: Solar disinfection (SODIS) is a simple water treatment method using solar radiation to destroy pathogenic bacteria and viruses present in the water. This technique was initiated by Eawag. At temperatures above 45°C, a strong synergetic effect of temperature and UV-A radiation significantly accelerates disinfection process. When the temperature reaches 65°C, the water also undergoes pasteurization.

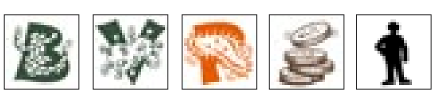
O&M and Lifespan: Bottle materials that should be used are those made of PET (Polyethylene terephthalate) or glass that is transparent and colourless; bottle should not be bigger than 3 litres. Water turbidity should be low. First, fill bottles with potentially contaminated source. After that, add water until full. Expose bottles to the sun for 6 hours on sunny days, or 2 consecutive days when the sky is more than 50% cloudy. Bottles and caps should be cleaned on a regular basis. Bottles become scratched or aged by sunlight and must be replaced periodically (every 4-6 months).

Efficiency and Considerations: The effectiveness of this treatment is dependent on the amount of solar energy available. With 6 hours exposures in 40°C, Eawag states removal of bacteria up to 99,999%, viruses 99,9-99,99%, while parasites removal is less effective (Giardia cysts are rendered inactive, limited effectiveness for Cryptosporidium oocysts and amoeba). During days of continuous rainfall, SODIS does not perform satisfactorily. Rainwater harvesting or boiling is recommended during these days. Since SODIS does not offer residual protection, bottle should be kept tightly closed. Unit price refers to 10 bottles of SODIS enough for family of five.

Unit price (Euro/m³)	**0,87**	**Medium**
Overall AT score	**7,0**	**Good**
Sub-score performance	7,0	Good
Sub-score people/planet	6,5	Good

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	0,40	4-6 months
Capacity	l/day	20	10 bottles
Volume in lifetime	m³	4,3800	sun factor 0,5
Investment	€	1,80	€ 0-3,6 / 10 bottles
Replacement during lifetime	€	5,40	€ 0-10,8 (3 times a year)
O&M lifetime	€		none
Salary cost Lifetime	€		none
Unit price	€/m³	0,87	used (€ 0-0,33); new (€ 0,65-2,5)

More information:
- www.sodis.ch
- www.akvo.org



AquaPak

Product description: AquaPak is made from low cost polyethylene plastic with UV inhibitors added, and air-filled bubble pack sheeting. It can heat water to temperatures up to 65°C (pasteurization), a temperature that will kill waterborne pathogens using only sunlight. It employs a reusable sealed glass tube indicator, called a WAPI, filled with coloured wax at one end that melts when heated to the required temperature, indicating the start of the pasteurization process.

O&M and Lifespan: Depending on the availability of sunlight throughout the day, an AquaPak can produce up to 5 litres of water per day. To use AquaPak, fill water into the bag and place it in direct sunlight for at least three hours. To ensure complete pasteurization, orange wax must completely melt and turn clear, indicating 65°C has been reached. The complete instruction is available on the backside of the AquaPak. The AquaPak should last at least one year before the solar UV deteriorates the Polyethylene plastic to a point where it may not work efficiently.

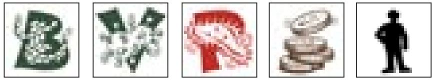
Efficiency and Considerations: Tests conducted by BioVir Laboratories, San Francisco, California, on virus contaminated water and by Environmental Engineering Laboratory, San Diego, California, on bacterial pathogens: eradication of 99,999% of the pathogens present. AquaPak is specifically developed for individual use. It is also dependent on the availability of intense sunlight, so in case of insufficient sunlight, chlorine tablets need to be supplied. Education and training can improve people's willingness to use the product. The business model of the AquaPak is to help developing world entrepreneurs to establish AquaPak "copy exactly" manufacturing facilities where demands are present.

Unit price (Euro/m³)	**3,13**	**Poor**
Overall AT score	**6,4**	**Good**
Sub-score performance	6,1	Good
Sub-score people/planet	6,0	Medium

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	1	sun factor 0,5
Capacity	l/day	5	
Volume in lifetime	m³	0,9125	sun factor 0,5
Investment	€	1,43	
Replacement during lifetime	€	1,43	
O&M lifetime	€		none
Salary cost Lifetime	€		none
Unit price	€/m³	3,13	

More information:

- www.solarsolutions.info



LifeStraw®

Product description: LifeStraw® is a product of Vestergaard SA. It is a portable and simple water filter device, which measures about 25 cm long and 29 mm in diameter. It contains a specially developed halogenated resin (iodine) that kills bacteria and viruses on contact. Additional chamber increases the exposure of micro-organisms to the halogenated resin, thereby enhancing the killing effect. Micro-filters are used to remove all particles down to 15 microns. Granular activated carbon (silver-impregnated) absorbs residual iodine thereby improving the taste of water.

O&M and Lifespan: Place LifeStraw® in water and sip through the mouthpiece. Regularly blow through LifeStraw® after drinking to keep the filters clean and to prevent them from clogging. LifeStraw® filters up to 700 litres of water. Assuming that daily water consumption is 2 litres, then the lifespan is nearly 1 year. Shelf-life is 2 years at 25°C or 1 year at 30°C.

Efficiency and Considerations: The University of North Carolina evaluated the performance of LifeStraw®. It removes > 99,99% of waterborne bacteria, more than 98% of waterborne viruses, and removes particles down to 15 microns. It is not effective in removing parasites, Giardia, high turbidity and chemicals. The released amount of iodine in treated water is not normally damaging to human health. However, people with thyroid problems and allergic reaction to iodine must seek medical advice before using this tool. LifeStraw® is also not suitable for children, primarily because they may not be able to produce the necessary sucking force. Due to its compact design, LifeStraw® is easy to distribute. However, the low capacity means a lack of sustainability as development tool.

Unit price (Euro/m³)	**4,08**	**Poor**
Overall AT score	**6,4**	**Good**
Sub-score performance	6,1	Good
Sub-score people/planet	6,3	Good

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	1	
Capacity	l/day	up to 10	
Volume in lifetime	m³	0,70	
Investment	€	2,86	
Replacement during lifetime	€		none
O&M lifetime	€		none
Salary cost Lifetime	€		none
Unit price	€/m³	4,08	

More information:

- www.vestergaard-frandsen.com

Product description: LifeStraw® Family is a point-of-use instant microbiological water purifier. The filtration begins in the 27 microns pre-filter bucket that removes coarser turbidity. At the bottom of the bucket, a halogen chamber releases minimal chlorine to prevent membrane fouling. Gravity forces water through the purification cartridge (ultrafiltration, pore size of 20 nm) that retains bacteria, viruses, parasites and fine particles. Subsequently, clean and safe water is then ready to flow from the attached blue tap.

O&M and Lifespan: LifeStraw® Family has high flow rate (average 8-10 l/hour). Complete O&M instructions are provided with the product. Approximate cleaning frequency: pre-filter every 30 hours, filter cartridge every 11 hours and bucket once a week. The red bulb provides backwashing for the filter cartridge. LifeStraw® Family filters a minimum of 18.000 litres of water. The calculated lifespan is 3 years, assuming family consumption of 15 l/day.

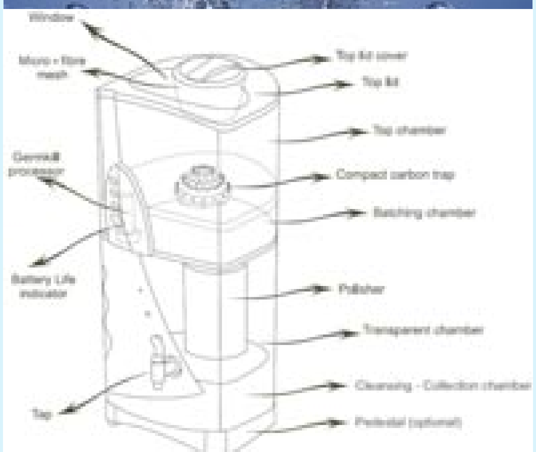
Efficiency and Considerations: It removes bacteria up to 99,9999 %, viruses to 99,99%, parasites to 99,9% and turbidity (as tested by the University of Arizona, USA). The system does not need electricity. It is robust and long lasting with an auto-clog mechanism that prevents the consumption of untreated water. A few of the drawbacks are the relatively small reservoir (refill every 2 litres), high hanging bucket, concerns about safe storage, somewhat complex daily cleaning, and complete replacement when systems are exhausted. The filter is not sold as individual unit, the distribution is focused on customers who can purchase large quantities of the products for the developing world (unit price depends on the total amount purchased).

Unit price (Euro/m³)	**0,79**	**Medium**
Overall AT score	**5,3**	**Medium**
Sub-score performance	4,9	Medium
Sub-score people/planet	5,2	Medium

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	3	
Capacity	l/day	15	
Volume in lifetime	m^3	18	
Investment	€	14,29	€ 12,1 - 14,3
Replacement during lifetime	€		whole system
O&M lifetime	€		none
Salary cost Lifetime	€		none
Unit price	€/m^3	0,79	€ 0,67 - 0,79

More information:

- www.vestergaard-frandsen.com



Pureit

Product description: Pureit is a compact drinking water treatment product suit-able for household use, developed by the Hindustan Unilever. The core of this system is its unique Germkill Battery Kit that consists of the compact carbon trap, Germkill processor, and Polisher. First, water is poured into the system passing through the micro-fibre mesh that removes visible dirt. The compact carbon trap will remove additional dirt, parasites and some pesticide impurities. Water then flows into the Germkill processor which uses a "sustained release chlorine technology" to kill harmful bacteria and viruses. Finally, water passes through the Polisher, which removes odour and improves water clarity.

O&M and Lifespan: Water has to be filled into the top chamber once a day. How-ever, if more than 9 litres of water is required, Pureit can be filled as often as necessary. Pureit is equipped with battery life indicator which tells user when the Germkill Battery Kit is still working. When Germkill Battery Kit is exhausted, all three parts of the kit must be replaced. Partial replacement is not recommended. The battery life may vary depending on daily water consumption. It is designed for 1.500 litres of water at a water temperature of 25°C, in moderate humidity conditions. The shelf-life of the battery is two years.

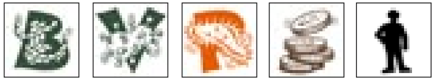
Efficiency and Considerations: Highly effective against bacteria and viruses. But not as effective against parasites. To avoid premature choking of the purifier, simple pre-sedimentation for highly turbid raw water is recommended. Although using the term "battery", Pureit does not need electricity. Concerns about this unit are the relatively short lifespan and the supply chains.

Unit price (Euro/m³)	**4,35**	**Poor**
Overall AT score	**5,1**	**Medium**
Sub-score performance	5,3	Medium
Sub-score people/planet	5,0	Medium

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	10	whole unit
Capacity	l/day	20	
Volume in lifetime	m³	73	
Investment	€	32,18	Rs 2.000
Replacement during lifetime	€	285,67	Rs 365/1.500 litres
O&M lifetime	€		none
Salary cost Lifetime	€		none
Unit price	€/m³	4,35	

More information:

- www.pureitwater.com



PUR Purifier of Water™

Product description: Procter&Gamble developed PUR Purifier of Water™ in conjunction with the Centers for Disease Control and Prevention. PUR sachets are now centrally produced in Pakistan, and sold to NGOs worldwide. PUR is a small sachet containing powdered ferric sulphate (a flocculant) and calcium hypochlorite (a disinfectant). PUR was designed to imitate a water treatment plant process, incorporating the multiple barrier processes of removal of particles and disinfection.

O&M and Lifespan: To treat water with PUR, open the sachet, add the contents to an open bucket containing 10 litres of water (1 sachet for 10 litres water), stir for 5 minutes, and let the solids settle to the bottom of the bucket. Then strain the water through a cotton cloth into a second container, and wait 20 minutes for the hypochlorite to inactivate the micro-organisms. Shelf-life of PUR is 3 years.

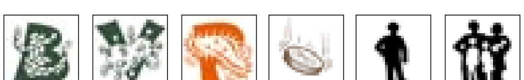
Efficiency and Considerations: PUR Removes more than 99,99% of bacteria, up to 99,99% of viruses and up to 99,9% of protozoa. It has been proven to reduce diarrhoeal disease incidence in the developing world by up to 90%. In addition, PUR removes high turbidity, heavy metals, such as arsenic, and some other dissolved chemical contaminants. Studies showing the effectiveness of PUR have been conducted in the laboratory and in developing countries, in rural and urban areas and refugee camps, and include adults and children that are poor and/or using highly turbid water. The drawback of PUR is its relatively high cost. It is also necessary to provide proper training and education for users, in order to promote correct O&M procedures.

Unit price (Euro/m³)	**7,14**	**Poor**
Overall AT score	**6,5**	**Good**
Sub-score performance	7,9	Good
Sub-score people/planet	4,6	Medium

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	3	
Capacity	l/day		NA
Volume in lifetime	m³	0,01	1 sachet
Investment	€		none
Replacement during lifetime	€		none
O&M lifetime	€	0,07	US$0,10/sachet
Salary cost Lifetime	€		none
Unit price	€/m³	7,14	

More information:

- www.csdw.org
- www.who.int
- www.purpurifierofwater.com
- www.pghsi.com



Chlorine

Product description: Chlorine began to be widely used as a disinfectant in the early 1900's. It revolutionized drinking water treatment and dramatically reduced the incidence of waterborne diseases. A non-scented, liquid household chlorine bleach that contains sodium hypochlorite can be used to disinfect water (do not use non-chlorine or detergents containing bleach to disinfect water). Sodium hypochlorite can be manufactured in most locations since it can be obtained through brine electrolysis. Typically, chlorine concentrations in the produced 'solutions' range from 0,5-10%.

O&M and Lifespan: Each product should have its own instructions for correct dosing. For commercial bleach with 5% chlorine, users have to add 3-5 drops to 20 litres of water. Bear in mind that required dose and contact time vary with water quality (e.g. turbidity, pH, temperature). A minimum contact time of 30 minutes before drinking is recommended. Chlorine should be stored in a cool, dark place in a closed container. Liquid chlorine expiry is 1 year if the pH of the solution is above 11,9. Safety measures are required, when working with chlorine.

Efficiency and Considerations: Chlorine is highly effective against bacteria and viruses (log2 to log8 removal; proven by plenty of testing and field assessments), but not as effective against protozoa and helminths. Residual chlorine also protects water from recontamination. The use of household bleach products for household water treatment is not recommended in the absence of ongoing quality control testing and should be supported with educational messages to ensure correct and consistent use. It is most appropriate in areas with a consistent supply chain. Chlorine is also part of the Safe Water Storage (SWS) approach.

Unit price (Euro/m³)	**0,24**	**Good**
Overall AT score	**7,0**	**Good**
Sub-score performance	**8,3**	**Good**
Sub-score people/planet	**4,6**	**Medium**

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year		
Capacity	l/day		NA
Volume in lifetime	m³	1	a bottle
Investment	€		none
Replacement during lifetime	€		none
O&M lifetime	€	0,24	€ 0,07 - 0,40
Salary cost Lifetime	€		none
Unit price	€/m³	0,24	€ 0,07 - 0,40

More information:

- www.cawst.org
- www.psi.org
- ww.cdc.gov
- www.jolivert.org

Jal-TARA Water Filter (SSF)

Product description: Jal-TARA works on the principle of gravity slow sand filtration (SSF). SSF ensures a simultaneous bacteriological (bio-film or schmutzdecke) and physical improvement in water quality comparable to the natural percolation of water through underground strata. Jal-TARA is standardized in 1 m^3 water tank; output water supply is 2-3 m^3/day. The filters contain pebbles and sands of different sizes. The system is complemented with a synthetic fabric filter designed with advanced technique of fabric protection. The sand filter can be fed under gravity flow or through conventional pumps or operated by solar photovoltaic.

O&M and Lifespan: SSF has to be operated under continuous flow to sustain the bio-film. The system is designed to require very little maintenance. Frequency of filter cleaning depends on input water quality (turbidity and bacteria contamination) and filtration rate. It includes cleaning of fabric filter and top sand layer. Fabric filter requires cleaning twice a year for turbidity 10-15 NTU of the input water. To simplify cleaning operation, backwashing facility is also provided. SSF is very durable and has long life span, approx. 15 years. After cleaning, the disinfection efficiency is restored after several days, during which consumption of untreated water is to be discouraged.

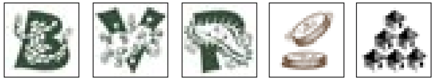
Efficiency and Considerations: Removal efficiency of suspended solids is up to 99,99%, pathogenic bacteria up to 99,99% and viruses 91-99,99%. It also provides iron removal of 80-85%. For optimum result, normally, water at low temperatures or with high turbidity levels and/or very low nutrient levels cannot be applied. Power supply is necessary to pump water into the overhead tank. The modular system allows flexible combinations to service as many people as is required.

Unit price (Euro/m³)	**0,22**	**Good**
Overall AT score	**5,2**	**Medium**
Sub-score performance	4,4	Medium
Sub-score people/planet	7,0	Good

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	15	
Capacity	l/day	2750	2500-3000
Volume in lifetime	m^3	15000	
Investment	€	1300	
Replacement during lifetime	€		none
O&M lifetime	€	500	
Salary cost Lifetime	€	1500	€ 100/year
Unit price	€/m^3	0,22	

More information:

- www.cleanindia.org



Naiade

Product description: Naiade is a combination of solar powered electronics, UV light water treatment and battery technology. The unit has been made of tropical resistant polyethylene. Its dimensions are 54x75x140 cm. Naiade contains two filter bags, 25 and 10 micron respectively, and a cylindrical tube with a UV lamp. The unit has its own 100 litre reservoir. Naiade can filter up to 3.500 litres of water per day (up to 400 people). The flow rate is 5 l/minute.

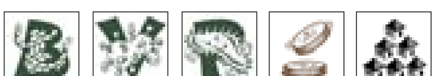
O&M and Lifespan: Naiade can be installed within 30 minutes by technically poorly educated people. After having filled the unit with raw water, one just pushes the button. Water will flow from the tap. This can be interrupted by pressing the button again. If this is not done, the tap closes after 2 minutes to avoid spillage of water. Photovoltaic (PV) panel needs to be cleaned of dust/dirt every now and then, the container and filter bags need to be cleaned and washed, respectively. The estimated lifespan of the unit is over 10 years. The replacement of UV lamp, after 10.000 hours of service, should preferably be carried out by trained technicians.

Efficiency and Considerations: The unit has been field tested by several universities and has proven to be highly effective in removing pathogens with additional turbidity removal. It also has received two prestigious international awards on sustainable development. Naiade features an automatic blocking of unsafe water. The aim of Naiade is regional production, but only if the business plans allow so. Otherwise, import is possible.

Unit price (Euro/m³)	**0,59**	**Medium**
Overall AT score	**5,8**	**Medium**
Sub-score performance	5,7	Medium
Sub-score people/planet	6,5	Good

Cost	Unit	Evaluation	Remark
Lifetime	year	10	
Capacity	l/day	2000	
Volume in lifetime	m^3	7300	
Investment	€	3000	
Replacement during lifetime	€	317	€ 95 per 3 years (UV lamp)
O&M lifetime	€		none
Salary cost Lifetime	€	1000	€ 100/year
Unit price	€/m^3	0,59	

More information:
- www.nedapnaiade.com
- www.cleanwaternow.nl
- www.akvo.org



WaterPurifier

Product description: The WaterPurifier is a self-contained, ready-to-use, water purification unit. The contaminated water is first filtrated with a ceramic UF membrane with a pore size of 40 nm. Then, with the application of solar-powered electrolysis that produces hypochlorous acid, the water is disinfected and recontamination can be avoided. The WaterPurifier is powered by solar panel. Adaptor is available in case of insufficient sunlight.

O&M and Lifespan: The WaterPurifier is very easy to operate. One main switch will set the unit in ready mode. On tapping the purified water the disinfection will start immediately. If one stops tapping water the disinfection is switched off. To generate enough pressure for the filtration process, water has to be kept in the barrel above the unit. If the water barrel is empty a LED alarm light will warn you. When it appears that the water does not contain enough chloride, household salt (NaCl) can be added. Recommended amount is 50 gram salt per cubic metre water. Maintenance consists of backwashing the filter with a hand-powered air pump. The estimated lifespan is 20 years if well maintained. The membranes and the electrodes have to be replaced after 5 years.

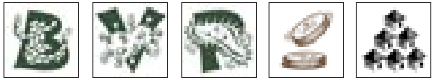
Efficiency and Considerations: The WaterPurifier effectively removes bacteria, viruses, protozoa, helminths and turbidity. Chemicals can be removed by additional external carbon filter. Indicator strip is also provided to check water quality (presence of residual chlorine). The WaterPurifier is designed to be robust, compact, and easy to transport. It can also be scaled up to 5 times in the same configuration. Membrane and electrolysis cell cannot be manufactured locally, but it is possible for the other parts of the unit.

Unit price (Euro/m³)	**1,21**	**Medium**
Overall AT score	**5,4**	**Medium**
Sub-score performance	5,7	Good
Sub-score people/planet	5,0	Medium

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	20	
Capacity	l/day	600	300-600 l/day (modular)
Volume in lifetime	m^3	4380	
Investment	€	1800	
Replacement during lifetime	€	1500	membrane € 400; electrode € 100
O&M lifetime	€		none
Salary cost Lifetime	€	2000	€ 100/year
Unit price	€/m^3	1,21	

More information:

- www.mobilewatermaker.nl



Perfector-E

Product description: Perfector-E is a self-contained portable water treatment sys-tem. It was originally developed for emergency aid purposes by PWN, the Netherlands. However, it is also applicable as a permanent, decentralised, stand-alone water supply unit. Surface water is supplied by a submerged pump. Next, the water passes through one microstrainer. The main purification consists of two Norit X-Flow ultrafiltration (UF) membranes. The vertical positioned modules operate in dead-end mode and are cleaned by backwashing. As a further barrier, UV disinfection is included. It uses Norit X-Flow elements in its membranes and modules with permanent hydrophilic low-fouling UF membranes. The capacity is approx. 2.000 l/hour, using power supply of 230 Volts/3,1 kW or via supplied power generator (5kW).

O&M and Lifespan: The maximum distance from water source is 25 metres. System operation is based on plug and play, making it easy for users to operate. Maintenance during its lifetime is cleaning on location once every 3 months, which takes 2 hours. Membrane lifetime is 3-5 years depending on the water source quality.

Efficiency and Considerations: Perfector-E is highly effective in removing total suspended solids, bacteria, protozoa, helminths and viruses, but not applicable for chemical contaminants. Another system called Perfector-O can be added if removal of dissolved chemicals is needed. Perfector-E has proven to be a robust water purification unit; installed in many places in the tsunami-affected area and in Haiti, 2010. Operational concern in rural area is the need for a power supply. However, solar panels/wind mill can be added. The system can be bought or rented from the manufacturer.

Unit price (Euro/m³)	**0,69**	**Medium**
Overall AT score	**6,2**	**Good**
Sub-score performance	6,6	Good
Sub-score people/planet	6,0	Medium

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	5	
Capacity	l/day	32000	16 hours operation
Volume in lifetime	m^3	58400	
Investment	€	30000	
Replacement during lifetime	€	750	2,5 * medium pressure UV lamp
O&M lifetime	€	7250	€ 1450/year
Salary cost Lifetime	€	2500	€ 500/year
Unit price	€/m^3	0,69	

More information:

- www.noritmt.nl
- www.atatwork.org

WATA®

Product description: Antenna Technologies has developed a line of WATA® devices as part of the Watasol approach, for local production of active chlorine through the electrolysis of salted water. The resulting solution can be used for drinking water chlorination (1 l for 4.000 l of contaminated water). WataTest™ and WataBlue™ reagents are part of the WATA kits that measure chlorine content in resp. chlorine solution and chlorinated water. Based on 12-15 hours of daily operation, WATA Mini can serve 240 individuals, WATA Standard 2.400, and WATA Maxi 36.000.

O&M and Lifespan: In general, the operation of WATA devices consists of mixing household salt with clear water (25 g of salt per litre), electrolysis of the solutions according to time needed, and safe storage of the chlorine solutions. Water disinfection is carried out by adding 5 ml chlorine to 20 litres water. The water will be drinkable after 30 minutes. With time, calcareous deposits form on the electrodes. Maintenance frequency depends on water hardness. It is advised to do it after about 150 hours of functioning (or one week working continuously). Safety measures are required, when working with chlorine. The lifespan of the device is approx. 20.000 hours or 4,5 years.

Efficiency and Considerations: Chlorine is highly effective against bacteria and vi-ruses and provides residual protection against recontamination. Raw water should be considerably clear, both for chlorine production and for drinking. WATA devices need electricity supply to operate. Nonetheless, solar versions are available for WATA Mini & Standard which allows chlorine production in rural areas (via solar panel) as well as in places with access to the grid. Cost evaluation is based on WATA Mini. Note that the AT score is based on the device & chlorine production. Evaluation of chlorine as disinfectant is available (see product Chlorine).

Unit price (Euro/m³)	**0,02**	**Good**
Overall AT score	**4,9**	**Medium**
Sub-score performance	5,3	Medium
Sub-score people/planet	5,8	Medium

Cost	**Unit**	**Evaluation**	**Remark**
Lifetime	year	4,5	
Capacity	l/day	4800	1,2 l chlorine
Volume in lifetime	m³	7884	
Investment	€	40,00	Standard € 200; Maxi € 1700
Replacement during lifetime	€		none
O&M lifetime	€	10,26	electricity (0,01 - 0,012kWh/m³)
Salary cost Lifetime	€	450,00	€ 100/year
Unit price	€/m³	0,02	water price

More information: • www.antenna.ch

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Appropedia	www.appropedia.org
Aqua for All	www.aquaforall.nl
AquaEst Europ	www.aquaestinternational.com
AT@Work	www.atatwork.org
Basic Water Needs	www.basicwaterneeds.com
Biosandfilter.org	www.biosandfilter.org
BushProof	www.bushproof.biosandfilter.org
CAWST	www.cawst.org
CDC	www.cdc.org
Clearinghouse	www.jalmandir.com
Eawag	www.sodis.ch
ENPHO	www.enpho.org
Hindustan Unilever	www.pureitwater.com
HydrAid™	www.hydraid.org
IRC	www.irc.nl
Medentech	www.aquatabs.com
MIT	www.web.mit.edu/watsan/
Mobile WaterMaker	www.mobilewatermaker.nl
Nedap NV	www.safe-drinkingwater.com
Norit Membrane Technology B.V.	www.noritmt.nl
NWP	www.nwp.nl
Potters for Peace	www.pottersforpeace.org
Procter&Gamble	www.pghsi.com
PSI	www.psi.org
PUR	www.csdw.org
Solar Solutions	www.solarsolutions.info
TARA Environment Monitoring Facility	www. cleanindia.org
Vestergaard Frandsen	www.vestergaard-frandsen.com
Water4Life	www.water4life.eu
WHO	www.who.int