WHO International Scheme to Evaluate Household Water Treatment Technologies

Results of Rounds III and IV

World Health Organization

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This report describes the products evaluated in Rounds III and IV of the WHO International Scheme to Evaluate Household Water Treatment Technologies (the Scheme) as meeting the WHO-recommended performance levels at the time of testing. WHO cannot guarantee that the products that met a stated performance level will continue to do so.

The results presented in this report are intended to guide WHO Member States and procuring UN Agencies in the selection of household water treatment (HWT) products.

The figures and tables included in this report do not provide an exhaustive overview of available HWT products. They reflect those products that were submitted to WHO for evaluation in Rounds III and IV of the Scheme, were found to meet the eligibility criteria for such evaluation and were subsequently evaluated. The fact that certain products are not mentioned in this report does not mean that they are not eligible for evaluation; nor does it mean that, if evaluated, they would not be found to meet any of the WHO-recommended performance levels.

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Declaration of Interest

All members of IAC completed the WHO Declaration of Interest form and declared no conflict of interest.

Abbreviations and acronyms

CTW	challenge test water
E. coli	*Escherichia coli*
EoI	expression of interest
GDWQ	WHO Guidelines for drinking-water quality
GTW	general test water
HWT	household water treatment
HWTS	household water treatment and safe storage
IAC	Independent Advisory Committee
NTU	nephelometric turbidity unit
Scheme	WHO International Scheme to Evaluate Household Water Treatment Technologies
UN	United Nations
UNICEF	United Nations Children's Fund
UV	ultraviolet
WASH	water, sanitation and hygiene
WHO	World Health Organization

Drinking-water storage in Rohingya settlement in Cox's Bazar. © WHO / Payden

Water safety and point-of-use/household water treatment

A preventable crisis

743 million people

drink water contaminated with faeces annually

Up to 4 million people

are affected by cholera outbreaks annually

505 000 people

die from diarrhoea due to unsafe drinking-water annually

743 million people

have **no water service** at their health care facility

288 million children

have **no water service** at their school

Improving water safety

Waterborne diarrhoeal disease is largely preventable through interventions aimed at identifying and managing water safety risks, including water safety planning

Household/point-of-use water treatment and safe storage as an interim measure allows households, schools and health care facilities to take charge of and improve water safety

HWTS

When effective products are used correctly and consistently, HWTS can reduce diarrhoeal disease by as much as

41%

Promoting maximum, sustained diarrhoeal disease reduction

The Scheme

Coordinate independent evaluation of HWT products against WHO norms, and strengthen capacity of countries to regulate and conduct complementary testing of HWT

HWTS Network

Support effective and collective action, share implementation strategies and disseminate knowledge

WHO's work on HWTS

Establish norms on HWT performance and evaluate products of global relevance

Support countries in implementing norms through risk-based approaches

Convene stakeholders on water safety

HWT: household water treatment; HWTS: household water treatment and safe storage; HWTS Network: International Network on Household Water Treatment and Safe Storage; HWT Scheme: WHO International Scheme to Evaluate Household Water Treatment Technologies; WHO: World Health Organization.

Sources: see (*1, 2, 3, 4, 5*).

Executive summary

The World Health Organization (WHO) International Scheme to Evaluate Household Water Treatment Technologies (the Scheme) was established to independently and consistently evaluate the performance of household water treatment (HWT) technologies in removing microbial contaminants from drinking-water. The Scheme is part of the WHO normative programme of work on drinking-water safety. Results from the Scheme inform Member States' and United Nations (UN) procuring agencies' selection of effective HWT technologies to reduce the risk of diarrhoeal disease from unsafe drinking-water. In particular, the Scheme helps to ensure products that provide limited or no pathogen removal are kept off the market.

Since establishment of the Scheme in 2014, 51 HWT products have been evaluated: 10 in Round I, 20 in Round II and an additional 21 in Rounds III and IV. Two previous reports have summarized the findings of the 30 HWT products tested in Round I and Round II *(6, 7)*. This report is the third and final report in a series of laboratory-based evaluations of HWT products. It summarizes the results of the 21 additional products evaluated in Rounds III and IV, and also includes a summary of the results of Rounds I and II. Additionally, this report provides an overview of capacity development efforts and the impact of the Scheme in HWT selection.

Flocculation/disinfection sachets for water treatment. © CAWST

Need for the Scheme

Unsafe drinking-water still accounts for over a third of the diarrhoeal disease burden in low- and middle-income countries

Although significant progress has been made in improving access to drinking-water, over one quarter of the world's population still lacks access to safely managed drinking-water services, and approximately 505 000 diarrhoeal deaths in low- and middle-income countries each year are attributable to unsafe drinking-water *(3)*.

HWT and safe storage can improve the safety of drinking-water

When effective methods are used, household water treatment and safe storage (HWTS) can reduce the risk of diarrhoeal disease by 41%, compared to drinking untreated water from an unimproved source *(3)*. With an increasing number of people affected by humanitarian crises (Box E1), HWTS is an important solution for improving the safety of drinking-water.

Harmonized, health-based criteria are essential for evaluating the performance of HWT technologies

The HWT market is diverse, and the performance of HWT technologies in removing contaminants varies widely. Consistent and rigorous evaluation against health-based criteria is essential for distinguishing underperforming technologies that do not provide any health benefit from well-performing technologies that protect against diarrhoeal disease.

Box E1
Safe water solutions in humanitarian crises

The number of people affected by humanitarian crises is at an all-time high. In 2024, it is projected that 299 million people will require humanitarian assistance, as they face crises arising from conflict, extreme weather events and disasters. Increasing economic instability, conflict and migration trends all suggest health crises will worsen in years to come, in terms of frequency, severity and duration, especially without a considerable policy shift and additional investments. Water, energy and health infrastructure and services are becoming increasingly under attack in conflict areas, with a doubling of attacks on water in the period 2017–2022, compared to pre-2017 *(8)*. The world also continues to face the worst cholera situation in decades, with 1 billion people at risk and 44 countries affected *(9)*. Safe water solutions are critical to the preparedness for and response to such situations. Point-of-use water treatment/HWT serves an immediate need for those affected, and helps to prevent the spread of waterborne disease, which can compound the health challenges in a crisis.

Results of Rounds III and IV of the Scheme

Building on the results from Rounds I and II, this report adds to the growing number of HWT products for which comprehensive, health-based performance evaluations are available

Performance is classified in three ascending tiers (Box E2): one star (★), two stars (★★) and three stars (★★★). Products that do not meet minimum criteria are assigned no star (−) and are classified as providing little or no protection.

Thirty-one expressions of interest for evaluation were received in Rounds III and IV of the Scheme; of these, 21 were selected for evaluation. Table E1 shows the WHO HWT performance criteria (log reduction requirements for the three microbial groups evaluated) and the performance classification.

Box E2
Why is the performance classification tiered as one, two and three stars?

While HWT technologies should ideally be as effective as possible against all three microbial groups (bacteria, viruses and protozoa), their capabilities in contaminant removal vary, depending on the nature of the microbes and sensitivities to various treatments. The performance tiers in Table E1 range from the highly conservative three-star (★★★) top tier, to one star (★), which represents relatively low-cost products that, if used correctly and consistently, would still lead to demonstrable health gains.

Three-star (★★★) products provide protection against all three microbial groups (bacteria, viruses and protozoa). The health-based targets used to derive the microbial reduction requirements for three-star classification are extremely conservative, and represent products that, if used correctly and consistently, would limit the diarrhoeal disease burden from unsafe water to extremely low levels. Products in this performance tier may provide higher levels of protection where water is highly contaminated, if they are used correctly and consistently.

Two-star (★★) products also provide protection against all three microbial groups. The microbial reduction requirements for this tier are less stringent than that those of the top tier, yet still consistent with the goal of providing high-quality, safer water. Use of products in this performance tier in areas with a suspected high burden of waterborne disease would still result in significant health benefits.

One-star (★) products are those that meet performance criteria for only two of the three microbial groups. These products may include for example, free chlorine, (which is effective against bacteria and some viruses, but not effective against most protozoa), or ceramic filters, (which are affective against protozoa and bacteria, but generally not effective against viruses). One-star products should be selected when the two microbial groups that they provide protection against are known to be the contaminant(s) of concern. They may also be used in combination with other products that provide protection against an additional microbial group, as part of a multi-barrier treatment approach.

Table E1
WHO performance criteria for HWT

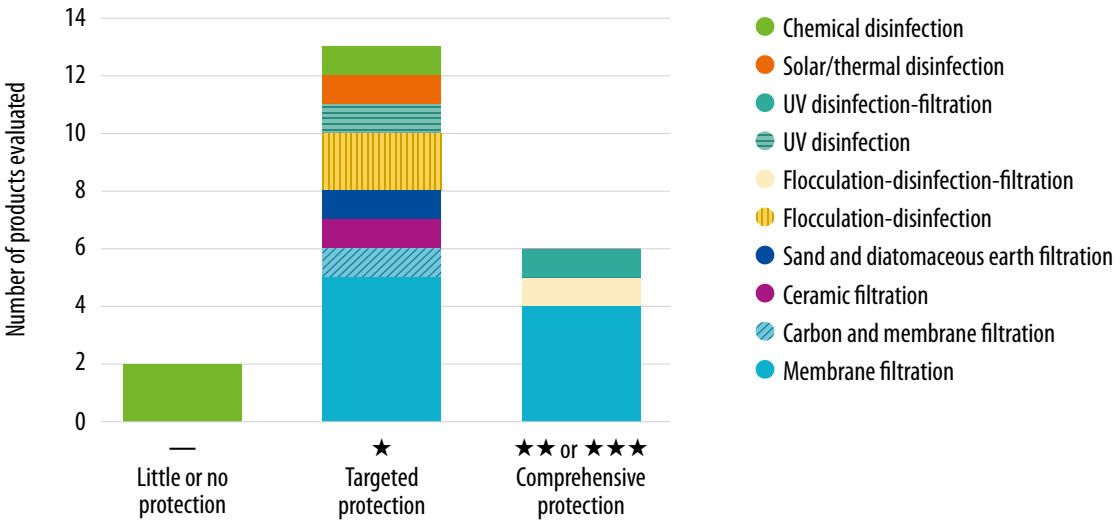
Performance classification	Bacteria (log_{10} reduction required)	Viruses (log_{10} reduction required)	Protozoa (log_{10} reduction required)	Interpretation (with correct and consistent use)
★★★	≥ 4	≥ 5	≥ 4	Comprehensive protection
★★	≥ 2	≥ 3	≥ 2	
★	Meets at least 2-star (★★) criteria for two classes of pathogens			Targeted protection
—	Fails to meet WHO performance criteria			Little or no protection

Note: The microbiological performance of HWT technologies is often presented as a comparison of the concentration of pathogens in water before, and after treatment, on a logarithmic basis. A 1 log reduction stands for a 10-fold or 90% reduction in the concentration of pathogens in water: 1 log_{10} reduction = 90% reduction; 2 log_{10} reduction = 99% reduction; 3 log_{10} reduction = 99.9% reduction; etc.

As presented in Fig. E1, of the 21 products evaluated in Rounds III and IV:

- six meet two- (★★) or three-star (★★★) criteria, and are classified as providing *comprehensive protection*;
- thirteen meet the one-star (★) criteria, and are classified as providing *targeted protection*; and
- two do not meet minimum performance criteria and are classified as providing *little or no protection*.

Fig. E1
Overview of results of Rounds III and IV of the Scheme



The majority of the products classified as providing *comprehensive protection* are based on membrane filtration. Products classified as providing *targeted protection* comprise a variety of treatment technologies, including membrane and ceramic filtration, chemical disinfection, solar disinfection and flocculation–disinfection. The two products that failed to meet minimum WHO performance criteria and are classified as providing *little or no protection* were chemical disinfectants.

Impact of the Scheme and national capacities for HWT regulation and evaluation

Most HWT products with a global reach have been evaluated under the Scheme

Building on the 30 products evaluated in Rounds I and II, a total of 51 products have been evaluated under the Scheme. These 51 products include most of those commonly procured for emergency response, including a range of chlorine disinfectants, flocculants–disinfectants and filters. Together, these 51 products are sold or distributed in over 100 countries around the world.

Awareness of the Scheme criteria and evaluation results is increasing

A growing number of Member States, UN agencies and implementers are aware of the Scheme's performance criteria and are applying them in procurement and approval requirements. Beginning with Round III, WHO published summary evaluation reports upon completion of testing of each product. Procuring agencies and governments have come to rely on the results list on the Scheme's webpage to inform product selection. These results are shifting markets towards better-performing products.

Regulatory oversight of HWT is vital and must be strengthened

WHO continued to support several countries in establishing national standards and regulations for HWT, including Ghana, where national standards for HWT performance have been established. Continued efforts is needed to accelerate the development of comprehensive standards and regulations for HWT performance in other countries.

A household biosand filter. © CAWST

1. Introduction

An estimated 2.2 billion people worldwide lack access to safely managed drinking-water, including 296 million people using unimproved sources and 115 million drinking surface water *(1)*. Target 6.1 of Sustainable Development Goal 6 seeks to ensure universal access to safe drinking-water by 2030. However, in 2022, it was estimated that at current rates of progress, the world will reach only 77% coverage by 2030, leaving 2 billion people without safely managed water services *(1)*.

In addition, diarrhoea remains among the top 10 causes of death globally, and is in the top five for low-income countries. Inadequate water, sanitation and hygiene (WASH) is a leading risk factor associated with diarrhoeal illness, and contributes to an estimated 69% of diarrhoeal deaths worldwide. Interventions such as household or point-of-use water treatment can significantly reduce the risk of diarrhoea by as much as 41%, compared with people drinking untreated water from an unimproved source *(3)*.

A critical factor in reducing the risk of diarrhoea is ensuring that the household water treatment (HWT) methods used can effectively remove or inactivate microbial contaminants, and thus improve the safety of drinking-water. Many types of HWT products are available, and their performance varies widely. Manufacturer claims often overstate performance, thus highlighting the need for independent evaluation of product performance.

1.1 The Scheme

To comprehensively assess effectiveness of HWT products, the World Health Organization (WHO) developed health-based performance criteria based on removal of the three main groups of pathogens that cause waterborne diarrhoeal disease: bacteria, viruses and parasitic protozoa *(10)*. Pathogens in these three microbial groups – enterotoxigenic *Escherichia coli (E. coli)* and *Shigella*, rotavirus and *Cryptosporidium* – have been found to be the main causes of moderate to severe diarrhoea among children under the age of 5 years in low- and middle-income countries *(11, 12)*. The WHO criteria provide the basis for evaluating and classifying HWT performance against these microbial groups in three ascending tiers of performance: ★ (one star), ★★ (two stars) and ★★★ (three stars).

Many low- and middle-income countries have neither the resources nor the capacity to assess HWT performance against WHO recommendations. Therefore, in 2014, WHO established the Scheme to support implementation of the performance criteria by independently evaluating the performance of commercially available HWT products. The objectives of the Scheme are to: (i) independently and consistently evaluate the performance of HWT products based on WHO criteria, and, in so doing, guide WHO Member States and procuring United Nations (UN) agencies in HWT product selection and (ii) strengthen national capacities in regulation and complementary evaluation of HWT. Together, these two objectives and the associated activities serve the ultimate aim of the Scheme, which is to reduce the burden of disease associated with unsafe drinking-water.

The Scheme is coordinated by the Water, Sanitation, Hygiene and Health Unit at WHO. In this role, WHO reviews and designates testing laboratories, develops testing protocols and report templates, coordinates testing of technologies, reviews testing results and communicates test results to Member States.

WHO works with an Independent Advisory Committee (IAC) of experts in drinking-water treatment, microbiology and epidemiology, and designated testing laboratories to independently evaluate the performance of submitted HWT products. The role of IAC is to provide advice on criteria for the selection of the testing laboratories, evaluation and testing procedures, development and update of testing protocols and review of test results. Two laboratories have been designated to conduct testing: KWR Watercycle Research Institute in the Kingdom of the Netherlands and NSF

International in the United States of America. Harmonized testing protocols that detail the approach and testing conditions for various treatment technologies have been developed *(13)*. The results of the Scheme evaluations are used to inform procuring UN agencies, national governments and nongovernmental organizations. Since the publication of the Round I report in 2016 *(6)*, the Scheme evaluation results have helped guide HWT product selection and are catalysing the shift towards better-performing products and better-informed users.

Alongside these efforts, WHO works to strengthen the capacity of national regulatory authorities and reference laboratories in regulating and carrying out complementary evaluations of HWT performance. This includes facilitating training and knowledge transfer on HWT performance evaluation, working with implementing nongovernmental organizations and supporting development of national health-based certification criteria for HWT products.

A woman shows a chlorine disinfectant tablet she is using to treat drinking-water during cholera outbreak in Ethiopia. © WHO / Mulugeta Ayene

1.2 This report

This report presents the results of 21 HWT products evaluated under Rounds III and IV of the Scheme, and also summarizes the products evaluated in Rounds I and II. These products represent a range of treatment technologies, including: chemical, solar and ultraviolet (UV) disinfection; ceramic and membrane filtration; and combined flocculation–disinfection.

Chapter 1 introduces the Scheme and its objectives.

Chapter 2 presents an overview of Rounds III and IV, outlining the evaluation procedure and evaluation results. It details the findings from the 21 product evaluations in Rounds III and IV and provides a summary of the 51 products evaluated to date.

Chapter 3 gives an update on WHO work on strengthening capacities for HWT regulation and evaluation, and how the Scheme results are being applied in product selection and certification. It also provides an outline of future directions for WHO work on HWT.

Chapter 4 provides the conclusions to this report.

The Annex presents descriptions of the products evaluated in Rounds III and IV.

2. Rounds III and IV of the Scheme and summary of Rounds I–IV

Throughout Rounds III and IV, WHO worked to expand evaluations across a wider range of treatment technologies, compared to in Rounds I and II. This entailed reviewing and updating testing protocols and ensuring quality management procedures with the designated testing laboratories. This chapter outlines the evaluation procedures and updates made to testing protocols and presents the test results and key findings from Rounds III and IV. It also provides the combined summary results of Rounds I–IV.

2.1 Updates to testing protocols

In Round II, several updates were made to the testing protocols, drawing on lessons learned from Round I. These updates led to reductions in the cost of testing and improved efficiencies, while maintaining scientific rigour *(7)*. These are key considerations in ensuring that all HWT products of public health significance are evaluated, and that testing protocols can be progressively adapted for use in countries where HWT is needed.

A key update in Rounds III and IV was a change in the acceptable allowance of deviation from the performance targets of the Scheme. Previously, up to 10% of sample points could have a deviation of up to 1 $\log_{10}$ below the required performance target per microbial group. This was updated to a maximum variation of 25% of sample points deviating by up to 0.2 $\log_{10}$ for the two-star performance target, and 0.4 $\log_{10}$ for the three-star performance target. This update was based on the lessons learned from Rounds I and II, where a major observation was inconsistent performance within products.

The changes implemented in Rounds III and IV "spread" the deviation allowance across a wider number of samples, providing greater insights into the performance of each unit of a product tested, while promoting adherence to the performance target, with a smaller deviation threshold.

Versions 3 and 4 of the Scheme's *Harmonized testing protocol: technology non-specific* provide further information on the updates *(14, 15)*.

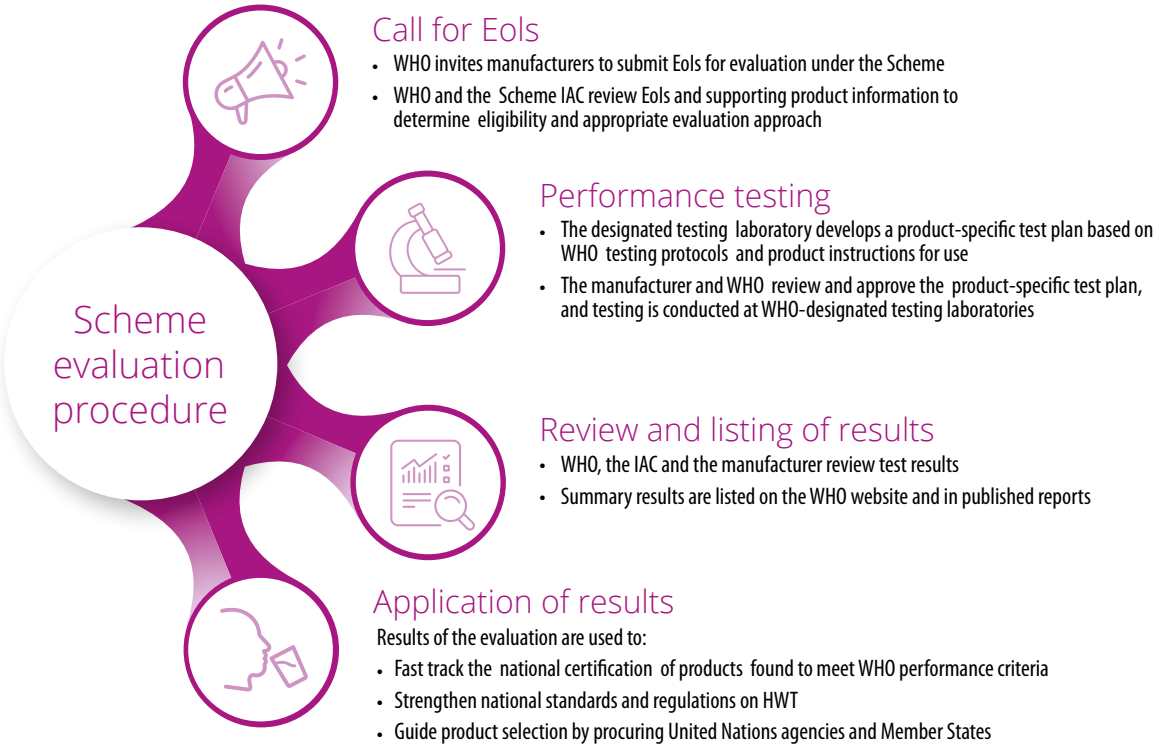
2.2 Evaluation procedure

Evaluation under the Scheme is based on the voluntary submission of an expression of interest (EoI) form by product manufacturers and the provision of supporting product information (Fig. 1).

Products prioritized for evaluation under the Scheme are relatively low cost, are intended for use in low- and middle-income settings, and are market ready or have a wide market. EoIs meeting these screening criteria are selected for detailed review by the Scheme Secretariat, with input from the Scheme's IAC. Upon receipt of the evaluation fee,[1] WHO works with the designated testing laboratories and IAC to develop a product testing protocol. WHO oversees testing, with input from IAC, which also reviews test reports and provides input on performance classification. Test reports are shared with manufacturers for review and comment before publication.

[1] Evaluation under the Scheme is subject to payment of a fee. Limited subsidies were available in Rounds I–IV, and the subsidy criteria are outlined in the *Procedure for evaluation: WHO International Scheme to Evaluate Household Water Treatment Technologies (17)*.

Fig. 1
Scheme evaluation procedure



EoI: expression of interest; HWT: household water treatment; IAC: Independent Advisory Committee; UN: United Nations; WHO: World Health Organization.

2.2.1 Testing protocols and evaluation criteria

As much as possible, test conditions are set to simulate actual source waters and use, to better estimate the effectiveness of the product in the field. Testing is conducted in defined water quality conditions, in two test waters, according to the product use instructions.

WHO has developed protocols that are specific to the treatment technology (e.g. solar/UV disinfection or ceramic filtration) that a product may employ, considering parameters such as temperature and turbidity that may affect performance *(17)*. The product-specific test plan is developed based on the technology-specific protocol in accordance with the product use instructions. The evaluation comprises laboratory performance testing and review of product information, including labelling and instructions for use. Table 1 outlines the evaluation criteria, with the Annex providing further details.

Evaluation under the Scheme considers removal of three microbial groups: bacteria, viruses and protozoa. The organisms used for laboratory testing under the Scheme are *E. coli* for the bacterial group, bacteriophages MS2 and phiX174 for the viral group[2] and *Cryptosporidium parvum* oocysts for the protozoan group.

The number of microbial groups tested may be reduced based on available evidence of performance against various microbial groups. For instance, for technologies based solely on size exclusion, it may be acceptable to evaluate the product's performance against bacteria and viruses only, and not include protozoa (the largest in size of the three microbial groups). Performance against protozoan cysts is then assigned based on the microbial reduction achieved for bacteria. Due to their physical characteristics, protozoa present a rigorous challenge for chemical disinfectants such as chlorine *(10)*. Therefore, unless there are supporting data on why a chemical disinfectant might perform well against

[2] Performance is based on the lower-performing phage.

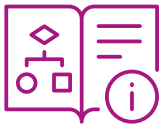
protozoa, testing against this microbial group is not conducted, and thus the highest performance level that chemical disinfectants could achieve is one-star (★) *targeted protection* against bacteria and viruses.

Products are tested in two types of test waters: general test water (GTW), representative of relatively "clean" non-turbid water such as groundwater, and challenge test water (CTW), representative of relatively "dirty" turbid water, which may represent surface water.

Variation in performance across production lots or units can indicate poor manufacturing quality. For devices, consistency in performance is assessed by testing three randomly selected units from a production cycle. For consumable products such as chemical disinfectants, sufficient sample units from two manufacturing lots, randomly selected, should be provided for testing. In addition, for chemical disinfectants expected to deliver a certain dose, the concentration in dechlorinated tap water is assessed.

Materials in contact with drinking-water must comply with the *Guidelines for drinking-water quality* (GDWQ) *(18)*. For products that have a wetted contact material that may have a contaminant leach, residual concentrations are measured in the posttreatment water samples. For example, for ceramic filters, posttreatment samples are analysed for

Table 1
The Scheme's evaluation criteria and considerations

Evaluation criteria	Specific considerations
Microbial performance 	**Microbial groups:** Product should meet at least two-star (★★) performance targets for two of the three microbial groups. **Test water characteristics:** Product should be effective across a range of water quality conditions (e.g. both GTW or "clean" water and CTW or "dirty" water).
Consistency/product quality 	**Manufacturing quality management:** There should be evidence of the quality management system that is in place. **Consistent microbial reduction:** For devices, at least three production units should be tested. For consumables, samples from at least two manufacturing lots should be tested. **Disinfectant concentrations:** For consumables such as chlorine, product samples should deliver expected concentrations in deionized/dechlorinated tap water.
Product safety 	**Leachates** from wetted contact material should not exceed health-based values specified in the GDWQ.[a] **Residual disinfectant concentrations** should be sufficient to prevent recontamination but not exceed concentrations that would be harmful to health or be rejected by consumers for reasons of taste or odour.
Labelling and instructions for use 	**Product information** should include product name, manufacturer name and contact. **Labelling** should include a list of chemical contents, manufacturing lot number/manufacture date and expiration dates, if applicable. **Instructions** should be simple, consistent across product literature (packaging, website, etc.), have a minimal number of steps, and with illustrations where appropriate, including: • *for devices:* procedures for cleaning and maintenance, indication of completed treatment, and restoring flow (where applicable) • *for disinfectants:* dosage, mechanism to deliver dose, contact time and instructions to stir/mix.

CTW: challenge test water; GDWQ: *Guidelines for drinking-water quality (18)*; GTW: general test water.

[a] Testing is currently limited to arsenic and silver leachates from ceramic filters in contact with water, and a desk review of materials in contact with drinking-water that may be potentially toxic.

arsenic (Table 1) and bacteriostatic additives such as silver and copper. Similarly, residual concentrations for chemical disinfectants such as chlorine are measured in the posttreatment water samples.

2.2.2 Performance classification

A critical aspect in HWT evaluation is whether a product consistently treats water to the required level and thus reliably protects health. Sample units should consistently meet or exceed the performance target for each microbial group in both test waters (GTW and CTW). However, a maximum deviation of 0.2 $\log_{10}$ is acceptable for 25% of sample points at the two-star performance tier and of 0.4 $\log_{10}$ at the three-star performance tier.[3]

This permissible deviation means that to be classified as a two-star product, up to three of the 12 sample points can achieve a reduction of 1.8 $\log_{10}$ for bacteria or protozoan cysts (instead of 2 $\log_{10}$), or 2.8 $\log_{10}$ for viruses (instead of 3 $\log_{10}$). For performance against viruses, the lower-performing virus is used for assigning performance criteria as described in the Scheme protocols.

2.2.3 Data management and quality assurance

Evaluation under the Scheme follows standard operating procedures for data management and quality assurance as detailed in the *Procedure for evaluation (17)*.

2.3 Products evaluated in Rounds III and IV

Thirty-one EoIs were received during Rounds III and IV. After screening for eligibility, 21 were selected for evaluation. The *Procedure for evaluation (17)* provides details of the eligibility criteria and screening process, and the annex below outlines each of the products evaluated.

2.4 Results and key findings

The 21 products evaluated in Rounds III and IV represented a range of treatment mechanisms, comprising mainly filtration, solar and/or UV disinfection, and chemical disinfection (chlorine dioxide and sodium dichloroisocyanurate). Separate summary reports for each product have been published on the Scheme's webpage *(16)*, and should be consulted for additional information on methods, product performance and interpretation of results.

2.4.1 Microbial performance

Table 2 shows the performance classification and mean log reductions for each product by test organism and test water. The product-specific reports are available on the Scheme's webpage *(16)*.

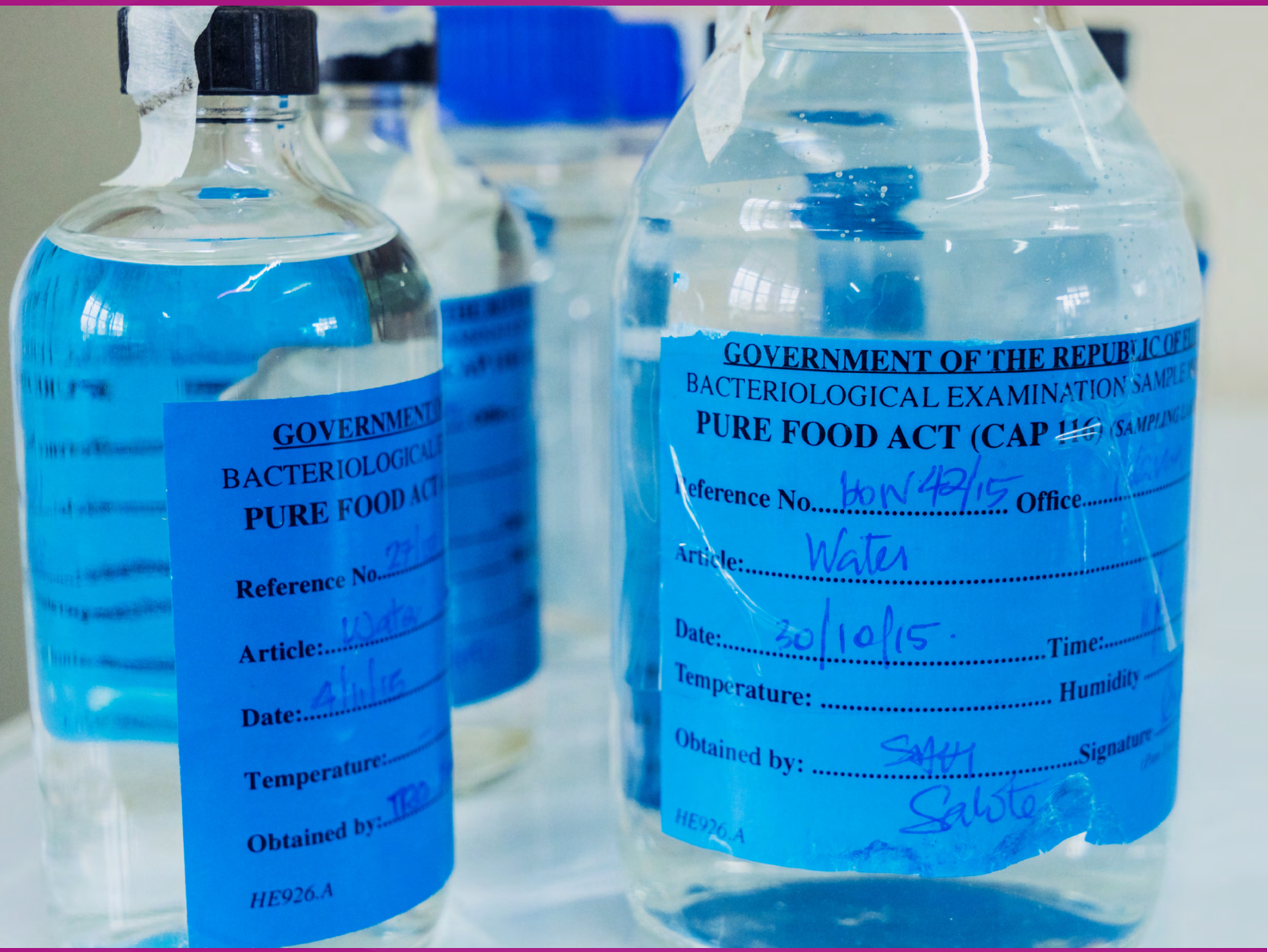
Of the 21 products evaluated in Rounds III and IV, 19 met WHO performance criteria. These comprise 13 products that met one-star criteria and are classified as providing *targeted protection*, and include membrane and ceramic filters, flocculants–disinfectants, a UV device and a chlorine disinfectant; and six products that met criteria for either two or three stars and are classified as providing comprehensive protection, comprising four membrane filtration and combined UV disinfection and filtration devices, as well as a combined flocculation–disinfection and filtration device. Two products did not meet any of the performance criteria and are classified as providing *limited* or *no protection*.

[3] These cut-off values were determined using quantitative microbial risk assessment modelling and selecting ranges that still resulted in appreciable health gains within a specific performance tier.

Table 2
Detailed results for products evaluated in Rounds III and IV

Treatment technology	Product	Manufacturer	Test water	*E. coli* log reduction	MS2 log reduction	phiX174 log reduction	*Cryptosporidium* log reduction	Performance classification
Membrane filtration[a]	BluAct Drinking Water Faucet (All-in-one water purifier)	BluAct Technologies GmbH	GTW	8.0	0.8	1.4	N/A	★
			CTW	7.1	1.2	2.8	N/A	
	Grifaid® Family Filter (GFF5)	The Safe Water Trust Ltd	GTW	5.2	5.8	5.9	N/A	★★★
			CTW	3.9	6.0	5.9	N/A	
	Katadyn First Response Gravity BeFree 3.0L	Katadyn Products Inc.	~	~	~	~	~	★
	Nanofilter™	Gongali Model Co. Ltd	GTW	7.6	0.5	2.1	N/A	★
			CTW	5.9	1.6	3.1	N/A	
	ORISA®	Fonto De Vivo	GTW	8.3	5.5	5.5	N/A	★★★
			CTW	8.4	6.1	5.3	N/A	
	ROAMfilter™ Plus	Wateroam Pte Ltd	GTW	8.6	5.1	4.4	N/A	★★
			CTW	7.5	4.1	3.9	N/A	
	Sydney 905 Filter	Sydney 905 Filters (Pty) Ltd	GTW	7.1	0.0	0.0	N/A	★
			CTW	—	—	—	N/A	
	Sydney 905 Purifier		GTW	6.8	4.9	4.5	N/A	★★
			CTW	7.9	6.5	5.7	N/A	
	VF100 Home Filter	Village Water Filters, Inc.	GTW	6.0	0.0	0.8	N/A	★
			CTW	—	—	—	N/A	
	VF100 Home Filter + VF200 Pre-Filter		GTW	9.4	0.1	0.4	N/A	★
			CTW	—	—	—	N/A	
Ceramic filtration	Katadyn Rapidyn Water Filter Kit	Katadyn Products Inc.	GTW	3.8	0.0	0.3	N/A	★
			CTW	4.4	0.0	0.2	N/A	
Sand and diatomaceous earth filtration	MINCH Household Water Filter	Desert Rose Consultancy PLC	GTW	5.9	4.9	4.9	N/A	★
			CTW	6.8	5.9	2.3		
Flocculation–disinfection	Bishan Gari Water Purifier	Bishan Gari Purification Industries, PLC	GTW	8.3	5.5	5.1	1.6	★
			CTW	8.2	5.3	5.2	1.7	
	WaterMaker Plus Water Purification Sachets	Control Chemicals (Pty) Ltd	GTW	7.4	6.2	5.3	0.2	★
			CTW	7.0	6.1	5.7	0.0	
Flocculation–disinfection and filtration	Puribag	PRAQUA PTY LTD	~	~	~	~	~	★★
Solar disinfection	SaWa[b1]	4Life Solutions ApS[b2]	GTW	6.6	1.3	6.0	5.0	★
			CTW	8.3	6.2	5.3	5.1	
UV disinfection	Solageo Better Water Maker	Trade Without Borders (HK) Limited	GTW	5.7	2.3	3.2	5.7	★
			CTW	7.2	2.0	4.6	7.2	
UV disinfection and filtration	Drop2Drink Unit	D2D Water Solutions B.V.	GTW	8.1	3.7	5.6	N/A	★★
			CTW	8.3	3.7	5.8	N/A	
Chemical disinfection (chlorine dioxide)[c]	Xinix AquaCare	Xinix International AB[d]	GTW	0.8	1.0	0.2	N/A	Little or no protection
			CTW	0.2	1.2	0.4	N/A	
	Biox Aqua 20	Scotmas Ltd	GTW	8.4	4.8	5.1	N/A	★
			CTW	7.5	7.0	4.6	N/A	
Chemical disinfection (sodium dichloroisocyanurate)[c]	Germisep 0.5 g	Hovid Berhad	GTW	1.9	1.8	3.2	N/A	Little or no protection
			CTW	4.6	2.6	2.4	N/A	

CTW: challenge test water; GTW: general test water.
The averages are listed in Table 2 to provide information on general performance. To determine the classification (one star, two star, three star), each of the three replicates must meet or exceed the target log removals for each microbial challenge.
~ Evaluation based on desk review of existing data. Sufficient data exist to determine performance but not the mean average.
— Evaluation of membrane seal integrity conducted in GTW only.
N/A indicates that the organism was not included in the product evaluation (see the annex for a summary of the evaluation for each product).
[a] For filtration technologies that rely on size exclusion, log reduction for protozoa (*Cryptosporidium parvum*) are assigned based on bacterial (*E. coli*) log reductions.
[b1] Formerly known as "SolarSack".
[b2] Formerly known as "SolarSack ApS".
[d] Now known as Xinix Global AB.
[e] For chemical (halogen) disinfectants, *Cryptosporidium parvum* oocysts were not evaluated due to limited evidence of disinfection efficacy.



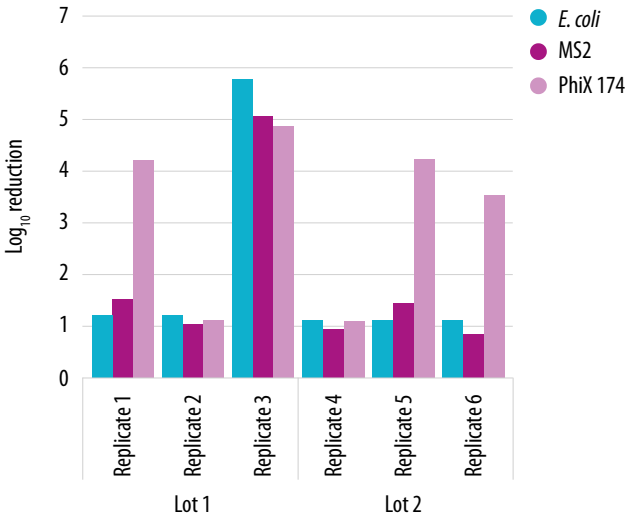
Water samples in the microbiology laboratory at the Fiji Centre for Communicable Disease Control. © WHO / Yoshi Shimizu

Almost half (10) of the products evaluated in Rounds III and IV were membrane filters and all met WHO performance criteria, with six of the products classified as providing *targeted protection*, and four classified as providing *comprehensive protection*.

2.4.2 Manufacturing consistency

The two chemical disinfection products that did not meet minimum performance criteria had high variability in performance between production lots. For one product, bacterial inactivation in GTW ranged from 0.3 to 2.7 $\log_{10}$. Fig. 2 illustrates the variability in six replicates from two production lots of the other product (lot 1: replicates 1–3; lot 2: replicates 4–6).

Fig. 2
Variability in performance across six replicates from two lots of a chlorine disinfectant in GTW



As illustrated in Fig. 2, only one of the six replicates tested (Replicate 3) met microbial reduction requirements for bacteria (*E. coli*) and viruses (bacteriophages MS2 and phiX174).

2.4.3 Product safety

For all chemical disinfectants and flocculant–disinfectants evaluated, the residual concentrations in posttreatment samples were within the limits set in the GDWQ. Similarly, posttreatment concentration of arsenic and silver leachates for the ceramic filter evaluated were within the GDWQ limits.

2.4.4 Product labelling and instructions for use

Product labels and instructions for use were reviewed for completeness, consistency, clarity and overall ease of use. In addition to microbial efficacy, correct and consistent use of HWT is critical to achieve health gains. As with previous rounds, evaluations consistently highlighted challenges with use instructions that were either overly complicated or failed to mention crucial steps. An additional challenge was inconsistent use instructions across product labels, leaflets and websites.

Notable challenges were among chemical-based products such as disinfectants and flocculants–disinfectants, where there were issues with dosing, contact time, expiry dates and consistency of product labelling and information. Several coagulation–flocculation–disinfection products had high log-reduction claims that were based on complex stirring–settling protocols; however, it is unlikely that users will adhere to these use instructions and thus product performance would be overstated. Conversely, some chemical disinfectants omitted stirring in the use instructions, or specified contact times that were too short, resulting in, for example, an effervescing chlorine tablet that stays at the

bottom of a water container causing a stratified free chlorine concentration, and therefore inconsistent disinfection in the water column.

For two of the chemical disinfectants tested, contact times and dose required were unclear, necessitating a lot of follow-up with the manufacturers for clarification. Additionally, products specified variable doses and contact times, depending on the contaminant to be treated. However, most users are unlikely to be aware of the specific contaminants in their drinking-water.

Throughout the evaluations, WHO worked with manufacturers to help understand why a product may have underperformed, and, where relevant, provided recommendations to improve use instructions.

2.5 Summary of Rounds I–IV

Fig. 3 presents an overview of Rounds I–IV: 97 EoIs for evaluation were received; of these, just over half (51) of the products were evaluated. The majority of the products evaluated met WHO performance criteria.

Fig. 4 presents an overview the performance classification of all 51 products evaluated to date. In total, 43 products met WHO performance criteria *(6)*.

Of the 51 products evaluated under the Scheme during Rounds I–IV:

- sixteen met two- (★★) or three-star (★★★) performance criteria and are classified as providing *comprehensive protection*;
- twenty-seven met one-star (★) performance criteria and are classified as providing *targeted protection*;
- seven did not meet the minimum performance criteria and are classified as providing *little or no protection*; and
- for one product, performance could not be determined due to manufacturing quality issues.

Fig. 3
Rounds I–IV of the Scheme at a glance

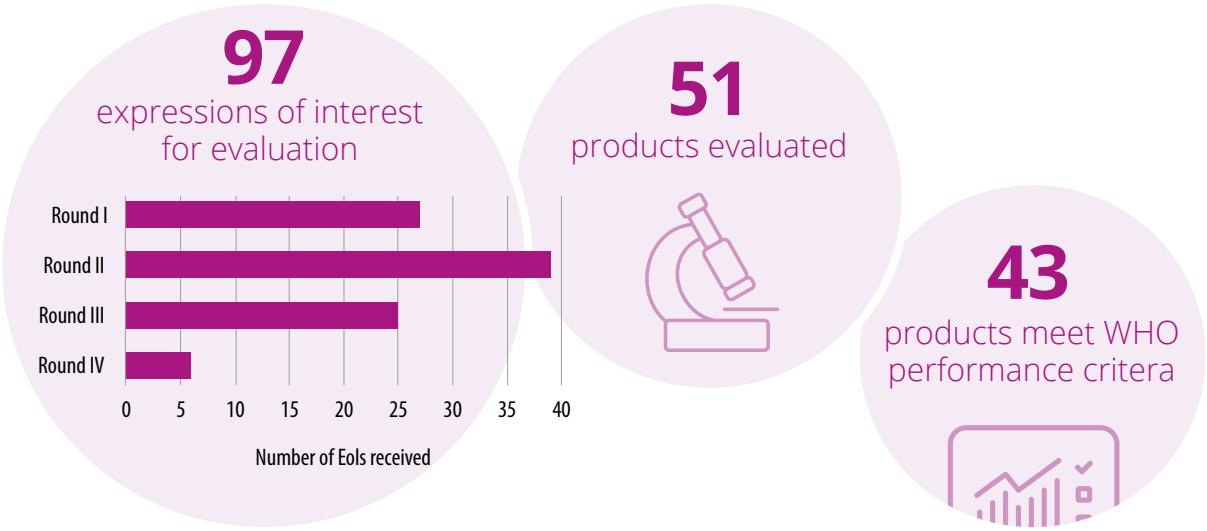


Table 3 lists the performance classification by product name, manufacturer and evaluation round. Ten products were evaluated in Round I; 20 in Round II; 18 in Round III and three in Round IV = 51 in total evaluated.

The majority of the seven products that failed to meet minimum performance criteria had high variability in treatment performance between units or batches, which is suggestive of weak manufacturing quality control. These are products that have been on the market and deemed of high potential. It is likely there are many more that have not been tested and which have similar or even greater variability in performance.

Each HWT product has strengths and limitations inherent to the underlying treatment technology. As shown in Fig. 4 and Table 3, the majority of the products classified as providing *comprehensive protection* are based on membrane filtration.

The main limiting factor for attaining three-star (★★★) *comprehensive protection* classification for membrane filters was performance against viruses, where filters with larger membrane pore sizes did not meet the performance targets for viruses. Viruses are the most challenging organism for filtration devices, which rely mainly on size exclusion, as they are the smallest test organism. Rounds I–IV revealed that membrane filters display wide variability in treatment efficacy for the two test viruses MS2 and phiX174 bacteriophages (Fig. 5).

Membrane filter products are highly variable in terms of cost, design, operating pressure, membrane chemistry, fouling and permeate flux, which can affect performance. Three out of the 14 membrane filtration products exceeded the highest 4 $\log_{10}$ reduction bacterial target for both GTW and CTW but displayed high variability in performance against viruses (Fig. 5).

Results from solar and UV disinfection products also demonstrated that viruses are a challenging microbial group to disinfect and are therefore the primary barrier to achieving two- (★★) or three-star (★★★) *comprehensive protection* classification.

Table 3
Summary results of products evaluated in Rounds I–IV

Performance classification	Product	Manufacturer	Evaluation round	Treatment technology
Comprehensive protection ★★★	AquaPak	Solar Solutions LLC	II	Solar disinfection
	Family Filter (GFF5)	Grifaid	IV	Membrane filtration
	LifeStraw Community	LifeStraw SA (part of the Vestergaard Group)	I	Membrane filtration
	LifeStraw Family 1.0		I	Membrane filtration
	ORISA®	Fonto De Vivo	III	Membrane filtration
	SolarBag®	SolarBag, Inc.[a]	II	Solar disinfection
Comprehensive protection ★★	AquaSure Tab10	AquaSure	II	Flocculation–disinfection
	DayOne WaterBag™	DayOne Response, Inc.	II	Flocculation–disinfection–filtration
	Drop2Drink Unit	D2D Water Solutions B.V.	III	UV disinfection and membrane filtration
	JAMEBI Solar Water Pasteurizer	Relevant Projects Ltd	II	Solar disinfection
	LifeStraw Family 2.0	LifeStraw SA (part of the Vestergaard Group)	I	Membrane filtration
	P&G™ Purifier of Water	The Procter & Gamble Company	I	Flocculation–disinfection
	Puribag	PRAQUA PTY LTD	III	Flocculation–disinfection–filtration
	ROAMfilter™ Plus	Wateroam Pte Ltd	III	Membrane filtration
	Sydney 905 Purifier	Sydney 905 Filters (Pty) Ltd	III	Membrane filtration
	Waterlogic Hybrid/Edge Purifier	Qingdao Waterlogic Manufacturing Company	I	UV disinfection

Table 3 *continued*

Performance classification	Product	Manufacturer	Evaluation round	Treatment technology
Targeted protection (bacteria and protozoa only) ★	BluAct Drinking Water Faucet (All-in-one water purifier)	BluAct Technologies GmbH	III	Membrane filtration
	BlueQ™ Two-Stage	Amway Corporation	II	Flocculation–biofiltration
	Katadyn First Response Gravity BeFree 3.0L	Katadyn Products Inc.	III	Membrane filtration
	Katadyn Rapidyn Water Filter Kit		III	Ceramic filtration
	Mesita Azul®	Fundación Cántaro Azul	II	UV disinfection[b]
	MINCH Household Water Filter	Desert Rose Consultancy PLC	III	Diatomaceous earth filtration
	Nanofilter™	Gongali Model Co. Ltd	III	Membrane filtration
	Nazava Water Filters	PT Holland for Water/Nazava	II	Ceramic filtration
	SaWa[c1]	4Life Solutions ApS[c2]	III	Solar disinfection
	Solageo Better Water Maker	Trade Without Borders (HK) Limited	III	UV disinfection
	SPOUTS Water Purifaaya Filter	SPOUTS of Water	II	Ceramic filtration
	Sydney 905 Filter	Sydney 905 Filters (Pty) Ltd	III	Membrane filtration
	Tulip Table Top Water Filter	Basic Water Needs B.V.	II	Ceramic filtration
	Uzima Filter UZ-1	Uzima Water Filters	II	Membrane filtration
	VF100 Home Filter	Village Water Filters, Inc.	III	Membrane filtration
	VF100 Home Filter + VF200 Pre-Filter		III	Carbon and membrane filtration
	Water Elephant	Years of Water Limited	II	UV disinfection
Targeted protection (bacteria and protozoa; limited protection against viruses) ★	WADI	Helioz GmbH	I	Solar disinfection
Targeted protection (bacteria and viruses only) ★	Aquatabs®	Medentech Ltd	I	Chemical disinfection
	Aquatabs Flo		II	Chemical disinfection
	Bishan Gari Water Purifier	Bishan Gari Purification Industries, PLC	III	Flocculation–disinfection
	Biox Aqua 20	Scotmas Ltd	IV	Chemical disinfection
	H2g0 Purifier	Aqua Research LLC	I	Chemical disinfection
	Oasis Purification Tablets	Hydrachem Ltd	II	Chemical disinfection
	Rubicon-Micro[d]	PrideCo Holdings (Pvt) Ltd	II	Flocculation–disinfection
	WATA-Standard™	Antenna Technologies	II	Chemical disinfection
	WaterMaker Plus Water Purification Sachets	Control Chemicals (Pty) Ltd	III	Flocculation–disinfection
Little or no protection[e]	Xinix AquaCare	Xinix International AB[f]	III	Chemical disinfection
	BioCool CleanWater	BioCool AB	II	Chemical disinfection
	Chloritard	Karnis & Hals Chemicals Pvt Ltd	II	Chemical disinfection
	Germisep 0.5 g	Hovid Berhad	IV	Chemical disinfection
	GrifAid®M3	Safe Water Trust	II	Membrane filtration
	LifeFilta LFJC Jerrycan with backwash	AquaNano Water Filters	II	Membrane filtration
	Silverdyne	World Health Alliance Inc.	I	Chemical disinfection
Performance undetermined	TEMBO Filter Pot[f]	MSABI Women's Group	I	Ceramic filtration

★★★ Removes at least 4 $\log_{10}$ of bacteria, at least 5 $\log_{10}$ of viruses and at least 4 $\log_{10}$ of protozoa.

★★ Removes at least 2 $\log_{10}$ of bacteria, at least 3 $\log_{10}$ of viruses and at least 2 $\log_{10}$ of protozoa.

★ Meets performance targets for at least two stars (★★) for only two classes of pathogens.

[a] Effective removal of bacteria and protozoa in non-turbid water only.
[b] Formerly manufactured by Puralytics.
[c1] Formerly known as "SolarSack".
[c2] Formerly known as "SolarSack ApS".
[d] Formerly known as "Rubicon".
[e] Do not meet any of the WHO performance criteria.
[f] Now known as Xinix Global AB.
[g] Performance could not be determined due to low flow in the filter.

Fig. 4
Performance classification by treatment technology for products evaluated in Rounds I–IV

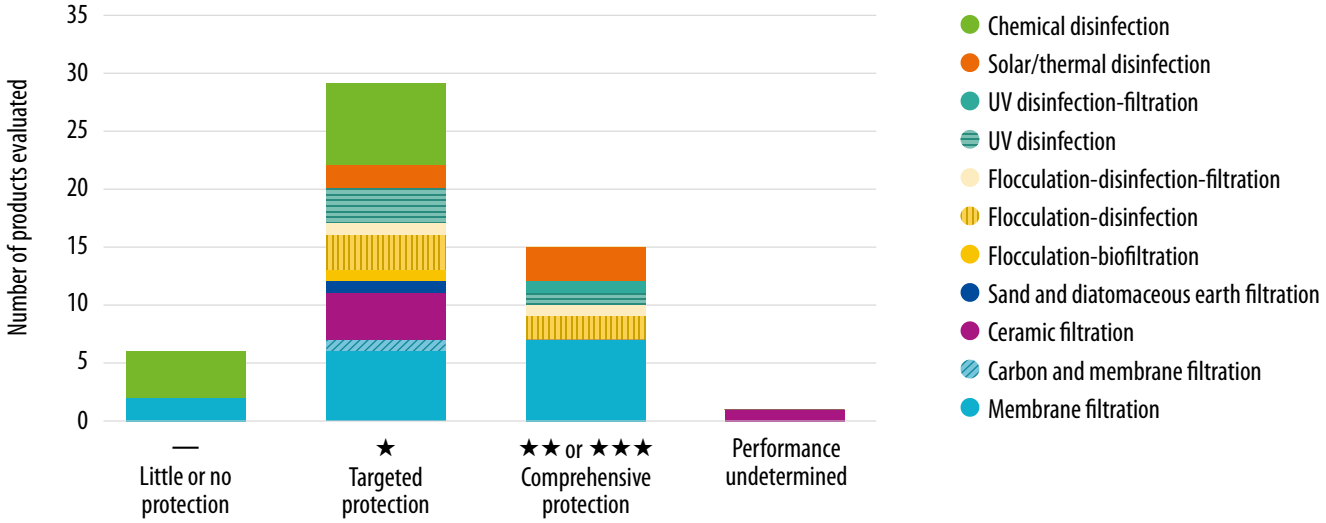
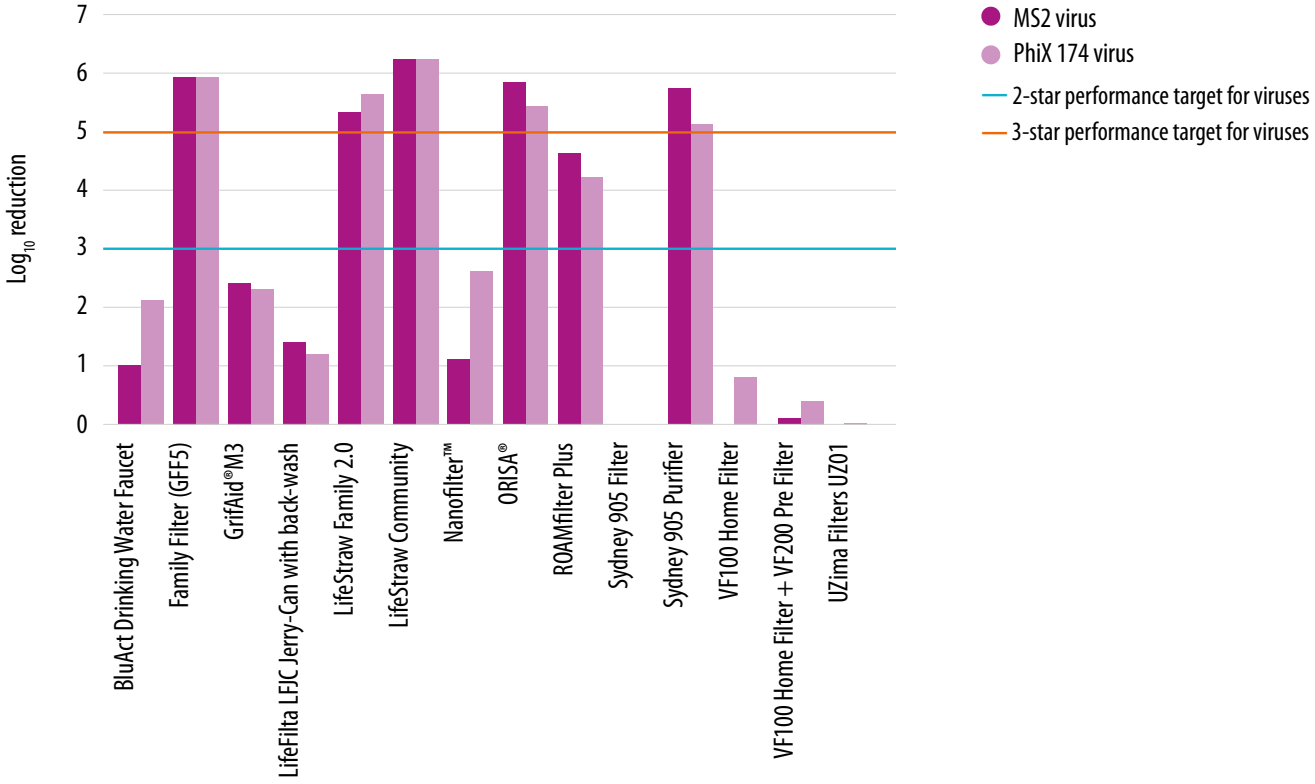


Fig. 5
Mean virus reduction for 14 membrane filtration devices tested in Rounds I–IV



2.6 Interpretation and application of the Scheme results in HWT product selection

While three-star products offer superior pathogen protection, under most water quality conditions, similar health gains can be achieved from two-star products when these are used correctly and consistently *(19)*. Essentially:

- two- and three-star products provide *comprehensive protection* and are effective when a range of pathogens causing diarrhoeal disease are present or when the causative pathogen(s) is(are) unknown; and

- when choosing between two- and three-star products, the focus should not be on the product with the higher performance classification, but on the product most likely to achieve high rates of correct and consistent use, and factors that support effective implementation, such as supply chains and cost.

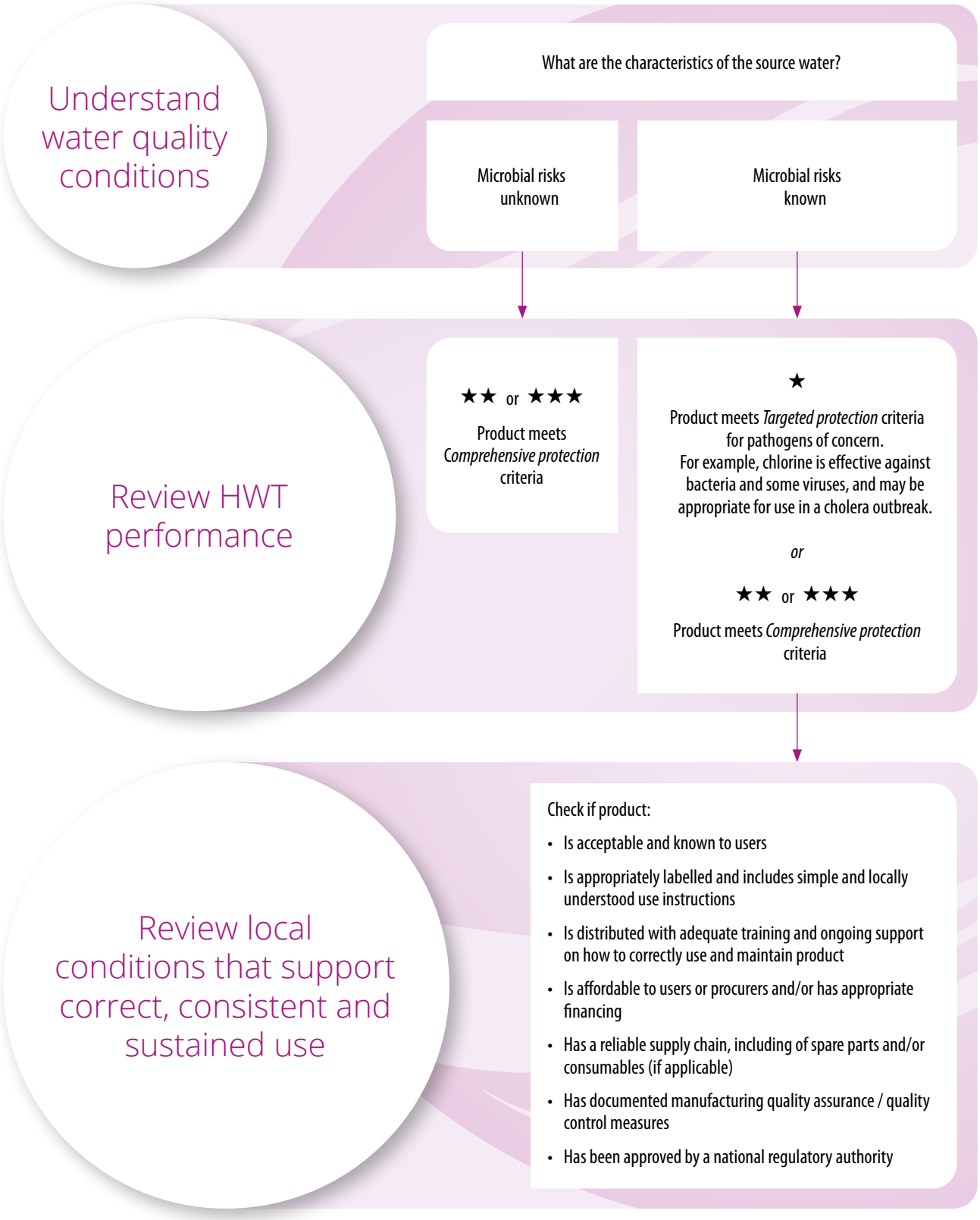
Selection of HWT products should consider microbial effectiveness and whether products are appropriate for the context in which they are to be used. No product is appropriate for all settings and all users.

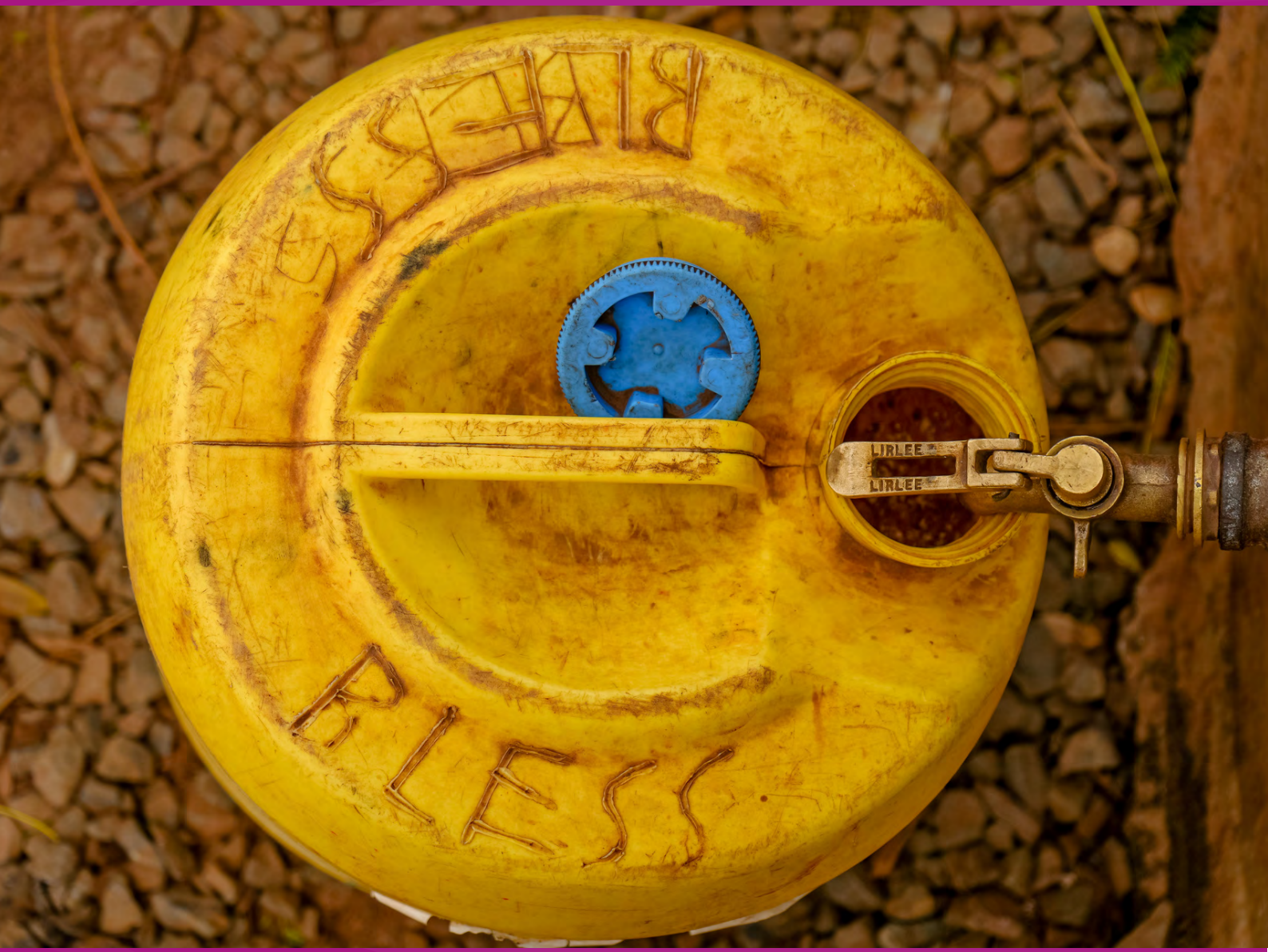
Once confirmed that a product meets minimum performance targets, other factors to consider include specific relevant water quality conditions, safe storage, and the likelihood of correct and consistent use and the factors that influence such use (Fig. 6).

Selection should be informed by an understanding of existing environmental risks, including source water quality and contamination risks. For example, for surface waters likely contaminated by animal waste, the product should remove protozoa; in cholera-endemic areas, the product should remove bacteria. Physicochemical parameters such as turbidity and total organic carbon also affect the effectiveness of treatment and should be considered in light of the limitations of various technologies. For instance, disinfection of turbid/organic-rich waters with UV or chlorine is most effective when part of a multibarrier treatment approach that includes flocculation/filtration to reduce turbidity and organic matter.

Additionally, HWT product selection should be informed by the likelihood of achieving correct and consistent use. A number of factors support high adherence to HWT; some relate to the product itself, such as acceptability/aesthetic appeal, or familiarity and ease of use. Having simple instructions that are available in an appropriate language also supports high adherence *(20)*. Other factors include making the product easily accessible (e.g. reliable supply chains with local stores); providing training on how to use and maintain the product; and ensuring provisions for product repair.

Fig. 6
Using Scheme results in HWT product selection





A container is filled with water from a storage tank at a primary school in Kajiado, Kenya. © WHO / Billy Miaron

3. Impact of the Scheme and future directions for HWT evaluation

Most of the focus of the Scheme so far has been on testing products, alongside some capacity development efforts. Moving forward, increased focus will be on strengthening national water quality laboratories, regulatory frameworks and understanding HWT performance and use. This chapter outlines some of the initial successes in these areas and plans to build on them.

3.1 Disseminating and supporting application of Scheme evaluation criteria and results

A key priority of the Scheme is to ensure the evaluation criteria and results of the products that have already been evaluated are used to inform product selection. During Rounds III and IV, WHO collaborated with the United Nations Children's Fund (UNICEF) Global Supply and Logistics Hub to incorporate HWT products that met WHO performance criteria into the *Household water filters product guide (21)*. The product guide serves to inform UNICEF's regional, country and/or field offices of the different products that are available on the market and their specificities. It is intended to guide local procurement of water filtration products.

Beginning in Round III, the Scheme results have been reported in brief product-specific reports that are developed and published as soon as each product evaluation is complete *(16)*. This has facilitated faster dissemination of results, rather than waiting until publication of the summary report. This approach to more rapidly disseminating results is not only useful for informing production selection by procurers, but has also facilitated fast-tracking of national approvals of product sale/distribution (e.g. Box 1). WHO will continue to explore options to further disseminate and support uptake of results from the Scheme.

WHO is also developing checklists to support review of HWT performance data. These checklists are based on the Scheme evaluation criteria and protocols, and outline key considerations in the evaluation of HWT performance, such as test water and test organisms. These checklists are intended to guide national certification/regulatory authorities and procurers who are reviewing test data, as well as manufacturers and others involved in product design.

Box 1

WHO testing for HWT products required by the Government of Burundi

The Government of Burundi is working to bring clean water to every citizen through multiple means, including HWT devices. The government has recognized the importance of a relevant and independent evaluation of performance, such as the WHO Scheme, and is requiring that HWT products be tested by WHO prior to approval.

3.2 Supporting development of national regulations for HWT

While the results from the Scheme are impactful for procuring agencies and consumer confidence (e.g. Box 2), very few countries have comprehensive HWT regulations, including many of the countries where HWT products are commonly used.

These regulations are important for facilitating approval of well performing products and keeping poor performing products off the market. There is a growing need for informed selection of HWT, given the increase in humanitarian crises arising from conflict (e.g. Box 3), extreme weather events and disasters.

Box 2

Confidence in evaluation results from the Scheme

"In terms of global credibility, the WHO testing results make a huge difference!"

JAMEBI Ltd

Box 3

Emergency HWT standards in Ukraine

Since 2022, the war in Ukraine has left 14.6 million people in need of humanitarian assistance and resulted in billions of dollars of damage to water and sanitation infrastructure through direct strikes, neglect of operations and maintenance, and cuts in energy *(22)*. HWT has thus become a critical intervention to protect health and prevent the spread of diseases such as hepatitis A and typhoid.

With support from WHO, emergency actors and the Ministry of Health of Ukraine drafted emergency guidelines *(23)*, based on WHO performance criteria and test results, to ensure products that are being distributed to households result in safer water and protect lives. In addition, WHO and UNICEF are working with the Ministry of Health to improve water quality and more generally WASH services as part of broader infection prevention and control and quality of care in health care facilities. Effective water treatment technologies are an important component of these efforts.

National standards and regulatory authorities can play a vital role in ensuring available HWT products are effective and improve the safety of drinking-water by adapting the WHO performance recommendations for HWT into national standards and using these standards as the basis for evaluating and regulating products in-country. Since 2015, WHO has worked with several countries including Ethiopia, Ghana and Nepal to support establishment or revision of HWT regulations to more comprehensively address microbial performance *(6, 7)*. While overall progress has been variable in most countries, national standards have been developed, for example, in Ghana (Box 4).

In addition to supporting the development of similarly comprehensive, health-based national standards and regulations for HWT in additional countries, WHO will continue to promote fast-tracking national approval and/or certification of products evaluated under the Scheme.

Box 4

National standards for HWT performance established in Ghana

In Ghana, the Ministry of Sanitation and Water Resources, the Ghana Standards Authority and other stakeholders have worked together to develop a national standard for HWT performance. The standard – *Requirements for performance of household water treatment products and technologies – pathogen removal* – is adapted from the WHO performance criteria for HWT and was finalized in 2022 *(24)*. It sets out the performance requirements for HWT products with respect to pathogen removal, defines methods for testing HWT product performance, and specifies HWT product labelling and packaging requirements. The standard defines performance classifications according to log-reduction criteria for three classes of pathogens (bacteria, viruses and protozoa). This standard was developed in response to the influx of a diverse range of HWT products into the Ghanaian market, necessitating performance testing to ensure the quality and effectiveness of these products.

Source: Personal communication with Francisca Frimpong, Chief Scientific Officer, Ghana Standards Authority (2023).

3.3 Strengthening capacities of national laboratories for HWT testing

WHO has developed training resources to support HWT product evaluations *(13)*. These resources draw on the existing evaluation protocols of the Scheme, and are adapted to limited-resource settings. Additionally, WHO will work with countries to adapt existing testing protocols of the Scheme to local contexts while providing a common basis for technology performance evaluation.

Among the key lessons learned from the capacity development efforts under the Scheme is the need to strengthen broader capacities in water quality management as a whole, including water quality testing for surveillance monitoring. Furthermore, laboratory systems such as procurement processes, financing and data management need to be improved in many countries.

With the publication and subsequent uptake of the *Guidelines for drinking-water quality: small water supplies (25)*, the need to strengthen the capacities of laboratories is more pressing, as more countries seek to progressively strengthen regulation of small water supplies, including water quality surveillance. WHO will be engaging with partners to support the aforementioned areas of work related to laboratory systems, with the aim to support water quality laboratories to progressively perform high-quality testing while being financially sustainable.

A water sample in the microbiology laboratory at the Fiji Centre for Communicable Disease Control. © WHO / Yoshi Shimizu

3.4 Facilitating HWT testing under the Scheme

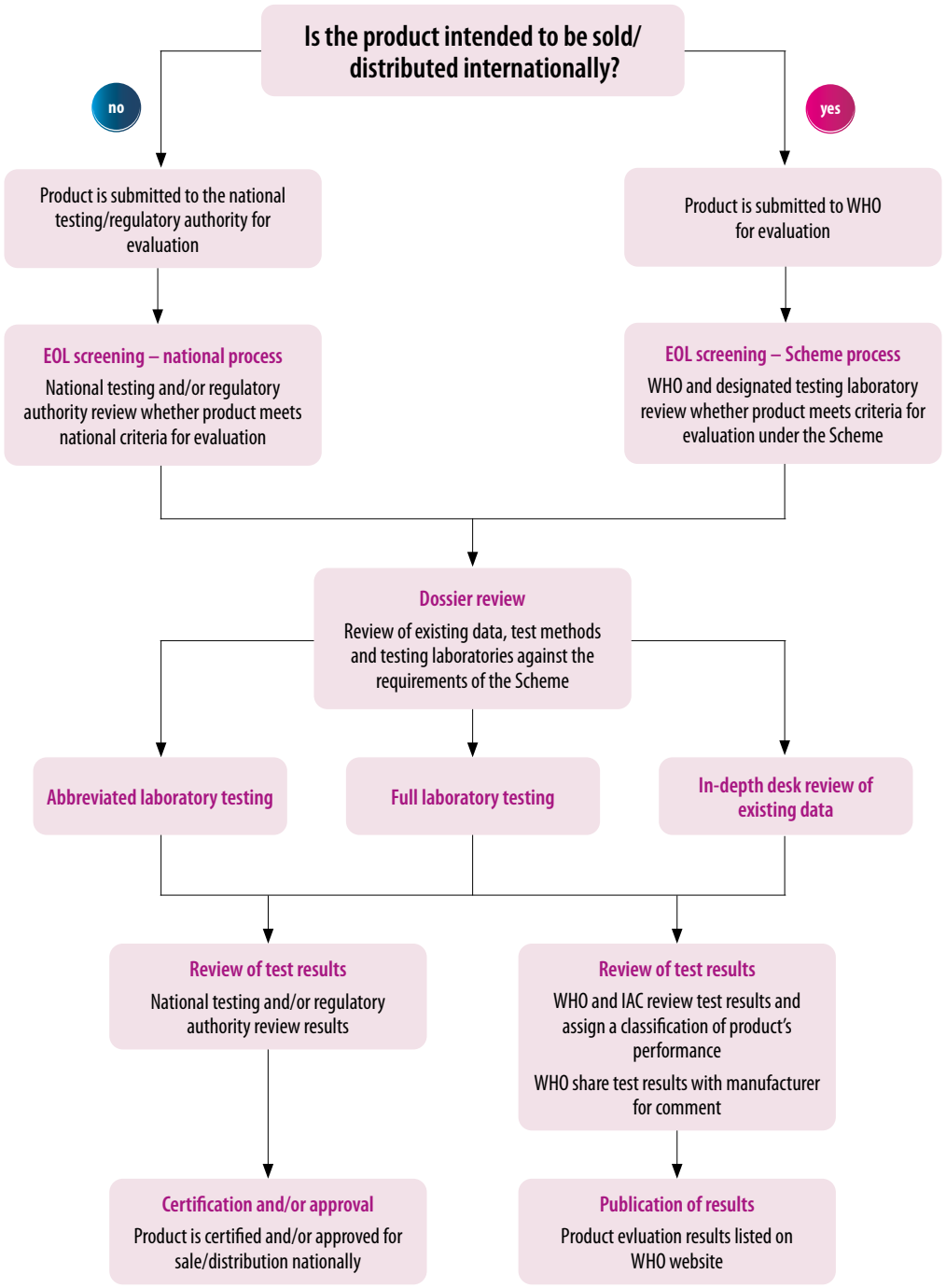
Over the course of Rounds I–IV, WHO received 100 EoIs; of these, 51 products were evaluated. Together, these products have a market reach of over 100 countries globally. While there is still interest in additional product evaluations, there was a significant decrease in the number of EoIs received and products evaluated in Round IV compared to the previous rounds.

The 51 products evaluated in Rounds I–IV represent many of the available products in the current HWT market, including many of the chlorine disinfectants, flocculants–disinfectants and filters that are most widely distributed/procured. This suggests that most HWT products of global relevance have been tested, and thus there is diminished demand for global testing.

Nevertheless, it is recognized that with new product development and innovation, there will still be a need for global testing and procurement. Increasing global humanitarian needs, including for safe water, will, in part, drive this need. Moving forward, WHO will continue to facilitate evaluation of products of global relevance under the Scheme. However, a notable change is that Round IV marked the end of WHO subsidies towards testing, and therefore future evaluations will require applicants to pay the full cost of testing. Additionally, products will be evaluated on a rolling basis, with no distinct "evaluation rounds". Fig. 7 outlines how the testing procedure under this new set-up will work.

Under the global testing track, applicants whose products are intended for an international market will continue to submit their expressions to WHO for evaluation, which will then refer the dossier to one of the WHO-designated testing laboratories, in accordance with the *Procedure for evaluation (17)*. Under the national testing track, products intended only for local/national markets may be submitted to national laboratories for testing. The national laboratories would test against adapted WHO testing protocols (see section 3.3 above), with national certification provided by the relevant national authority.

Fig. 7
Overview of the national and Scheme HWT evaluation procedures



4. Conclusions

The Scheme has filled an important gap in independent, comprehensive and health-based evaluation of HWT product performance. Testing protocols have been developed and validated for a range of HWT technologies. The evaluations have provided valuable insights into technology performance and manufacturing quality, and are catalysing a shift towards the manufacture and procurement of better-performing, protective products.

Furthermore, capacity-building efforts in various countries have led to increased awareness and understanding of HWT performance criteria, as well as important initial efforts to strengthen HWT regulation. WHO will continue to disseminate and support uptake of results for products that have been evaluated, with the goal of ensuring informed HWT technology selection which protects health.

A glass and a pitcher of clean water. © WHO / Malin Bring

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Annex
Household water treatment products tested under Rounds III and IV of the Scheme

This Annex presents an overview of treatment technologies represented in Rounds III and IV, as well as brief descriptions of the specific products and evaluation methods. Detailed results from products tested in Round I and Round II can be found in Round I and Round II global test reports, respectively. In addition, product-specific reports for all products tested in Rounds I–IV are available on the Scheme webpage *(1)*.

A.1 Membrane filtration

Membrane filtration removes microorganisms from drinking-water through size exclusion. The filters used typically comprise hollow membrane fibres in a cartridge through which microbes are removed by physical straining. Key determinants of the performance of the membrane filtration systems are filter pore size, integrity of the filter medium and seals, and manufacturing quality. Not all membrane types are effective against viruses, which is the smallest of the three microbial groups evaluated under the Scheme (see figure. A1).

Fig. 1. Relative effectiveness of membrane filter pore sizes against viruses

Table A.1 provides an overview of the microbial performance, limitations and advantages of membrane filtration for household water treatment (HWT).

Table A.1. Selected properties of membrane filtration for HWT

Microbial performance	• Effective against bacteria, viruses (depending on the integrity and pore size of the membrane) and protozoa
Key factors affecting efficacy	• Membrane pore size relative to pathogen size • Membrane fouling • Integrity of membrane, seals and interconnecting plumbing
Advantages	• Minimal likelihood of recontamination (when there is an integrated safe storage container) • Appearance of treated water is improved, providing a visual indicator that reinforces the benefits of treatment • Minimal change in taste of water • Often simple to use • Typically no power source required
Limitations	• Need to clean receptacles and membrane regularly • Membrane fouling • Difficulty in sourcing spare parts
Application	Most appropriate where: • the pathogen of concern is unknown (depending on membrane integrity and pore size) • external funding or microfinance schemes are available to support the initial cost of the filter for low-income populations

Sources: see *(2, 3)*.

BluAct Drinking Water Faucet (All-in-one water purifier)

Manufacturer: **BluAct Technologies GmbH**

Manufacturer location: **Switzerland**

Treatment technology: **Membrane ultrafilter**

BluAct Drinking Water Faucet connected to a kitchen faucet.
©BluAct Technologies GmbH

Product description[a]

The BluAct Drinking Water Faucet (All-in-one water purifier) is an amyloid-carbon membrane filtration device. The filter cartridge comprises a hybrid of milk protein fibrils and activated carbon granules for removal of microbial pathogens, and includes a washable fabric prefilter. The device can operate under gravity flow, or can be plumbed into a water supply.

The full product description, illustrations and use instructions are available at: www.bluact.com.

Product specifications[a]

	Water quality conditions	Suitable for all water quality conditions
	Fail-safe/indicator of treatment complete	Digital flow meter with blinking indicator light for filter cartridge replacement
	Maintenance and lifespan	Reusable; the filter can be backwashed to remove clogging
	Integrated safe container/residual protection	Estimated filter lifespan of 1 year, dependent on use
	Energy requirements	None; it is a direct water faucet
	Countries where sold/distributed	None
	Estimated annual production (no. of units)	Global distribution planned

Product evaluation

Evaluation of the BluAct Drinking Water Faucet (All-in-one water purifier) followed the requirements of the *Testing protocol for filtration technologies – version 3.2 (4)*, and investigated the ability of the device to reduce bacteria and viruses in general test water (GTW) and challenge test water (CTW). Reduction of protozoa was assigned based on the mean bacterial reduction achieved.

[a] Based on information provided by the manufacturer.

Grifaid® Family Filter (GFF5)

Grifaid® Family Filter (GFF5).
© The Safe Water Trust

Manufacturer: **The Safe Water Trust**

Manufacturer location: **United Kingdom of Great Britain and Northern Ireland**

Treatment technology: **Membrane ultrafiltration**

Product description[a]

The Grifaid® Family Filter (GFF5) is a HWT device that uses a polymer ultrafiltration membrane. The filter is clamped to a vessel containing raw water. Manual pumping forces water through the membrane filter, trapping microorganisms and dispensing filtered water. The filter does not have an integrated clean water receptacle as clean water is provided on demand. If a separate storage container is required, the user would need to provide a suitable container.

The full product description, illustrations and instructions are available at: www.grifaid.org.

Product specifications[a]

	Water quality conditions	Suitable for all water quality conditions
	Fail-safe/indicator of treatment complete	None
	Maintenance and lifespan	Daily membrane flushing is recommended, or more frequently if the raw water is more turbid Clean the prefilter as necessary Replace the pump seal about once per year Grease the pump seal about twice per year Estimated lifespan of up to 5 years
	Integrated safe container/residual protection	None
	Energy requirements	None
	Countries where sold/distributed	Worldwide
	Estimated annual production (no. of units)	10 000

Product evaluation

Evaluation of the Grifaid® GFF5 followed the requirements of the *Testing protocol for filtration technologies – version 3.2 (4)*, and investigated the ability of the device to reduce bacteria and viruses in GTW and CTW. Reduction of protozoa was assigned based on the mean bacterial reduction achieved.

[a] Based on information provided by the manufacturer.

Katadyn First Response Gravity BeFree 3.0 L

Katadyn First Response Gravity BeFree 3.0 L.
© Katadyn Products Inc.

Manufacturer: **Katadyn Products Inc.**

Manufacturer location: **Switzerland**

Treatment technology: **Membrane microfiltration**

Product description[a]

The Katadyn First Response Gravity BeFree 3.0 L is a hollow-fibre membrane microfiltration device. It comprises a 3 L bag and a microfilter cartridge that is screwed to the mouth of the bag. The bag can be suspended, or carried as a backpack with the filtration cartridge at the bottom. Water is filtered through the cartridge under gravity to a separate clean water receptable.

The full product description, illustrations and use instructions are available at: www.katadyngroup.com.

Product specifications[a]

	Water quality conditions	Preferably clear water but suitable for all water quality conditions
	Fail-safe/indicator of treatment complete	None
	Maintenance and lifespan	Depending on the water quality, the filter should be cleaned after every second filling Cleanable Estimated lifespan of up to 1 000 L of water, depending on turbidity of untreated water
	Integrated safe container/residual protection	None
	Energy requirements	None
	Countries where sold/distributed	Through the Katadyn sales offices and distribution partners in over 100 countries
	Estimated annual production (no. of units)	200 000

Product evaluation

Evaluation of the Katadyn First Response Gravity BeFree 3.0 L was based on a desk review of existing data on performance against bacteria and protozoa. The submitted data were reviewed against the requirements of the *Testing protocol for filtration technologies – version 3.2 (4)*.

[a] Based on information provided by the manufacturer.

Nanofilter™

Manufacturer: **Gongali Model Co. Ltd**

Manufacturer location: **United Republic of Tanzania**

Treatment technology: **Combined slow sand, bone char and membrane microfiltration**

Product description[a]

The Nanofilter™ is a gravity-fed three-stage filtration device that combines slow sand, bone char and membrane filtration. The assembled unit comprises a series of three stacked buckets. Untreated water is poured into the top bucket containing sand, which is intended to remove turbidity and other particulates. In the next bucket, the water filters through a layer of bone char and a 0.1 µm ultrafiltration cartridge attached to it. The filtered water then passes into the third bucket with a spigot attached, through which the treated water can be collected. The device is also available in two other models: the Double-NanofilterTM with two filtration cartridges and the Mega-Nanofilter™ with four filtration cartridges.

The full product description, illustrations and instructions are available at: www.gongalimodel.com.

Product specifications[a]

	**Water quality conditions**	Suitable for all water quality conditions
	**Fail-safe/indicator of treatment complete**	None
	**Maintenance and lifespan**	Maintenance is recommended every 3 months; the maintenance procedure includes changing of saturated/used materials, backwashing of the filter, cleaning the buckets and replacing any broken parts Reusable Estimated lifespan of up to 5 years
	**Integrated safe container/residual protection**	None
	**Energy requirements**	None
	**Countries where sold/distributed**	Kenya, United Republic of Tanzania and Zambia
	**Estimated annual production (no. of units)**	5 200

Product evaluation

Evaluation of the Nanofilter™ followed the requirements of the *Testing protocol for filtration technologies – version 3.2 (4)*, and investigated the ability of the device to reduce bacteria and viruses in GTW and CTW. Reduction of protozoa was assigned based on the mean bacterial reduction achieved.

[a] Based on information provided by the manufacturer.

MEMBRANE FILTRATION

ORISA®

ORISA® membrane filter.
© Fonto De Vivo

Manufacturer: **Fonto De Vivo**

Manufacturer location: **France**

Treatment technology: **Membrane ultrafiltration**

Product description[a]

The ORISA® is a membrane ultrafiltration device. It is operated by clamping it to a vessel containing raw water and manually pumping water through it. Forcing water through the hollow-fibre membranes removes the microorganisms. The device has an optional gravity operated mode. The device does not have an integrated clean water receptacle; a separate collection/storage vessel is required.

The full product description, illustrations and use instructions are available at: www.fontodevivo.com.

Product specifications[a]

	Water quality conditions	Suitable for all water quality conditions
	Fail-safe/indicator of treatment complete	None
	Maintenance and lifespan	Daily backwashing is recommended Regular greasing of the O-rings may be required; O-rings should be changed after 1 year Estimated lifespan of up to 12 years by using additional membranes
	Integrated safe container/residual protection	None
	Energy requirements	Can be operated manually or by gravity if connected to a tap or elevated tank
	Countries where sold/distributed	Bahamas, Bangladesh, Belgium, Burkina Faso, Burundi, Cambodia, Cameroon, Central African Republic, Colombia, Côte d'Ivoire, Croatia, Democratic Republic of the Congo, France, Guinea, Haiti, Lao People's Democratic Republic, Lebanon, Madagascar, Malawi, Malaysia, Mali, Morocco, Netherlands (Kingdom of the), Nigeria, occupied Palestinian territories, Pakistan, Peru, Philippines, Rwanda, Senegal, Sierra Leone, South Sudan, Spain, Sudan, Thailand, Togo, Uganda, United Kingdom, Yemen and Zimbabwe
	Estimated annual production (no. of units)	100 000

Product evaluation

Evaluation of the ORISA® followed the requirements of the *Testing protocol for filtration technologies – version 3.2 (4)*, and investigated the ability of the device to reduce bacteria and viruses in GTW and CTW. Reduction of protozoa was assigned based on the mean bacterial reduction achieved.

[a] Based on information provided by the manufacturer.

ROAMfilter™ Plus

Manufacturer: **Wateroam Pte Ltd**

Manufacturer location: **Singapore**

Treatment technology: **Membrane ultrafiltration**

ROAMfilter™ Plus membrane filter.
© Wateroam Pte Ltd

Product description[a]

The ROAMfilter™ Plus is a membrane ultrafiltration device. It is operated by clamping it to a vessel containing raw water and manually pumping. Forcing water through the hollow-fibre membranes removes the microorganisms. The device can also be operated by an electric pump, or under gravity feed. The device does not have an integrated clean water receptacle; a separate collection/storage vessel is required.

The full product description, illustrations and instructions are available at: www.wateroam.com.

Product specifications[a]

Water quality conditions	Suitable for all water quality conditions
Fail-safe/indicator of treatment complete	None
Maintenance and lifespan	Daily flushing is recommended Backflushing and chemical cleaning is recommended when the flow rate diminishes or the filter is clogged Reusable Estimated lifespan of up to 2 years
Integrated safe container/residual protection	None
Energy requirements	Can be operated manually, under gravity or via an electric pump
Countries where sold/distributed	Distributors in Indonesia, Malaysia, Nepal and South Africa The ROAMfilter™ Plus has been sold in Australia, Bangladesh; Cambodia; Canada; Chad; China; China, Hong Kong Special Administrative Region; Fiji; India; Indonesia; Malaysia; Netherlands (Kingdom of the); Nigeria; Papua New Guinea; Philippines; Singapore; Sri Lanka; Sweden; United States and Viet Nam
Estimated annual production (no. of units)	Not provided

Product evaluation

Evaluation of the ROAMfilter™ Plus followed the requirements of the *Testing protocol for filtration technologies – version 3.2 (4)*, and investigated the ability of the device to reduce bacteria and viruses in GTW and CTW. Reduction of protozoa was assigned based on the mean bacterial reduction achieved.

[a] Based on information provided by the manufacturer.

Sydney 905 Filter

Sydney 905 Filter.
© Sydney 905 Filters (Pty) Ltd

Manufacturer: **Sydney 905 Filters (Pty) Ltd**

Manufacturer location: **South Africa**

Treatment technology: **Membrane microfiltration**

Product description[a]

The Sydney 905 Filter is a 0.1 µm hollow-fibre membrane microfiltration device. The filter can be plumbed to a pressurized water supply or connected to a raw water reservoir outlet such as a bucket or water tank and operated by gravity flow.

The full product description, illustrations and use instructions are available at the manufacturer's website: www.safewater4u.com or the product website: www.sydney905filters.com.

Product specifications[a]

	Water quality conditions	Suitable for all water quality conditions
	Fail-safe/indicator of treatment complete	None
	Maintenance and lifespan	Backwashing recommended at least twice per week Reusable Estimated lifespan of up to 10 years
	Integrated safe container/residual protection	None
	Energy requirements	None
	Countries where sold/distributed	Global
	Estimated annual production (no. of units)	Monthly capacity of 120 000 units

Product evaluation

Evaluation of the Sydney 905 Filter comprised a desk review of existing data and an abbreviated laboratory test aimed at evaluating the device's seal integrity. This abbreviated testing procedure allows for verification of the filter's sealing mechanisms that prevent untreated water from bypassing the filtration media. The laboratory test followed the requirements of the *Testing protocol for filtration technologies – version 3.2 (4)*, and investigated the ability of the device to reduce bacteria and viruses in GTW. Reduction of protozoa was assigned based on the mean bacterial reduction achieved.

[a] Based on information provided by the manufacturer.

Sydney 905 Purifier

Sydney 905 Purifier.
© Sydney 905 Filters (Pty) Ltd

Manufacturer: **Sydney 905 Filters (Pty) Ltd**

Manufacturer location: **South Africa**

Treatment technology: **Membrane ultrafiltration**

Product description[a]

The Sydney 905 Purifier is a 0.01 µm hollow-fibre membrane ultrafiltration device. The filter can be plumbed to a pressurized water supply or connected to a raw water reservoir outlet such as a bucket or water tank and operated by gravity flow.

The full product description, illustrations and use instructions are available at the manufacturer's website: www.safewater4u.com or the product website: www.sydney905filters.com.

Product specifications[a]

Water quality conditions	Suitable for all water quality conditions
Fail-safe/indicator of treatment complete	None
Maintenance and lifespan	Backwashing recommended daily Reusable Estimated lifespan of up to 10 years
Integrated safe container/residual protection	None
Energy requirements	None
Countries where sold/distributed	Global
Estimated annual production (no. of units)	Monthly capacity of 120 000 units

Product evaluation

Evaluation of the Sydney 905 Purifier followed the requirements of the *Testing protocol for filtration technologies – version 3.2 (4)*, and investigated the ability of the device to reduce bacteria and viruses in GTW and CTW. Reduction of protozoa was assigned based on the mean bacterial reduction achieved.

[a] Based on information provided by the manufacturer.

VF100 Home Filter

VF100 Home Filter.
© Village Water Filters, Inc.

Manufacturer: **Village Water Filters, Inc.**

Manufacturer location: **United States of America**

Treatment technology: **Membrane ultrafiltration and activated carbon prefiltration**

Product description[a]

The VF100 Home Filter is a hollow-fibre membrane ultrafiltration device. The filter can be plumbed to a pressurized water supply, or connected to a raw water reservoir outlet such as a bucket or water tank and operated by gravity flow. The VF100 can be used as a stand-alone device, or can be attached to a reticulated carbon foam filter, the VF200 Pre-Filter.

The full product description, illustrations and use instructions are available at: www.villagewaterfilters.org.

Product specifications[a]

	Water quality conditions	Suitable for all water quality conditions
	Fail-safe/indicator of treatment complete	None
	Maintenance and lifespan	Backflushing of VF100 is necessary on a regular basis to increase flow Reusable VF100 estimated lifespan of 7 years
	Integrated safe container/residual protection	None
	Energy requirements	None
	Countries where sold/distributed	Global, in over 70 countries
	Estimated annual production (no. of units)	200 000

Product evaluation

Evaluation of the VF100 Home Filter comprised a desk review of existing data and an abbreviated laboratory test aimed at evaluating the device's seal integrity. This abbreviated testing procedure allows for verification of the filter's sealing mechanisms that prevent untreated water from bypassing the filtration media. The laboratory test followed the requirements of the *Testing protocol for filtration technologies – version 3.2 (4)*, and investigated the ability of the device to reduce bacteria and viruses in GTW.

[a] Based on information provided by the manufacturer.

VF100 Home Filter + VF200 Pre-Filter

VF100 Home Filter attached to a VF200 Pre-Filter.
© Village Water Filters, Inc.

Manufacturer: **Village Water Filters, Inc.**

Manufacturer location: **United States of America**

Treatment technology: **Membrane ultrafiltration and activated carbon prefiltration**

Product description[a]

The VF100 Home Filter is a hollow-fibre membrane ultrafiltration device. The filter can be plumbed to a pressurized water supply, or connected to a raw water reservoir outlet such as a bucket or water tank and operated by gravity flow. The VF100 can be used as a stand-alone device, or can be attached to a reticulated carbon foam filter, the VF200 Pre-Filter. The VF200 Pre-Filter is infused with silver.

The full product description, illustrations and use instructions are available at: www.villagewaterfilters.org.

Product specifications[a]

	Water quality conditions	Suitable for all water quality conditions
	Fail-safe/indicator of treatment complete	None
	Maintenance and lifespan	Backflushing of VF100 is necessary on a regular basis to increase flow; the VF200 prefilter sponge can be washed out by opening the casing Reusable VF100 estimated lifespan of 7 years; VF200 Pre-Filter estimated lifespan of 4 years
	Integrated safe container/residual protection	None
	Energy requirements	None
	Countries where sold/distributed	Global, in over 70 countries
	Estimated annual production (no. of units)	200 000

Product evaluation

Evaluation of the VF100 Home Filter plus VF200 Pre-Filter comprised a desk review of existing data and an abbreviated laboratory test aimed at evaluating the device's seal integrity. This abbreviated testing procedure allows for verification of the filter's sealing mechanisms that prevent untreated water from bypassing the filtration media. The laboratory test followed the requirements of the *Testing protocol for filtration technologies – version 3.2 (4)*, and investigated the ability of the device to reduce bacteria and viruses in GTW.

[a] Based on information provided by the manufacturer.

A.2 Ceramic filtration

Ceramic filtration removes microorganisms physically from water by a combination of size exclusion and adsorption. The ceramic filter matrix comprises clay and combustible material such as rice husks or sawdust that provide a porous structure through which water is filtered under gravity. The filters are often impregnated or coated with bacteriostatic agents such as colloidal or nanoparticles of silver or copper. Pore size and quality of manufacturing are key determinants of the performance of ceramic filters; they are typically not effective against smaller microorganisms such as viruses. Ceramic filters are commonly available as pots and candles, although discs are also available.

Table A.2 provides an overview of the microbial performance, limitations and advantages of ceramic filtration for HWT.

Table A.2. Selected properties of ceramic filtration for HWT

Microbial performance	• Effective against most bacteria and protozoa • Limited effectiveness against viruses[a]
Key factors affecting efficacy	• Filter media and pore size • Quality of manufacturing • Flow rate
Advantages	• Minimal likelihood of recontamination when held in an integrated safe storage container • Appearance of treated water is improved, providing a visual indicator that reinforces the benefits of treatment • Minimal change in taste of water • Simple to use • No power source required • Possibility of local production may benefit the economy and allow easy supply • Low relative cost per litre of water treated
Limitations	• Variability in quality of locally produced filters • Fragile and difficult to transport over long distances • Filters and receptacles need to be cleaned regularly • Flow rate is low at 1–3 L/hour (slower in turbid waters)
Application	Most appropriate where: • the pathogen of concern is known (e.g. *Cryptosporidium*), as ceramic filtration does not provide protection against enteric viruses • there is capacity and proven quality ceramic filter production

[a] Because of this limitation, products based on ceramic filtration alone are unlikely to achieve a performance classification higher than one star (★).

Sources: see *(2, 3)*.

Katadyn Rapidyn Water Filter Kit

Katadyn Rapidyn Water Filter Kit.
© Katadyn Products Inc.

Manufacturer: **Katadyn Products Inc.**

Manufacturer location: **Switzerland**

Treatment technology: **Ceramic candle filtration**

Product description[a]

The Katadyn Rapidyn Water Filter Kit is a gravity-fed ceramic filtration device. The assembled filter set comprises two 10 L buckets stacked on top of each other. These buckets serve as receptacles for raw and filtered water. The filter cartridge is screwed to the bottom of the raw water bucket. Water is filtered through the cartridge under gravity into the clean water bucket. The estimated flow rate when the filter is new is up to 3 L/hour, with non-turbid water.

The full product description, illustrations and use instructions are available at: www.katadyngroup.com.

Product specifications[a]

	Water quality conditions	Suitable for all water quality conditions
	Fail-safe/indicator of treatment complete	Includes a plastic tool to measure the diameter of the candle; once the plastic gauge fits around the thinnest part of the candle, the candle must be replaced
	Maintenance and lifespan	Depending on the water quality, the filter candle should be cleaned weekly with the abrasive cleaning paper provided Reusable Estimated lifespan of up to 2 years One filter treats up to 20 000 L, depending on the untreated water turbidity
	Integrated safe container/residual protection	Yes
	Energy requirements	None
	Countries where sold/distributed	Through the Katadyn sales offices and distributions partners in over 50 countries worldwide
	Estimated annual production (no. of units)	100 000

Product evaluation

Evaluation of the Katadyn Rapidyn Water Filter Kit followed the requirements of the *Testing protocol for filtration technologies – version 3.2 (4)*, and investigated the ability of the device to reduce bacteria and viruses in GTW and CTW. Reduction of protozoa was assigned based on the mean bacterial reduction achieved.

[a] Based on information provided by the manufacturer.

MINCH Household Water Filter

MINCH Household Water Filter.
© Desert Rose Consultancy PLC.

Manufacturer: **Desert Rose Consultancy PLC**

Manufacturer location: **Ethiopia**

Treatment technology: **Sand and diatomaceous earth filtration**

Product description[a]

The MINCH Household Water Filter is a size exclusion filter employing sand and diatomaceous earth for removal of microbial pathogens. The assembled filter comprises a metallic container with a sand and diatomaceous earth cartridge, and a spigot at the bottom of the container. Water is filtered through the cartridge under gravity to the bottom of the container.

The full product description, illustrations and use instructions are available at: www.minchfilter.com.

Product specifications[a]

	Water quality conditions	Suitable for all water quality conditions
	Fail-safe/indicator of treatment complete	None
	Maintenance and lifespan	The top vessel should be filled with a small amount of water, and the filter surface wiped with a cloth or sponge weekly; repeat as necessary to restore flow Reusable Estimated lifespan of up to 2 years for slightly turbid water
	Integrated safe container/residual protection	Yes
	Energy requirements	None
	Countries where sold/distributed	Ethiopia
	Estimated annual production (no. of units)	1 000

Product evaluation

Evaluation of the MINCH Household Water Filter followed the requirements of the *Testing protocol for filtration technologies – version 3.2 (4)*, and investigated the ability of the device to reduce bacteria and viruses in GTW and CTW. Reduction of protozoa was assigned based on the mean bacterial reduction achieved.

[a] Based on information provided by the manufacturer.

A.3 Ultraviolet disinfection

Ultraviolet (UV) irradiation inactivates microorganisms by damaging their intracellular proteins and nucleic acids, thus impairing their cell binding ability and/or ability to replicate.

The effectiveness of UV disinfection depends on the delivered fluence/dose, which is based on intensity and exposure time. UV disinfection is most effective at UVC wavelengths (200–280 nm). Most household or small-scale water treatment technologies employ low-pressure lamps that emit UV radiation at 254 nm. Typically, these technologies allow water in a vessel or in flow-through reactors to be exposed to UV radiation from UV lamps at sufficient fluence/dose to inactivate waterborne pathogens.

Table A.3 provides an overview of the microbial performance, limitations and advantages of UV technologies for HWT.

Table A.3. Selected properties of UV disinfection for HWT

Microbial performance	• Effective against bacteria, some viruses (depending on the type of UV lamp[a]) and protozoa
Key factors affecting efficacy	• Turbidity or suspended matter (measured as transmittance or absorbance) • Lamp power • Flow rate/contact time
Advantages	• Simple to use • Minimal change in water taste
Limitations	• Need to pretreat waters of higher turbidity (e.g. > 30 nephelometric turbidity units (NTUs)) by filtration or flocculation • Does not provide residual protection against recontamination unless the treated water is safely stored • Often requires a power source and a clean UV lamp to operate effectively • High relative cost per litre of water treated
Application	Most appropriate where: • water is of low turbidity • electricity or another power source is available

[a] Medium-pressure UV is more effective than low-pressure UV in activating resistant viruses *(5, 6)*.

Sources: see *(2, 3, 7)*.

Drop2Drink Unit

Manufacturer: **D2D Water Solutions B.V.**

Manufacturer location: **Kingdom of the Netherlands**

Treatment technology: **Multistage membrane microfiltration and ultrafiltration, and UV disinfection**

Drop2Drink Unit combines membrane filtration and UV disinfection.
© D2D Water Solutions B.V.

Product description[a]

The Drop2Drink Unit uses a combination of multistage filtration and UV disinfection for removal of microbial pathogens. The assembled unit comprises a microfilter, an active carbon filter, an ultrafilter membrane, a UVC disinfection chamber and an electric pump. The device is intended to treat rainwater. To operate, the device is connected to a rainwater harvesting system and electric power, and the pump draws the water through the multistage filters and UVC chamber.

The full product description, Illustrations and use instructions are available at: www.d2dwatersolutions.com.

Product specifications[a]

Water quality conditions	Suitable for all water quality conditions
Fail-safe/indicator of treatment complete	Yes, includes an integrated membrane integrity check
Maintenance and lifespan	Automatic forward and backflush 5 year warranty on the membrane ultrafilter
Integrated safe container/residual protection	None
Energy requirements	Operated via 230 V AC electricity supply; 40 W consumption
Countries where sold/distributed	Austria, Belgium, Bulgaria, Caribbean, Czechia, Ireland, Italy, Netherlands (Kingdom of the), Slovakia, Spain and United Kingdom
Estimated annual production (no. of units)	75 in 2021, 200 in 2022 and 500 in 2023

Product evaluation

Evaluation of the Drop2Drink Unit followed the requirements of the *Testing protocol for UV technologies (with or without filtration) – version 3.1 (8)*, and investigated the ability of the device to reduce bacteria and viruses in GTW and CTW. Reduction of protozoa was assigned based on the mean bacterial reduction achieved.

[a] Based on information provided by the manufacturer.

Solageo Better Water Maker

Solageo Better Water Maker is a handheld UV water treatment device.
© Trade Without Borders (HK) Limited

Manufacturer: **Trade Without Borders (HK) Limited**

Manufacturer location: **China, Hong Kong Special Administrative Region**

Treatment technology: **UV disinfection**

Product description[a]

The Solageo Better Water Maker is a handheld UV water treatment device. It comprises a low-pressure UV lamp with a pump, stainless steel mesh and plastic filter, and a carbon cartridge filter. To operate, the device is submerged in a vessel containing the water to be treated, connected to a power supply, and the pump draws the water up through the filters and along the UV lamp. The Solageo Better Water Maker can be powered manually using an integrated hand crank, or connected to electrical power or a solar-charged battery.

The full product description, illustrations and use instructions are available at: www.b9plastics.org.

Product specifications[a]

	Water quality conditions	Suitable for all water quality conditions
	Fail-safe/indicator of treatment complete	None
	Maintenance and lifespan	Replaceable carbon cartridge: estimated lifespan of 18–24 months UV lamp: estimated lifespan of over 10 000 hours
	Integrated safe container/residual protection	None
	Energy requirements	Can be operated via a 12 V DC electricity supply from a hand crank, solar-charged battery or AC/DC adaptor
	Countries where sold/distributed	Global
	Estimated annual production (no. of units)	6 000

Product evaluation

Evaluation of the Solageo Better Water Maker followed the requirements of the *UV technologies (with or without filtration) – version 3.1 (8)*, and investigated the ability of the device to reduce bacteria and viruses in GTW and CTW. Reduction of protozoa was assigned based on the mean bacterial reduction achieved.

[a] Based on information provided by the manufacturer.

A.4 Solar disinfection

Solar disinfection inactivates microorganisms through a combination of UV irradiation, visible light radiation and heat. The UV irradiation damages nucleic acids, thus impairing their ability to replicate. Meanwhile, photosensitive molecules in the water absorb the visible light, resulting in oxidative activities that damage cell structures. The exposure to sunlight also results in temperature increases that denature proteins within the microorganisms and/or cause oxidative damage associated with dissolved oxygen products and heat. The effectiveness of solar disinfection depends on the Sun's intensity, which is affected by weather conditions and geographical location. Solar disinfection is most effective in tropical or subtropical regions of up to 35° latitude.

A variety of solar disinfection technologies are available, including: dark/opaque containers that rely on heat from the Sun to disinfect water; clear polyethylene terephthalate containers that rely on the combined action of UV radiation, oxidative activity associated with dissolved oxygen and heat; or combinations of these effects in other types of containers, such as UV-penetrable bags and panels.

An important aspect in solar disinfection is an indicator to provide feedback on the process and signal when sufficient sunlight has been received for effective disinfection.

Table A.4 provides an overview of the microbial performance, limitations and advantages of solar technologies for HWT.

Table A.4. Selected properties of solar disinfection for HWT

Microbial performance	• Effective against bacteria, viruses and protozoa
Key factors affecting efficacy	• Weather conditions • Type of container material • Water quality matrix, including turbidity
Advantages	• Minimal likelihood of recontamination when held in a disinfecting container • Simple to use • Low relative cost per litre of water treated • Little to no maintenance • Minimal change in water taste
Limitations	• Need to pretreat waters of high turbidity (e.g. > 30 NTUs) by filtration or flocculation • Volume to treat is dependent on the availability of clean, intact containers • The time needed to treat water is relatively long and varies depending on the intensity of the Sun (approximately 6 hours under 50% cloudy sky) • Containers must be placed where they will be exposed to sunlight and not disturbed (e.g. on a roof) • May not have a visual indicator to indicate treatment is complete
Application	Most appropriate where: • water is of low turbidity • there is sufficient solar radiation – between 35° N and 35° S latitude • clean, transparent and intact containers for treatment are available

Sources: see *(2, 3)*.

SaWa

Manufacturer: **4Life Solutions ApS**

Manufacturer location: **Denmark**

Treatment technology: **Solar disinfection**

Product description[a]

The SaWa is a solar disinfection bag comprising a 4 L multilayered polymer foil pouch. When exposed to sunlight for 4 hours, microbial contaminants in the water are inactivated through a combination of photo-induced reactive oxygen species, thermal and direct UV processes.

The full description, illustrations and instructions are available at: www.4lifesolutions.com.

Product specifications[a]

	**Water quality conditions**	Should not be used where turbidity is higher than 30 NTUs
	**Fail-safe/indicator of treatment complete**	Includes an integrated visual turbidity indicator
	**Time to treat**	4 hours exposure in direct sunlight before consumption
	**Maintenance and lifespan**	If visual sediments occur, the bag should be cleaned by flushing it with clean water Estimated lifespan of 500 cycles or 2 000 L of water
	**Integrated safe container/residual protection**	Yes
	**Energy requirements**	Direct sunlight
	**Countries where sold/distributed**	Ghana, India, Kenya, Nigeria, South Sudan, Uganda and United Republic of Tanzania,
	**Estimated annual production (no. of units)**	500 000

Product evaluation

Evaluation of the SaWa was based on the testing protocol for *Solar disinfection batch systems (with or without pre-filtration and/or disinfection addition) – version 3.0 (9)*, and investigated the ability of the device to reduce bacteria, viruses and protozoa in GTW and CTW.

[a] Based on information provided by the manufacturer.

A.5 Flocculation–disinfection

Flocculants–disinfectants employ a multibarrier approach to water treatment. The coagulant–flocculant (e.g. iron or aluminium salts) aggregates suspended particles and larger microorganisms such as protozoa to form flocs, which are removed by subsequent sedimentation. The disinfectant (e.g. calcium hypochlorite or sodium dichloroisocyanurate) inactivates the smaller microorganisms such as bacteria and viruses through oxidative processes that degrade their biochemical building blocks and disrupt vital cell functions.

Flocculants–disinfectants are commonly available as powders, although some are available in tablet form.

Table A.5 provides an overview of the microbial performance, limitations and advantages of flocculation–disinfection for HWT.

Table A.5. Selected properties of flocculation–disinfection for HWT

Microbial performance	• Effective against bacteria, viruses and protozoa
Key factors affecting efficacy	• Contact time • Mixing conditions
Advantages	• Residual protection against recontamination • Visual improvement in treated water • Reduction of some heavy metals (e.g. arsenic) and particle-associated pesticides • Portable: lightweight, easily packaged and easy to transport in emergencies
Limitations	• Multiple steps required • High relative cost per litre of water treated • Potential user taste and odour objections
Application	Most appropriate where: • water is of relatively high turbidity

Sources: see *(2, 3)*.

Bishan Gari Water Purifier

Manufacturer: **Bishan Gari Purification Industries, PLC**

Manufacturer location: **Ethiopia**

Treatment technology: **Flocculation–disinfection**

Product description[a]

The Bishan Gari Water Purifier is a combined flocculant–disinfectant powder containing aluminium sulfate, ferric sulfate and calcium hypochlorite. The aluminium sulfate and ferric sulfate act as coagulating and flocculating agents that aggregate particulates and some of the microorganisms suspended in water. The resulting floccules sediment at the bottom of the water vessel, and the calcium hypochlorite acts as a disinfectant. The product is available as 2.1 g and 2.2 g sachets that can each treat 20 L of water.

The full product description, illustrations and use instructions are available at: www.bgpigroup.com.

Product specifications[a]

	**Water quality conditions**	Can be used to treat turbid water
	**Fail-safe/indicator of treatment complete**	None
	**Time to treat**	Wait time of 25 minutes prior to consumption
	**Maintenance and lifespan**	No maintenance required Consumable
	**Integrated safe container/residual protection**	Yes
	**Energy requirements**	None
	**Countries where sold/distributed**	Not provided
	**Estimated annual production (no. of units)**	Not provided

Product evaluation

Evaluation of the Bishan Gari Water Purifier followed the requirements of the testing protocol for *Chlorine chemical disinfectant technology – version 3.2 (10)* and the testing protocol for *Chemical coagulation and flocculation technology for performance against protozoa microbial group only – version 3.0 (11)*, and investigated its ability to reduce bacteria, viruses and protozoa in GTW and CTW. Free residual and total chlorine concentrations were collected and analysed in posttreatment samples.

[a] Based on information provided by the manufacturer.

Puribag

Puribag combines flocculation-disinfection and filtration.
© PRAQUA PTY LTD

Manufacturer: **PRAQUA PTY LTD**

Manufacturer location: **Australia**

Treatment technology: **Flocculation–disinfection and carbon filtration**

Product description[a]

The Puribag is a 10 L flatpack that combines flocculation–disinfection and filtration using sachets of P&G™ Purifier of Water, and an activated carbon filter. Each complete Puribag system includes sachets of the flocculant–disinfectant, each treating 10 L. The P&G™ Purifier of Water contains ferric sulfate and calcium hypochlorite. Ferric sulfate acts as a coagulant and flocculant by aggregating suspended particulates and some microorganisms in water; calcium hypochlorite acts as a disinfectant. The resulting floccules sediment at the tapered bottom of the bag, and can be removed through a lock and twist process. The activated carbon filter at the dispensing outlet removes the chlorine taste and odour following the disinfection step.

The full product description, illustrations and use instructions are available at: www.puribagwater.com.

Product specifications[a]

	Water quality conditions	Suitable for all water quality conditions, except brackish/saline water
	Fail-safe/indicator of treatment complete	None
	Time to treat	30 minutes contact time before consumption
	Maintenance and lifespan	Replace carbon filter after 150 L of treatment Single-use sachets with a shelf life of 3 years The bag is reusable and needs replacing only if damaged
	Integrated safe container/residual protection	Yes
	Energy requirements	None
	Countries where sold/distributed	Not provided
	Estimated annual production (no. of units)	150 000

Product evaluation

Evaluation of the Puribag was based on a desk review of existing data on performance against bacteria, viruses and protozoa, and followed the requirements of the testing protocol for *Chlorine chemical disinfectant technology – version 3.2 (10)* and the testing protocol for *Chemical coagulation and flocculation technology for performance against protozoa microbial group only – version 3.0 (11)*. The P&G™ Purifier of Water comprising the flocculant–disinfectant component of the product was previously evaluated in Round I of the Scheme, where it met two-star performance targets for bacteria, viruses and protozoa *(12)*.

[a] Based on information provided by the manufacturer.

WaterMaker Plus Water Purification Sachets

WaterMaker Plus Water Purification Sachets.
© Control Chemicals (Pty) Ltd

Manufacturer: **Control Chemicals (Pty) Ltd**

Manufacturer location: **South Africa**

Treatment technology: **Flocculation–disinfection**

Product description[a]

The WaterMaker is a combined flocculant–disinfectant powder containing aluminium sulfate and sodium dichloroisocyanurate. The aluminium sulfate acts as a coagulating and flocculating agent that aggregates particulates and some of the microorganisms suspended in water. The resulting floccules sediment at the bottom of the water vessel, and the sodium dichloroisocyanurate acts as a disinfectant. The product is available as 2.5 g and 5.0 g sachets that can each treat 10 L and 20 L of water, respectively.

The full product description, illustrations and use instructions are available at: www.watermakersachets.com.

Product specifications[a]

	Water quality conditions	Can be used to treat all water types, including turbid water
	Fail-safe/indicator of treatment complete	None
	Time to treat	Wait time of 15 minutes prior to consumption
	Maintenance and lifespan	No maintenance required Consumable
	Integrated safe container/residual protection	Yes
	Energy requirements	None
	Countries where sold/distributed	Not provided
	Estimated annual production (no. of units)	30 000 000–60 000 000

Product evaluation

Evaluation of the WaterMaker followed the requirements of the testing protocol for *Chlorine chemical disinfectant technology – version 3.2 (10)* and the testing protocol for *Chemical coagulation and flocculation technology for performance against protozoa microbial group only – version 3.0 (11)*, and investigated its ability to reduce bacteria, viruses and protozoa in GTW and CTW. Free residual and total chlorine concentrations were collected and analysed in posttreatment samples.

[a] Based on information provided by the manufacturer.

A.6 Chemical disinfection

Chemical disinfectants inactivate microorganisms by oxidizing their biochemical building blocks and disrupting vital cell functions. Chlorine is the most commonly used chemical disinfectant for drinking-water, although oxidants such as bromine, iodine and peroxide are also available.

The efficacy of chemical disinfectants depends on how reactive they are against specific microorganisms, the concentration/dose delivered, the contact time, and water quality characteristics such as pH, oxidant demand and temperature. For example, chlorine is ineffective against microorganisms with strong cell walls, such as *Cryptosporidium* oocysts and some bacterial spores. In addition, chlorine reacts rapidly with organic and inorganic compounds in water, which exert a demand on the chlorine, affecting the concentration available for microbial disinfection *(13)*.

For treatment at the household level, chlorine is generally available in liquid form as hypochlorous acid (commercial household bleach or more dilute sodium hypochlorite solution) or in dry form as calcium hypochlorite or sodium dichloroisocyanurate.

Table A.6 provides an overview of the microbial performance, limitations and advantages of chlorine products for HWT.

Table A.6. Selected properties of chemical disinfection for HWT

Microbial performance	• Effective against viruses and bacteria • Ineffective against protozoan cysts such as *Cryptosporidium*[a]
Key factors affecting efficacy	• Organic content and turbidity • Free chlorine concentration • Contact time
Advantages	• Residual protection against recontamination • Simple to use • Local production may benefit the economy • Low cost • Portable: lightweight, easily packaged and easy to transport in emergencies
Limitations	• Less effective in organic and inorganic-rich or turbid waters[b] • Users may object to taste and odour • Need to adjust dosing to meet variable chlorine demand in water • Need to ensure quality control of locally manufactured chlorine
Application	Most appropriate where: • the pathogen of concern is known (e.g. *Vibrio cholerae*), as chlorine does not provide protection against some protozoa • water is of relatively low turbidity and organic content

[a] Products based on simple chlorination alone are therefore unlikely to achieve a performance classification higher than one star (★).

[b] High levels of organic material in water can react with chlorine to form potentially hazardous disinfection by-products. However, the health risks from these by-products at the levels at which they occur in drinking-water are relatively small in comparison with the risks associated with inadequate disinfection. As such, disinfection should not be compromised in attempting to control such by-products *(14)*.

Sources: see *(2, 3, 15)*.

Xinix AquaCare

Manufacturer: **Xinix International AB**[a]

Manufacturer location: **Sweden**

Treatment technology: **Chlorine disinfection**

Product description[b]

Xinix AquaCare is a stabilized chlorine dioxide solution. The product is available in bottles of 50–200 mL and 300 mL. One capful of the disinfectant liquid treats between 10 and 12.5 L of water.

The full product description, illustrations and use instructions are available at: www.xinix.se.

Product specifications[b]

	**Water quality conditions**	Not provided
	**Fail-safe/indicator of treatment complete**	None
	**Time to treat**	Wait time of 2 minutes prior to consumption
	**Maintenance and lifespan**	No maintenance required Consumable
	**Integrated safe container/residual protection**	None
	**Energy requirements**	None
	**Countries where sold/distributed**	Not provided
	**Estimated annual production (no. of units)**	Not provided

Product evaluation

Evaluation of Xinix AquaCare followed the requirements of the testing protocol for *Chlorine chemical disinfectant technology – version 4.1 (16)*, and investigated its ability to reduce bacteria and viruses in GTW and CTW. Free residual and total chlorine concentrations were collected and analysed in posttreatment samples.

[a] Now known as Xinix Global AB.
[b] Based on information provided by the manufacturer.

Biox Aqua 20

Manufacturer: **Scotmas Ltd**

Manufacturer location: **United Kingdom of Great Britain and Northern**

Treatment technology: **Chlorine disinfection**

Product description[a]

Biox Aqua 20 is a tablet that generates chlorine dioxide. The tablet ingredients react when added to water to form chlorine dioxide in situ, which acts as a disinfectant to inactivate microorganisms. The use instructions indicate to filter water through a "filter, t-shirt, or fine weave fabric" prior to adding one tablet to 20 L of water. The water can be consumed after 4 hours.

The full description, illustrations and instructions are available at: www.scotmas.com.

Product specifications[a]

	**Water quality conditions**	Can be used to treat turbid water
	**Fail-safe/indicator of treatment complete**	None
	**Time to treat**	4 hours
	**Maintenance and lifespan**	Consumable No maintenance required
	**Integrated safe container/residual protection**	Chlorine dioxide residual
	**Energy requirements**	None
	**Countries where sold/distributed**	Not provided
	**Estimated annual production (no. of units)**	Not provided

Product evaluation

Evaluation of the Biox Aqua 20 was based on the testing protocol for *Chlorine chemical disinfectant technology – version 4.1 (16)*, and investigated its ability to reduce bacteria and viruses in GTW and CTW. The concentration of chlorine dioxide delivered in deionized water with no oxidant demand was measured.

[a] Based on information provided by the manufacturer.

Germisep 0.5 g

A container of Germisep NaDCC tablets.
© Hovid Berhad

Manufacturer: **Hovid Berhad**

Manufacturer location: **Malaysia**

Treatment technology: **Chlorine disinfection**

Product description[a]

Germisep 0.5 g is a tablet containing sodium dichloroisocyanurate. The tablets effervesce in drinking-water to release free chlorine in the form of hypochlorous acid, which acts as a disinfectant. The product is available as 0.5 g tablets that can treat 80 L of high-quality water at a target dose of 4 mg/L free chlorine.

The full description, illustrations and instructions are available at: www.germisep.com.

Product specifications[a]

Water quality conditions	Usage is dependent on water quality Treatment by one 0.5 g tablet limited to 15 L for poor-quality heavily contaminated source water as compared to one 0.5 g tablet for 80 L in high-quality source water
Fail-safe/indicator of treatment complete	None
Time to treat	10 minutes
Maintenance and lifespan	Not applicable
Integrated safe container/residual protection	Free chlorine residual from sodium dichloroisocyanurate
Energy requirements	Not applicable
Countries where sold/distributed	Malaysia
Estimated annual production (no. of units)	>15 000 000 tablets

Product evaluation

Evaluation of the Germisep 0.5 g was based on the testing protocol for *Chlorine chemical disinfectant technology – version 4.1 (16)*, and investigated its ability to reduce bacteria and viruses in GTW and CTW. Free residual and total chlorine concentrations were collected and analysed in posttreatment samples.

[a] Based on information provided by the manufacturer.

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