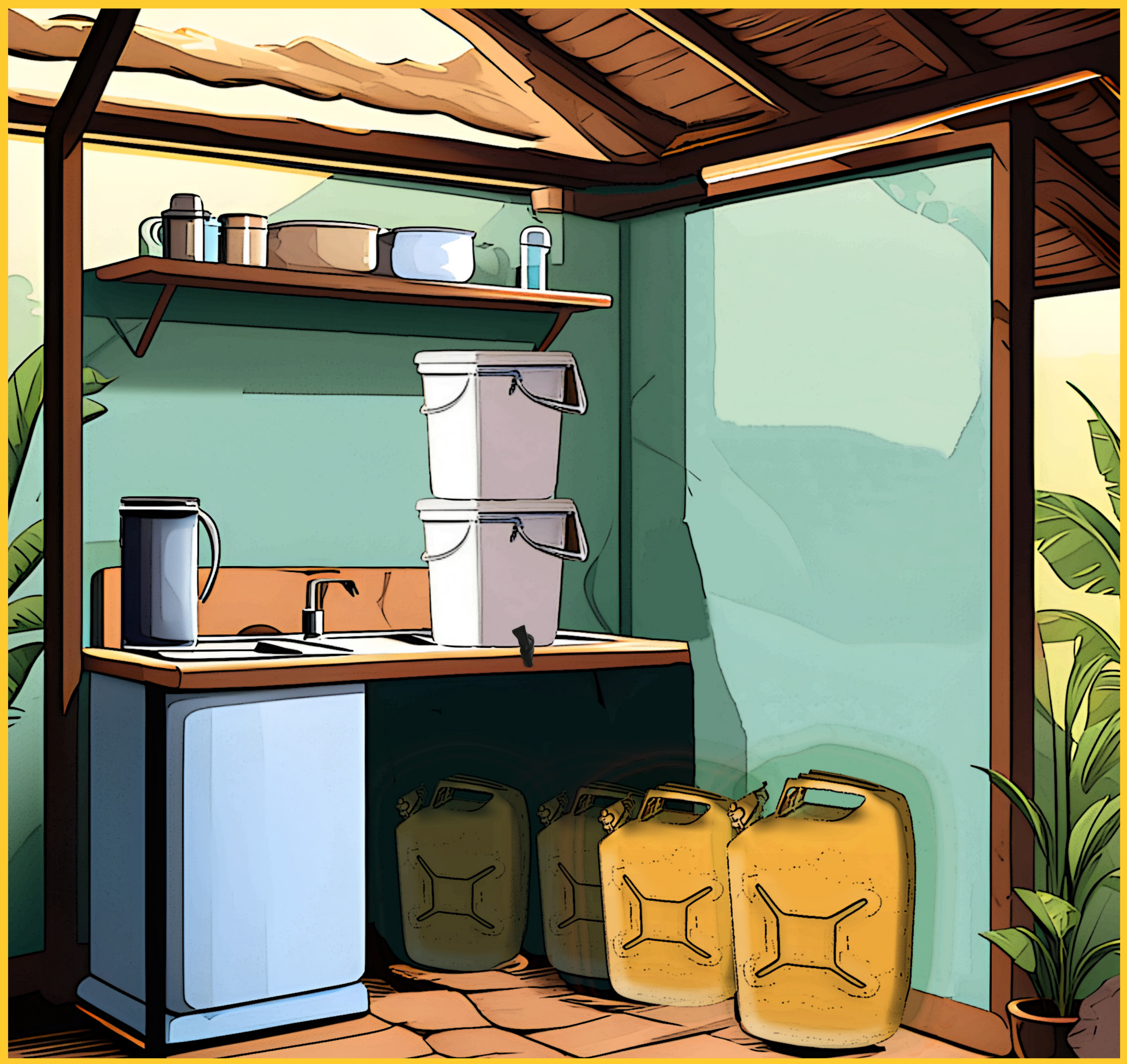
Selecting household water filters in emergencies

a manual for field evaluation



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RANAS SPIN-OFF of Eawag
We Understand Behaviour Change

Selecting household water filters in emergencies

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Second Edition, 2023

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Content

Background and target audience

Household water treatment and safe storage (HWTS) devices are an essential intervention within humanitarian emergencies to improve the quality of drinking water and achieve health impact. However, despite demonstrating technical efficacy under laboratory settings, evidence that HWTS products are used correctly and consistently in emergency settings and therewith perform satisfactorily is limited. To increase the ability of Humanitarian Agencies to make informed choices about the procurement and distribution of household water filters in emergencies, and motivate producers to improve the design, Humanitarian Innovation Fund (HIF) initiated the project on evaluation of household filters in emergencies in 2017. During that project, we have developed and applied an extensive field methodology for testing household filters in emergencies. The methodology developed addressed the technical performance of the filters, ease of use, acceptance and applicability aspects. The elements of the methodology proved to be essential for evaluation of the household filters in the field and have been used by other manufacturers and implementers beyond the project partners to evaluate their products. The feedback by different stakeholders showed a high need for a concise, simple and affordable methodology for evaluation of household filters in the field by the non-scientific community. The evaluation in the field is required to assure the products perform according to their specifications, are accepted, can be operated and maintained by users and can be implemented in the required context. This manual is developed based on our experiences, those of other organisations implementing household filters in the field, and published HWTS evaluation studies.

The manual is meant for a non-scientific audience interested to apply and evaluate household water filters in the field in resource-limited settings. This includes non-governmental and public implementing organisations distributing filters in emergency contexts and manufacturers developing or optimizing products. Although the manual is designed with an emergency context in mind, it can be used also in non-emergency settings. In essence, the methodology can be applied to other household water treatment and safe storage (HWTS) interventions besides filters.

This manual represents the second edition, revised in 2023 to integrate hands-on field experiences gathered from past projects. The methodology has been updated to reflect these insights. The major changes include expanding the focus beyond filters addressing microbial contamination to include Reverse Osmosis filters, providing a more comprehensive overview of the different design features of the filters, and updating the methods.

Objectives

This manual offers a modular guideline for the field evaluation of household water filters using our established methodology. Our approach encompasses various methods to assess both technical and non-technical factors, including the technical performance of the filters, ease of assembly, operation, and maintenance, user acceptance and behavior change, as well as applicability and feasibility for emergency response. It serves as a valuable tool for designing studies focused on testing new products or evaluating existing ones that have been in use for an extended period. Additionally, the manual can be utilized during team training sessions. While it can aid in the development of project proposals or documentation, it does not provide specific guidance on these aspects. The evaluation of a filter can be conducted individually, compared to another filter, or against multiple products to address key questions such as:

- Which filter is best adapted?
- Is the filter suitable for our context?
- How does this filter perform, and is it accepted by users?

Moreover, when manufacturers or developers are engaged, they can explore how to optimize the filter to more effectively meet the requirements and context of the implementer.

Structure

The methodology is built in a modular way, providing the flexibility for the implementer to design their own study by combining methods from different groups.

Part 1

introduces and describes a general study set-up. It provides an overview of the different modules and summarizes major considerations during the implementation of the study and analysis of the results. Finally, it proposes and discusses the decision process.

Part 2

comprises information sheets for each method, offering a concise overview, outlining major steps and considerations, and proposing approaches to present and visualize the collected data. These sheets are categorized into five color-coded sections for easy reference.

- S Filter and context pre-evaluation
- L Logistics and preparation
- D Distribution, user information and training
- T Technical performance evaluation
- U User acceptance evaluation

Detailed protocols and questionnaires can be utilized as-is or modified to better suit the local context.

How to use the manual

The process for designing and implementing the study using the manual involves several key steps:

Initiation Step:	• Evaluate and define the objectives of the study, including the questions to address and the filters to evaluate. • Consider the suitability of the context and assess the needs of the population. • Section S of the manual provides support for this process.
Preparation Step:	• Customize the methodology using the template provided in Part 1 of the manual. Select methods that best address the defined questions and assess your capacity to implement them. • Set up a workplan, ensure delivery of filters and materials, obtain necessary authorizations, and address ethical considerations before conducting the study. Section L of the manual addresses logistics, training, and authorization. • Review and adapt protocols for the selected methods, and train the team accordingly. Summaries of methods are provided in sections T, D, and U of the manual.
Implementation Step:	• Use the methodology and the manual as a reference document during team training and implementation to address questions and ensure adherence to protocols.
Data Analysis and Results:	• Once data is collected, use the manual to review objectives and analyze the data to inform decision-making processes. Part 1 of the manual supports this process.

PART 1 Study design, planning and implementation

Part 1 of the manual offers an overview and outlines key considerations regarding the main objectives and research questions, as well as the major phases and milestones of the study implementation. It delineates the boundaries and provides guidance on results-based decision-making, elucidating how the findings can inform the selection of filters and their applicability in particular contexts. This section encompasses the following information sheets:

Study questions	Discusses the questions the study should answer
Study phases	Provides the overview of the study design
Study implementation	Provides flowchart with major milestones and limitations during implementation
Study results and results-based decision-making	Provides suggestions on how to analyse the results and use them in decision making process

Initiation step: study questions

The initiation step involves precisely defining the question that the study aims to address. Three primary questions are identified, each potentially requiring distinct study designs:

- Which filter is best adapted?
- Is the filter suitable for our context?
- How does this filter perform and is it accepted by users?

Information sheets S1, S2, and S3 in Part 2 offer detailed insights into each question. Table 1 provides a summary of the questions, major considerations, and references to the relevant information sheet. Additionally, you can formulate your questions and devise a procedure to select the suitable context and products for evaluation.

Table 1 Study questions and major considerations

Study question	Is the filter defined?	Considerations	Information sheet
A. Which filter is best adapted?	Yes	In the evaluation process, multiple filters, already pre-selected by the implementer, are to be assessed. The initial step involves assessing the feasibility of the filters for the given context. At this stage, the filters may not be known and need to be identified and selected.	S2
	No	The implementer might have a preference for a particular type of filter, or may need to decide to test different filters to identify the product that best addresses user needs in a specific context from the available options. This selection process plays a critical role in determining the success and effectiveness of the filtration system within the designated environment.	S1
B. Is the filter suitable for our context?	Yes	In this scenario, the evaluation focuses on a single filter within a specific context, emphasizing both technical performance and user acceptance within the defined settings. The evaluation does not involve comparative elements; rather, its results are intended to guide product adaptation to meet user requirements or to support large-scale implementation and supply chain development.	S2
	No	In cases where the filter is not yet known and must be identified and selected, evaluating multiple filters, whenever feasible, can offer additional insights. Providing users with a choice of filters has the potential to improve acceptance and satisfaction, potentially leading to more favorable outcomes in terms of adoption and effectiveness.	S1
C. How does this filter perform and is it accepted by users?	Yes	The evaluation of the filter can take place in one or multiple contexts, each chosen based on the intended use of the filter. The study may be designed as a comparative analysis involving two or more different contexts, or it may be implemented in a single context only. In the latter scenario, the transferability of the results to other contexts may be limited, potentially affecting the generalizability of the findings.	S3

The output of this step involves defining the primary research question for the study, as well as selecting the filters to be evaluated and determining the study context.

Study phases

Once the initiation step is done and questions to answer are defined, each filter study requires preparation. The preparation phase is followed by the four major study phases summarized in Table 2.

Table 2 Study phases and their considerations

Phase	Objectives and considerations	Information Sheets
Preparation phase	Defines the study objectives, as well as evaluates suitability and safety of filters, addresses logistical considerations, ethical approval and provides practical information on setting up water quality monitoring and data management processes. Define potential timeline.	L1, L2, L3, L4, L5, L6
Baseline data collection	Baseline data collection is essential for the study to evaluate the situation before the project is implemented, and to understand users' perceptions and attitudes to the products before they collected experience in using them. The questions asked during the baseline overlap with the questions asked during the final data collection to enable comparison and estimation of the effects of the study on attitudes and perceptions of users regarding filters, but also general WASH situation. If the hygienic conditions are poor and the population is likely to reject household water filtration, the RANAS approach to behaviour change can be implemented to enable evidence-based development of behavior change interventions. The questionnaires relevant for RANAS can be integrated into the Baseline questionnaire.	U1, U3
Introduction visit	Filters are distributed and introduced to users during a household visit. The introduction visit includes non-participatory observation of users installing the filters and using them the first time without training. It is directly followed by training, basic technical monitoring and first reactions regarding acceptance and use experience. The baseline data collection and introduction can be combined when the population and contexts are well known to the implementers and the risk of baseline population not being suitable for the study objectives is low. When there is an intention to sell filters to users during the scale-up or subsequent implementation phases, a willingness to pay can be evaluated. This should not be done, if the distribution of filters is and will remain free of charge, i.e. in acute emergency contexts.	D1, D2, U4, U5, T1, T2, T3, T4, T5 U8, T6
Monitoring	The monitoring includes general technical monitoring, as well as user acceptance monitoring. One or multiple monitorings can be conducted. Short studies (10-12 weeks) would imply only one monitoring. Longer studies 3-12 month would require multiple monitoring visits (at least two visits). If multiple monitorings are done, consider that always the same technical measurements/sampling, as well as the same questionnaire to the same respondents, has to be used. Follow up training might be required during the monitoring visit, especially when operation and maintenance are perceived as complex or the filter damage or dropout rates are high. All trainings and additional information provided to users needs to be documented.	D2, U5, T1, T2, T3 ,T4, T5 T6
Final data collection	The final data collection is similar to the monitoring, however, an extended questionnaire list is used to collect more detailed information, as well as to repeat the questions asked during the baseline data collection and willingness to pay evaluation. Focus group discussion as well as co-design workshops could be useful tools to collect less structured and more detailed qualitative information through open-end discussions. If the results of the study are rather unexpected, Focus Group Discussions (FGDs) might help to identify the reasons. A Co-design workshop, where potential users and manufacturers discuss the design of the filter, is especially recommended when manufacturers have an intention to further optimize their products for the local context, or filters are partly produced locally (e.g. local housing is used). If this is not the case than a co-design workshop will raise expectations in users, which will not be addressed and should be skipped.	D3, U5, T1, T2, T3 ,T4, T5 T6, U6, U7, U8,

Figure 1 provides a summary of various study phases (initiation, preparation, and the four implementation phases) and method modules in a single schema. This schema can serve as a template for creating your final study design by placing the relevant method modules and adjusting the timeline. The upper part of the figure summarizes the modules typically required for a filter evaluation study, while the optional modules are presented below. The modules are organized based on their characteristics, such as technical performance evaluation, user perception, and training. The same structure is maintained in Part 2, which summarizes all information sheets for each module.

	3 - 6 months before Preperation
Filter and context pre-evaluation	S1 Selecting filters
	S2 Assesing feasibility of a filter
	S3 Selecting ermergency context
Logistics and study preperation	L1 Laboratory filter evaluation
	L2 Filter logistics
	L3 Selecting locations and users
	L4 Study approvals
	L5 Data management
	L6 Field lab management
	L7 Team training

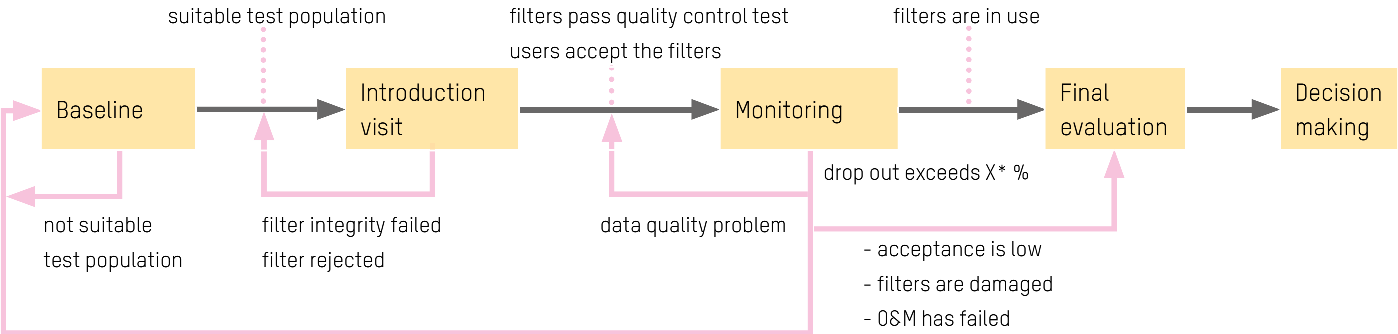
		week 1 - 3 Baseline	week 1 - 3 Introduction visit	week 5 - 6 Monitoring	week 10 - 12 Final Data collection
required	Distribution & user training		D1 Filter distribution		
			D2 User training	D2 User training	D3 Follow-up briefing
	User perceptions		U4 Non-participatory observation		
		U1 Baseline questionaire	U5 Monitoring Questionaire	U5 Monitoring Questionaire	U5 Monitoring Questionaire
					U9 Final data collection
	Technical performance		T1 Microbial water quality	T1 Microbial water quality	T1 Microbial water quality
			T2 Integrity	T2 Integrity	T2 Integrity
			T3 Flow rate	T3 Flow rate	T3 Flow rate
			T4 Use	T4 Use	T4 Use
			T5 Durability	T5 Durability	T5 Durability
optional	User perceptions	U3 RANAS	U8 Willingness to pay		U6 FDG
					U7 Co-design workshop
					U8 Willingness to pay
	Technical performance		T6 General water quality parameters	T6 General water quality parameters	T6 General water quality parameters

Study implementation

This manual does not address the project implementation steps in detail as we assume that most implementers have long experience in implementing projects, and the overall project management activities will be guided by standard organisational processes. The manual can be used for planning as supporting information to develop a budget, evaluate the needs and level of training of human resources or estimate the overall needs related to organisational logistics, etc.

As with any project, a filter evaluation study may encounter unforeseen challenges. It is crucial to establish clear "go/no-go" boundaries to determine situations where certain phases need to be repeated, redesigned, or if the entire study needs to be interrupted or stopped before completion to prevent wasted time and resources. Figure 2 illustrates the flow diagram, including possible loops. Each phase serves as a milestone, making it imperative to analyze collected data and convene milestone meetings to decide on the project's continuation as planned or to explore alternative approaches.

Figure 2 Decision flow during the study



* X is usually 20% or higher. This number should be agreed with partners in advance. The context leading to dropout can be taken into consideration too.

Table 3 provides a concise summary of the study phases along with the major risks that could impact them.

Table 3 Study phases and major risks

Phase	Risk	Description and clarification	Possible actions
Preparation	Filters fail the minimal requirements for safety or do not address user needs	• Filters fail the minimal requirements for water quality or water flow. Currently, we set it at Log removal value (LRV, measure of treatment efficiency, see L1) for bacteria in an integrity test is less than 2 and the filter can provide less than 20 L per day. However, the implementer can set their minimal values before the study. • Users might prioritize other water quality parameters beyond microbial contamination. When salinity of water is a problem, users might reject filters that do not address this problem, as most filters only address microbial contamination.	Evaluate another product, put the study on hold until manufacturer clears the problem
	Filters cannot be delivered (in time)	• Filters cannot be delivered to the location due to import bans, lack of required certificates, etc.	Select another location, delay the start or chose another produc if study objective allows it.

Phase	Risk	Description and clarification	Possible actions
Baseline	The population is not suitable for the study	The population can be considered as not suitable on different occasions. Few examples: • Users refuse to participate or sign consent forms, • Water is of good quality and there is no need for household filter, • Another organisation is implementing a WASH project addressing water quality issue directly or indirectly, • Users may prioritize water quality parameters beyond microbial contamination. For instance, in areas where water salinity poses a challenge, users may refuse filters that do not tackle this issue, especially considering that most filters primarily target microbial contamination.	Conduct rapid needs assessments in a few other locations and repeat the baseline in the most suitable location.
Introduction visit	Filter integrity test failed	Failed filter integrity in the field can be caused by multiple reasons and depend usually on the design of the filter. Common reasons include: • Leakage of the filter elements due to failed installation • Quality control issues at production • Damage of the filter elements during transport, storage or use	Identify and fix the problem. If possible – repeat the technical evaluation. If not – delay the filter distribution till troubleshooting is successful or chose another filter
Introduction visit and/or Monitoring	High drop out or filters are rejected by the users	User acceptance can be low when filters do not address the needs (too small, too complex, inappropriate design) or the expectations of the users regarding the product or the project in general. There might be concerns about leaking particles, taste and odour of water, flow rate, colour, or expectation to have tap water provided instead of the filter.	Organize a Focus group discussion to find out the causes with users and decide on the next steps together with the users.
Monitoring	Data quality is poor	Data collected is of poor quality meaning that there is missing data, water quality samples are out of range of detection (e.g. too many to count in most samples), or there is a concern regarding data fraud.	Ensure quality control procedures are in place, train staff and repeat monitoring.
	Filters are damaged or O&M is not conducted properly leading to health risks	This can happen when the filters are not robust and start to fail during the study. When more than 25 % of the filters fail for technical reasons, it might be important to evaluate the remaining regarding the risks to users, and finalize the study beforehand. If possible, provide users with alternative more robust product.	Proceed to final data collection on user acceptance and complete the study in advance
All phases		Populations evicted Deterioration of the security situation Allocation of resources into acute emergency response	Interruption or delay of the study

Study results and results-based decision-making

The results obtained from the study can be utilized in various ways to fulfil the primary objectives, typically encapsulated in one or more questions:

- √ **Which filter is best adapted?** - Comparative analysis of different filter models helps in determining the most suitable option based on performance and ease of use, user acceptance, and contextual factors.

- √ **Is the filter suitable for our context?** - Evaluation of filter performance within the specific context provides insights into its compatibility with local water quality, hygiene and infrastructure settings, user preferences and needs and implementers` constrains. Results indicating the filter's durability and robustness under varying environmental and operational conditions inform decisions regarding its suitability for emergency response scenarios.

- √ **How does this filter perform and is it accepted by users?** Evaluation of the filter's technical performance determines its effectiveness in removing contaminants and providing safe drinking water considering also post-contamination. Results from water quality tests and filter performance assessments are critical indicators of its functionality. Detailed analysis of filter performance data helps in identifying any deficiencies or limitations in the filter design or operation that need to be addressed. The study results provide insights into the usability (ease of use) of the filter among the target population. This includes assessing whether users can easily understand and operate the filter without significant barriers or challenges. Elaborate user feedback and observations from the study can identify usability issues and inform improvements in filter design or communication materials.

User feedback and performance metrics inform decisions regarding the adoption and scaling up of the filter intervention, considering its effectiveness and acceptability among the target population. Furthermore, the study results serve as valuable evidence for understanding the context and user groups. They can shed light on specific challenges and preferences within the community, guiding efforts to tailor filter deployment strategies and optimize user engagement. In many instances, the evidence produced during the study can trigger a dialogue and decision-making process. However, when results are ambiguous or subject to varied interpretations, a more structured approach may be warranted.

To facilitate decision-making among multiple options, a simplified multi-criteria decision analysis (MCDA) approach can be employed. This method involves the following six steps:

1. Identifying "no-go" attributes. The "no-go" attributes can be used for pre-screening and are attributes which absolutely must be fulfilled by each option. The data might show that the implementation of the filter is not feasible or even dangerous in the defined context. The checklist in table 4 summarizes the main "no-go" attributes, and corresponding data, which indicate that the filter should not be used in any or a specific context. The checklist should be adapted based on the study context and priorities.

Table 4 «No go» attributes

Technical performance and functionality	Log removal values (LRV, measure of treatment efficiency, see L1) for integrity test are < 2 for > 60 % of all samples. Water after treatment contains > 10 CFU/100 ml of E.coli in > 60% of all samples.	Filters are likely not to provide the required protection.
User perception	Drop out of the study exceeds 40 %	Acceptance is low
Deployment in an emergency	Durability: Number of filters damaged during the study exceeds 40%	Durability is not sufficient

2. Identifying attributes, which can be used to evaluate an option, or compare the options based on the results of the study. Table 5 summarizes the attributes (column 2, blue) and the related data source (column 3, light blue) and according questions derived from the provided questionnaireor technical data collected (column 4, green).

3. Assigning scores to attributes (column 5, orange and 6, red). This makes them comparable. In the example in table 5, scoring in the range of 0 to 4 points is applied for multiple questions for each attribute. For the questions from the monitoring questionnaire, the percentage of users who gave a specific answer defines the score (column 5). This means that if 0-20% of all users have answered this specific valid answer, assign 0 points, 21-40%= 1 point, 41-60%=2 points, 61-80%=3 points, 81-100%=4 points (column 6, red). For the attribute with multiple questions, the mean score should be calculated.

4. Assigning weights for each attribute. This is required to reflect the relative importance of each attribute to the decision. A scale of 0-100 can be used. The attributes considered most important can be assigned 100 points. The stakeholders can decide which attribute they think is the least important one and judge how much less important it is to the decision compared to the most important one. For the other attributes, the weighting is chosen in between, according to their relative importance. In the end, the weights are scaled down so that their sum equals 100%. Table 6 shows an example of weighting for the attributes summarized in table 5.

5. Calculating the weighted total score. Combine the weights and scoresto derive the overall value for each option. This can be done by multiplying scores by weights for each attribute and summing the products up for each option (table 7). Each stakeholder generates different total values according to their weighting.

6. Ranking the options according to their total values. Consider that the highest value corresponds to the best option. Different stakeholders will generate different rankings, due to different weighing. At this point, it is important to compare and discuss the ranking of options by different stakeholders and their different weightings, discuss any doubts and disagreement, explore how sensitive the results are to the weighing of different stakeholders. When the results are not clear or contradictory, it might be needed to reconsider the attributes, adding additional questions, or scoring and weighing each question separately, and not aggregated for each attribute. The scoring proposed in table 5 might be reconsidered as well.

7. The method proposed does not take into consideration more subjective data or results of the Focus group discussion. Thus, it should be considered as an aid tool for decision making.

Table 5 Questions, attributes, data and valid answers for multicriteria decision analysis. Answers are transferred directly from the surveys for each question.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
Category	**Attribute**	**Data source**	**Questionnaire item / Question**	**Valid answer(s)** (if 0-20% answered this valid answer(s) assign 0 points, 21-40%= 1, 41-60%=2, 61-80%=3, 81-100%=4 points)	**Assigned points (0-4)**	**Mean point for attribute**
User acceptance	Assembly	Observation check-list	OB4: Has filter been installed correctly? OB6: Is the tap installed correctly? OB7: Has the filter element been contaminated during installation on the clean side? OB8: Was the storage tank contaminated?	Answer 3 and 4 Answer 3 Answer 0 Answer 2 (if 77: not applicable)		
	Operation and maintenance	Observation check-list Monitoring	OC4: Does the user easily understand how to use the filter? OE1: Does the user understand how the maintenance should be done? OE3: Can the user do the cleaning properly? MB2: Is the filter functional? MB8: Is the filter visibly clean? MB9: Is a container for storing water visibly clean? MB3: Does the filter have any damages? MC3: How easy is it for you to use the filter? MC5: How easy is it to clean the filter?	Answer 2 and 3 Answer 3 and 4 Answer 1 Answer 1 Answer 1 Answer 1 Answer 0 Answer 3 and 4 Answer 3 and 4		
	Acceptability	Extended list (final data collection)	FE1: How much do you like or dislike your current filter? For the following features, how do you rate your filter? FG17: Size of the filter FG18: Amount of water FG19: Design FG20: Ease of use FG21: Water storage tank FG22: Taste of water FG23: Look of water FG24: Cleaning of the filter element FG25: Cleaning of the filter housing FG26: Perceived safety of water	Answer 3 and 4 Answer 3 and 4 Answer 3 and 4 Answer 3 and 4 Answer 3 and 4 Answer 3 and 4 Answer 3 and 4 Answer 3 and 4 Answer 3 and 4 Answer 3 and 4 Answer 3 and 4		

Filter functionality	Protection levels	Monitoring	Does the filter reduce bacteria in the water? Does filter improve water quality at a household level? Does the re-contamination of treated water occur? Does microbial regrowth in filter occur?	LRV in integrity test is ≥2 Samples with 0 CFU/100 ml for E.coli in treated water Samples with 0 CFU/100 ml E.coi in stored water Samples with ≤ 10 CFU/100 ml in treated water		
	Treatment capacity and flow rate	Monitoring	MC9: Do you have enough filtered water? MC10: Should the filter treat more water? MC16: Is the water filtered fast enough? What is the measured flow rate of the filter?	Answer 1 Answer 1 Answer 1 Samples with Flowrate ≥ 1 L/h		
	Filter use	Monitoring	What does the filter costs (Filter cost / expected filter lifespan: Euro/year) Investment filter costs including logistics until country office for 1 filter	> 60 Euro/year – 0 points 41-60 Euro/year – 1 point 21-40 Euro/year – 2 points 11-20 Euro/year – 3 points ≤ 10 Euro /year – 4 points > 110 Euro/year – 0 points 81-110 Euro/year – 1 point 51-80 Euro/year – 2 points 21-50 Euro/year – 3 points ≤ 20 Euro – 4 points		
	Robustness	Monitoring	Are filters robust enough to be deployed in an emergency? (Indicator: dispersion of all integrity tests values measured in the field)	Interquartile range (the middle 50% of all data values for LRV for integrity test) ≤ 1.		

Deployment in an emergency	Filter costs	Preparation L2	What does the filter costs (Filter cost / expected filter lifespan: Euro/year) Investment filter costs including logistics until country office for 1 filter	> 60 Euro/year – 0 points 41-60 Euro/year – 1 point 21-40 Euro/year – 2 points 11-20 Euro/year – 3 points ≤ 10 Euro /year – 4 points > 110 Euro/year – 0 points 81-110 Euro/year – 1 point 51-80 Euro/year – 2 points 21-50 Euro/year – 3 points ≤ 20 Euro – 4 points		
	Logistical foot-print	Preparation	Shipping volume for 40 filters, m3	> 2.5 m3 – 0 points 1.5-2.5 m3 – 1 point 0.8-1.49 m3 – 2 points 0.3-0.79 m3 – 3 points < 0.3 m3 - 4 points		
	Durability	Monitoring	Are the filters durable in the study context? (Indicator: number of dam-aged filters)	Number of filters which never get damaged during the study		
	Quality control of the products be-fore deployment		What is the production quality of the products? Indicator: integrity test in the lab for at least five filters	LRV in integrity test is ≥ 4 (or value provided by manufactur-er if LRV is expected to be in the range of 2-4).		

Table 6 Example: Weighing - Assigning weights for each attribute to reflect their relative importance to the decision

	Assembly	O&M	Accepta-bility	Protection levels	Treatment capacity/ flowrate	Filter use	Robustness	Filter costs	Logistical footprint	Durability	Quality control	Total
Weighting stakeholder A	50	70	100	100	70	100	30	50	10	40	40	680
Weighing, %	7.6%	10.6%	15.2%	15.2%	10.6%	15.2%	4.5%	7.6%	1.5%	6.1%	6.1%	100%

Table 7 Example: Weighed total score - combining the weights and scorers for each attribute and option

	Assembly	O&M	Accepta-bility	Protection levels	Treatment capacity/ flowrate	Filter use	Robustness	Filter costs	Logistical footprint	Durability	Quality control	Total
Weighting stakeholder A	50	70	100	100	70	100	30	50	10	40	40	680
Weighing, %	7.6%	10.6%	15.2%	15.2%	10.6%	15.2%	4.5%	7.6%	1.5%	6.1%	6.1%	100%
Option 1, scores	0.75	3.38	3.18	2.75	3.75	3	3	2	3	4	3	2.93*
Option 2, scores	0	4	3.6	1.5	4	2	1	1	0	3	2	2.35*

* The total weighted score is calculated as a sum of the score and weigh for all attributes

PART 2 Information sheets

Part 2 – Information sheets consist of five main sections, based on Figure 1 of this manual and include:

- S Filter and context pre-evaluation
- L Logistics and preparation
- D Distribution, user information and training
- T Technical performance evaluation
- U User acceptance evaluation

S Filter and context pre-evaluation

Section S summarizes the information sheets, focusing on selecting and pre-assessing filters for field studies and understanding their suitability across different emergency contexts. It consists of three sheets. S1 is intended to support studies that require pre-selection of filters from certain production lines or the entire market. S2 outlines major considerations for pre-assessing filters for specific contexts, while S3 delves into various emergency contexts.

S 1	Selecting filters
S 2	Assessing the feasibility of a certain filter
S 3	Selecting emergency context

S.1 Selecting filters

Required	Optional	Group	Detailed protocol/questionnaire	
	X	Filter and context pre-evaluation		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X				

Background

The market offers a vast array of filter products, making the selection process for study evaluation challenging and prone to personal biases. Prior to initiating the selection process, it is essential to grasp the diversity of filters and their characteristics. Table 8 provides a summary of some key filter features. However, it's important to note that filters within each category may differ based on design, manufacturer, and other factors. Table 9 provides overview of the typical filter designs independently of the key element.

The summary is not exhaustive and may not cover all available options or their combinations.

Table 8 Overview of filter types and typical filter features

	Ceramic filters	Membrane filters	Biosand filters	Multistage filters	Reverse Osmosis filters
Filter elements	Ceramic candles, disks, candles produced out of compressed activated carbon	MF and UF filter modules in hollow fibres and flat sheet configuration	Household sand filters	Combination of technologies, usually ceramics followed by slow release disinfection technologies or activated carbon	Multistage filters that partially or entirely remove salinity in water
Pressure generation	Gravity	Gravity and manual pumping	Gravity	Gravity	Water network pressure or electric pump (usually 3-10 bar).
Typical designs	Pot filter Two containers on top of each other Syphon filters	Filters with a manual pump to be installed in jerry cans or buckets Standalone filters with manual pump and container integrated Gravity filters with two containers on top of each other Gravity filters with one source container only	Housing is locally constructed out of concrete, plastic, metal. Water can be abstracted directly or stored in a safe water storage container under the filter	Gravity filters with two containers on top or next to each other. Often aspirational designs	Filters with multiple cartridges usually installed under a sink, on table or next to a well.
Locally used supplies	Locally available buckets might be used as housing. Local production is possible	Locally available buckets might be used as housing. Membranes are imported	Local production	Often imported	Often imported cartridges, local assembly by a service provider

	Ceramic filters	Membrane filters	Biosand filters	Multistage filters	Reverse Osmosis filters
Flowrate	Approx. 0.5-1L/hour, 15-20 L/day	Varies between 2-10 L/hour – 40-240 L/day	10-20 L/h, 100-200 L/day	Approx. 0.5-2L/hour, 15-20 L/day	50-500 L/day
Transportability	Yes	Yes	No	Yes	No
Pathogen removal	Comprehesive to targeted protection for Protozoa and Bacteria, limited or no removal for viruses. Protection varies depending on production quality/pore size	Depending on the type of the membrane used, comprehensive protection for bacteria and protozoa, virus removal varies for different membranes from comprehensive protection to limited or no removal. Protection also varies depending on product quality and quality control.	Highly variable depending on O&M	Limited data, in principle comprehensive protection for all three classes of pathogens should be expeced for new systems but fouling and reduction of removal in time are likely	Comprehensive protection for all three classes expected with well maintained filters.
Salinity removal	No	No	No	No	Yes
Clogging	Mechanical cleaning of the ceramic elements	Automatic backflushing for manual pump systems, no backflushing or manual backflushing required for some gravity-driven systems	Removal of the schmutzdecke (upper layer of sand)	Mechanical cleaning of the ceramic elements, replacement of cartridges	Filters cannot be used to treat turbid water. Regular (3-12 month) replacement of cartridges is needed. Chlorine, Calcium and Magnesium in water can destroy the RO membrane. Regular replacement of Activated carbon cartridges to remove chlorine and ion exchange to soften water from the network is required.
Consumables	No	No	No	Yes – cartridges containing disinfectant or activated carbon	Yes, cartridges for mechanical filtration and activated carbon
Regrowth and recontamination	Depends on design, silver-containing systems have some bacteriostatic properties reducing microbial regrowth	Microbial regrowth is likely in warm climates, membrane preservatives might support this process. Recontamination depends on the design	Microbial regrowth is unlikely, as biosand filtration improves biostability of water, recontamination depends on handling water after filtration	Disinfectants protect water from regrowth and reduce recontamination. Efficiency depends on the technology used and fouling properties of water	Water is produced when needed, and microbial regrowth is limited due to very low nutrient context in water. pH of water is reduced that might lead to corrosion.
Life span of filter elements	3-12 month	3 month - 5 years	Over 5 year with appropriate O&M	3-12 month	6-12 month for cartridges, up to 5 years for RO membrane

Based on the overview of the typical characteristics of filters, certain types of technologies can be excluded. For example, low transportability of the BSF filters, the low flow rate observed for some ceramic syphon and bottle top filters can and should lead to exclusion of this technologies for certain contexts.

Table 9 Filter design options

Filter description	Containers	Pressure generation method	Filter element or media	Internal storage	Locally procured container
Bottle top filter	PET or other drinking bottles	Water is sucked with a mouth directly from the filter	Hollow fibre microfiltration or ultrafiltration membrane	No	Yes, bottle
Syphon filter	Bucket or another open container	Syphon effect initiated by a small hand vacuum bulb pump	Ceramic candle or hollow fibre microfiltration membrane	No	Yes, bucket
One outlet filter	The filter is attached to an outlet in a container outside of it. Containers could be buckets, or flexible bags. Sometimes the container needs to be fixed on the wall.	Gravity	Hollow fibre ultrafiltration membrane	No	Yes, bucket. Sometimes delivered with bags.
One container filter	Filter media is filled in the container. Or filter element is installed in one container, with the permeate outlet of the filter being/ attached to the tap	Gravity	Gravel and sand, specialized filter media such as bone chart for fluoride removal or granular activated carbon, membrane module	No	Yes, bucket or plastic box
Two containers filter	Filter is installed in the upper container and water is filtered in the lower container	Gravity	Ceramic candle, ceramic disk, hollow fibre or flat sheet microfiltration or ultrafiltration membrane module	Yes	Yes, two buckets
Manual pump filter	Filter is placed in a jerry can or bucket and water is pumped out of it with a manual pump. Sometimes can be installed in-line	Manual pumping	Hollow fibre ultrafiltration membrane	No	Yes, jerry can or bucket
Multistage filter	Usually two container design, the filter is designed with multiple compartments filled with different filter media	Gravity	Ceramic candle, ceramic disc, hollow fibre microfiltration or ultrafiltration membrane	Yes	No
Cartridges	3-5 cartridges are installed sequentially under a sink	Network pressure or electric pump	Cartridges include particle or ceramic filter, activated carbon, ion exchange resign, reverse osmosis module. UV lamp might be used instead of ion exchange and RO.	Yes, small tank	No

Considerations

Filter selection is inherently subjective, influenced by individual perspectives within the team and varying interpretations of available data. Due to this subjectivity, there can be divergence in opinions among team members regarding the most suitable filter. The results obtained from the filter evaluation process serve to bring clarity to this decision-making process by providing empirical evidence and performance metrics.
To facilitate a comprehensive evaluation, it can be advantageous to select and compare filters from different categories. For instance, comparing gravity-driven filters against those equipped with a manual pump enables to assess how users can cope with different operating mechanisms. Similarly, comparing filters with integrated storage capabilities to those without provides insights into the convenience and functionality of storage features for the users.

By evaluating filters across different categories, teams can gain a holistic understanding of filter strengths, weaknesses, and suitability for specific contexts. This comparative approach enables informed decision-making and enhances the likelihood of selecting the most appropriate filter for the intended application.

S.2 Assessing the feasibility of a certain filter

Required	Optional	Group	Detailed protocol/questionnaire	
	X	Filter and context pre-evaluation		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X				

Background

When filters are pre-selected by implementers or when a specific product requires evaluation in a particular context, it's beneficial to conduct a pre-assessment of the filter. This pre-assessment involves evaluating the filter's suitability for the local context, aligning with the expectations of the implementing team, and assessing the credibility of available data. Pre-assessment serves to anticipate potential problems or challenges in advance, allowing for discussions with manufacturers and implementers to address them effectively.

Description

Table 10 provides a summary of the major filter features and their significance in the local context, as well as expectations and feasibility for implementation. The table serves as a checklist and can guide the pre-assessment process. While it's not exhaustive, the table can be expanded depending on the specific filter design and requirements.

Table 10 Filter features and related information and context related considerations

Filter feature	The information available for the filter	Context and implementer`s requirements and expectations
Capacity and flow rate	Daily and immediately capacity of the filter	Size of the households and minimal requirment for drinking water based on the needs assessment or sphere standards
Targeted contaminants	Technology used and its ability to address the contaminants of concern	Water quality parameters of concern, perception and expectations of the households in terms of water quality (e.g. is salinity a problem or not)
Microbial removal performance	Data/certificates available on the removal of protozoa, bacteria and viruses and its credibility (third party or not, WHO evaluation results, etc)	The desired level of protection according to WHO HWTS evaluation scheme, source water quality and related health risk, Country drinking water guidelines
Removal performance for other compounds	Data/certificates available that show the removal of other target contaminants, such as salinity, fluoride, arsenic or metals.	The drinking water guidelines, the results of the water quality tests and assessment, user expectations
Water storage	Availability of water storage container	Hygienic conditions in households and the need for external storage
Protection from contamination	Design features or post-treatment protecting produced water from re-contamination	Expectations to design as well as knowledge and attitude regarding specific technologies (silver, bromine, chlorine, activated carbon)
Type of technology used	Filtration element used in the filter	Expectations and preferences regarding the potential for local production

Filter feature	The information available for the filter	Context and implementer`s requirements and expectations
Lifespan	Predicted or known filter lifespan	Minimal required lifespan
Source water quality	Limitations regarding water turbidity or organic matter content	Source water quality and expectations regarding filter performance
Local assembly	Need for using local containers, drilling holes and any other steps required for local assembly. Overall perceived simplicity of the assembly.	Feasibility of the local assembly in the context of the study, the decision on who and where the assembly should be done
Design features	Appearance and filter design, number of small parts, moving parts or parts which appear to be fragile and can be easily damaged	Requirements regarding the robustness of the filter as well as ease of operation, maintenance and use
O&M	Description of the operation and maintenance requirements for the filter	Are O&M procedures easily understood and can they be implemented by the members of the team?
Instructions	Printed instructions	Are printed instructions clear? Can they be used directly or require translation?
Costs	Actual costs of the filter including packaging, shipment, taxes, certification	Willingness to pay for the filter by implementing, value for money
Logistical footprint	Size of the filter, packaging	International and local logistics and suitability for local transport and distribution

Considerations

This pre-assessment process is subjective, and different team members may have varying views and interpretations of the available data. When the team involved in the pre-assessment and decision-making process holds contradictory views, simplified multi-criteria decision analysis tools can be utilized. To facilitate this, the team should assign weights to different factors and subsequently rate them. The resulting scores can then serve as a foundation for discussion.

S.3 Pre-assessing the emergency context

Required	Optional	Group	Detailed protocol/questionnaire	
	X	Filter and context pre-evaluation		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X				

Background

Three general phases of the humanitarian response can be identified*.

Acute Response: This pertains to humanitarian relief interventions implemented immediately following natural disasters, conflicts, epidemics/pandemics, or further escalation of events during protracted crises. Typically, this phase covers the initial hours and days, extending to the first few weeks or months, during which effective short-term measures are deployed to swiftly alleviate the emergency until more permanent solutions can be established. Depending on the nature of the disaster, individuals affected by crises often face heightened vulnerability to diseases, largely due to the absence or inadequacy of WASH facilities and challenges in maintaining proper hygiene practices. The primary objective of interventions in the acute response phase is to ensure the survival of the affected population, guided by principles of humanity, neutrality, impartiality, and independence. Critical water-supply-related services required during this phase include the provision of clean water for drinking, personal hygiene, and cooking in sufficient quantities, primarily on a communal level. It also involves ensuring a safe environment and preventing contamination of water sources.

Stabilisation: The stabilisation or transition phase typically begins after the initial weeks or months of an emergency and may extend for approximately six months or longer. During this phase, in addition to expanding service coverage, the primary emphasis is on the step-by-step enhancement and re-finement of temporary emergency structures that were initially installed during the acute phase. This may involve replacing temporary technologies with more durable, long-term solutions.

This phase includes the establishment of community-supported structures with a stronger focus on the entire WASH system, the gradual involvement of water utility structures where applicable and the consideration of water safety and risk management measures. Reassessment of water and energy sources is imperative, considering environmental factors and long-term sustainability. This is particularly critical in cases where groundwater serves as the primary water source or where water supply relies on water tracking.

Recovery: The recovery phase, sometimes referred to as the rehabilitation phase, usually starts after or even during relief interventions (usually >6 months) and aims to recreate or improve on the pre-emergency situation of the affected population by gradually incorporating development principles. It can be seen as a continuation of already executed relief efforts and can prepare the ground for subsequent development interventions and gradual handing over to medium/long-term partners. Depending on local needs the general timeframe for recovery and rehabilitation interventions is usually between six months to three years and in difficult situations up to five years (or more in conflict-affected areas). Recovery and rehabilitation initiatives are distinguished by the active participation and engagement of local partners and authorities in planning and decision-making processes, leveraging local capacities to enhance the sustainability of interventions. These interventions should incorporate a well-defined transition or exit strategy, facilitating the handover of responsibilities to local governments, communities, or service providers. This ensures that the service levels established can be sustained effectively over time.

* Adapted from the Compendium of Water Supply Technologies in Emergencies, (Coerver et al., 2021)

In general, conducting research and evaluation studies in acute contexts can be challenging and may raise ethical concerns, particularly regarding competition for available resources and alignment with local team priorities. Conversely, conducting a filter evaluation project during stabilization, recovery, or protracted crises contexts can be more feasible and ethically acceptable.

During the recovery phase, market-based approaches become more viable, making assessments of willingness to pay useful. Factors such as durability, robustness, and dependency on consumables should also be taken into account. These phases allow for more stable conditions and better access to resources, facilitating more comprehensive and ethically sound evaluations.

Description

The potential for implementing household filters during each phase of an emergency heavily relies on the local context. Household filters are often regarded as a practical solution in remote rural areas where contaminated water sources exist, yet providing community-based options may be limited or impractical for various reasons. They can also complement community-based systems in cases where water quality deteriorates between the source and household due to poor hygienic conditions. This scenario occurs in refugee or IDP camps where water sources are available, but water quality is compromised and centralized chlorination is not feasible. In situations where source water quality is already good and can be adequately chlorinated at the community, camp, or centralized level, household water filters may not be utilized or recommended by implementing organizations.

Table 11 Typical criteria for recommending or implementing household water treatment methods

Remote rural areas, IDP and refugee camps, informal settlements	Urban peri-urban areas with available centralized or community water supplies
Multiple scattered unprotected water sources	One protected water source
Water from accessible sources is contaminated	Drinking water is chlorinated
There is a high risk of contamination of water between source and household	Water has residual chlorine and is not likely to be contaminated
Walking distance between the source and household exceeds 30 min	Water is available on-premises or at the distance less than 30 min round trip including queuing.
There is a high risk of water recontamination in the household due to prolong storage	Water is stored in the household for a limited time in safe storage containers
Water has high nutrient or organic matter content and is biologically unstable	Water is clear and has a low potential for microbial regrowth and formation of biofilms
Household water filers or other household water treatment technologies are available on the market and known to users	Household water treatment technologies and methods have never been used in the area previously

For the filter evaluation study, it is generally preferable to focus on contexts where filters are likely to be recommended for use.

Reference

Coerver, A., Ewers, L., Fewster, E., Galbraith, D., Gensch, R., Matta, J., Peter, M. (2021). Compendium of Water Supply Technologies in Emergencies. German WASH Network (GWN), University of Applied Sciences and Arts Northwestern Switzerland (FHNW), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA). Berlin. Germany

L Logistics and preparation

Logistics and preparation section addresses different steps required to prepare and set up the study. The seven information sheets cover different aspects including logistical consideration, pre-evaluation of products in a lab, ethical approvals, setting up field lab and data management systems.

L1 focuses on the evaluation of the selected filters in the laboratory and defines the minimal standards for field evaluation of the filters. L2 discusses logistical constraints and considerations around a shipment of the filters into filed locations. L3 focuses on the selection of the users and locations for filter evaluation within a pre-defined area. L4 considers ethical research permits and approvals required to conduct such a study. L5, L6 and L7 address the set up of infrastructure for water analysis, major considerations around a data management system and finally training of the team.

L.1	Pre-evaluation of the filters in a laboratory
L.2	Filter logistics
L.3	Selecting locations and users
L.4	Study approvals
L.5	Data management system
L.6	Field laboratory management
L.7	Team training

L.1 Pre-evaluation of the filters in the laboratory

Required	Optional	Group L	Detailed protocol/questionnaire	
X		Logistics and preparation		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X		X		

Filter types selected for the field study should be safe for users, provide sufficient volume of water, be easy to install and operate and be accompanied by a user-friendly manual. Pre-evaluation of the filter should be done to assure that filters correspond to all those requirements. Pre-evaluation can be done in the laboratory or offices of the implementing organisation, research partner or a third party organisation capable of such evaluations. Methods used during the study can be used for technical evaluation.

Background

Manufacturers should obtain a third party evaluation or certification of their products before planning a field evaluation. This evaluation should provide basic technical information such as removal performance for bacteria, viruses and protozoa and turbidity, any limitation regarding tentative use of filters such as highest turbidity values the filter is capable of managing, as well as flowrate and expected life span. For newly developed products this data might not yet be available, or company/organisation manufacturing the filters or prototypes has only internal data. Production quality control brings another uncertainty into the performance of the products. Thus, the filter integrity as well as flowrate should be tested before study using the same methods planned for the study including filter integrity testing using spiked probiotic bacteria and flow rate measurement. These tests will also help to establish and verify the methods for the field and can be used as a basis for training local field staff. If any undisclosed post-disinfection system is incorporated in the filters, the toxicity, as well as immobility of the chemicals used, should be evaluated in an independent specialized research laboratory.

Description

We recommend testing 3-5 filters, possibly obtained from different production batches. The filters should be set and taken into operation using non-chlorinated water according to the user manual provided by the manufacturer. The filter should be operated during at least 1 day, filtering the daily amount of water before the testing is conducted to assure that any preservatives, air, etc. have left the filter. The user manual can be evaluated for applicability and modifications suggested to the manufacturer. Since the user manuals often need to be translated into local languages, small modifications might be relatively easy to implement. The integrity test, as well as flow rate measurement, should be conducted in triplicate with all filters following the Technical sheet T.2 and protocol P2 for integrity testing and Technical sheet T.3. for flow rate testing.

During the testing, operation and maintenance of the filter should be documented. Potential risks to users can be analysed according to the following checklist (table 11):

Table 12 Checklist for assessment of potential risks

√	Can the filter be assembled correctly using the manual provided and would incorrect assembly lead to a health hazard?
√	Is filter likely to release or leak any toxic substance into the water? Are materials in contact with water known and certified for drinking water use? Materials, which are not certified for drinking water use, such as some types of plastics, e.g. PVC or ABS, should not be used.
√	Can any parts of the filter cause harm to users and specifically children in household if broken, or detached?
√	Can taps or tubes be mixed leading to consumption of untreated water?
√	Can filter cause harm in any way?
√	Are operation and maintenance procedures clear? Can the filter be easily destroyed by improper maintenance?
√	Does filter have any fail indicator in place?

In case of any doubt, a discussion should be thought with manufacturers and implementers, and in case of disagreement, an opinion of an independent third party considered.

Resources and materials

3-5 filters. Materials required for integrity testing and flow rate evaluation (see T.2 and T.3).

Data analysis and visualization

To estimate the performance of the filter, the log reduction values (also called Log removal values or LRV) are commonly used to calculate the magnitude of change of bacterial numbers due to a filtration process. Log reduction is calculated using the formula: Log reduction = Log

10(A)- Log10(B) where A is the colony count in raw water, and B is the colony count in the filtered water. We should consider that both raw water and filtered water will influence the LRV value, meaning that when raw water has low counts, the LRV will below, which can lead to misinterpretation of the filter removal performance. The LRV values proposed by WHO should be used as an indication of the acceptable performance.

Table 13 Performance classification for housheold water treatment and safe storage based on removal of bacteria, viruses and protozoa proposed by WHO*

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

* https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/water-safety-and-quality/household-water-treatment-and-safe-storage

The integrity test should show at least LRV of 2 for all filters tested. If a lower value is repeatedly observed for two or more productions, filters should not be used in the field. If only one out of 3-5 filters shows repeatedly LRV < 2, the manufacturer should provide two additional products, which should be evaluated and both provide at least LRV 2 value.

If filters are implemented for entire households, the volume of water provided by filter per day should be at least 20 L. If the filter treats less than 20 L/day, multiple filters should be used in the same household or another filter type is chosen.

Considerations

The main goal of the pre-evaluation to assure that filters will not harm the field implementation. Thus, it is important to consider and discuss any doubts related to the use and implementation of the products. This step has a relatively high conflict potential between manufacturer and implementer, as it might lead to a delay or cancellation of the field study. The objectives of the evaluation, as well as the detailed protocol and consequences, should be discussed and agreed beforehand with the manufacturer.

References

International scheme to evaluate household water treatment technologies:
https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/water-safety-and-quality/household-water-treatment-and-safe-storage

L.2 Filter logistics

Required	Optional	Group L	Detailed protocol/questionnaire	
X		Logistics and preparation		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X				

Filters must be delivered to the study locations before the commencement of the research. Large implementing organizations typically have logistics officers or entire departments dedicated to managing procurement and delivery while adhering to local regulations and requirements. However, for smaller organizations lacking experience in country logistics, dealing with new products, prototypes, or relying on small manufacturing organizations for delivery and custom clearance can pose logistical challenges.

Background

Each country has its own import regulations that must be followed at all times. While humanitarian goods may be eligible for import tax waivers in some cases, for a few products, it may be simpler and more cost-effective to pay the import tax rather than seek a waiver. Import regulations in certain countries may also necessitate local certification of goods' performance and conformity to local standards. In some instances, a certificate of conformity must be obtained from an international certification organization like SGS, which provides verification, testing, and certification services globally. Regardless, it is essential to clarify import procedures before shipment. Consulting or subcontracting a local specialist in importing specialized products may be necessary to manage the import process. Additionally, sending 1-3 filters in advance for certification and evaluation within the country may be required. This entire process can take up to 6 months in some locations, demanding thorough planning and preparation. Goods should never be shipped to a country without confirmation from local customs authorities, as they could be held at the border for extended periods, resulting in significant fines and penalties for storage. Sometimes, double importing may be necessary, particularly when goods need to cross different borders by sea or land.

Description

Key steps include clarifying import regulations and laws and obtaining necessary documents. In many cases, hiring a specialized registered subcontractor may be the only viable option. It is crucial to ensure that the subcontractor has experience with water filters or similar products. Certifications by SGS or similar international organizations are typically straightforward and can often be conducted remotely using virtual visit software, eliminating the need to ship products or have external experts visit facilities. Certification by local authorities may require pre-shipment of prototypes, incurring additional costs.

Shipment can be conducted by air, land, or sea, depending on the location. Cargo flight shipments usually take between 3-5 days, with most airlines offering direct cargo services, which are often cheaper compared to shipping companies. Delivery by land or sea typically takes up to 1 month but is usually more cost-effective and environmentally friendly. Depending on whether the country is landlocked or not, sea shipment may also be a feasible option for a small number of filters. All shipped goods must be adequately insured to cover loss or damage. The actual costs of the filters combined with logistics costs (shipment, taxes, insurance) must be carefully documented. In studies comparing multiple products, logistics costs are an important consideration that must be factored in. When multiple products are shipped together, costs can be segregated based on volume. Since most filters are relatively light, volume, rather than weight, determines the cost of shipment. Table 14 summarizes potential cost categories related to filter shipment.

Table 14 Template table to summarize the costs related to logistics of the fitlers

	Procurement	Packaging	Shipment	Insurance	Import taxes	Certification	Other	Total
40 filters A								
40 filters B								

When a shipment of any laboratory material is required for the study, it can be done together with the filters and the documents collected and prepared in parallel. Some suppliers of laboratory goods might have local distributors in various countries.

Considerations

All partners, team members, and potential subcontractors must be informed of and adhere to a zero-tolerance policy for corruption. If legal importation of filters is not possible or feasible, an alternative field-testing location should be chosen. All payments and transactions involving local import and certification authorities must be supported by valid official receipts.

L.3 Selecting locations and users

Required	Optional	Group	Detailed protocol/questionnaire	
X		Logistics and preparation		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X				

This process consists of two steps: the first step involves identifying a location within your target area where the study should take place. The second step is the selection of households within the defined location. The number of households to be considered in your study depends on several criteria outlined in this chapter.

The choice of study location hinges on various factors that must be carefully considered and weighed against each other to determine where the conditions are optimal for obtaining information that serves your organization and informs decision-making processes. Moreover, the selection of individual house-holds participating in the study should ideally adhere to a random design to mitigate biases in the selection process.

Identifying locations

Here are some points to consider:

Is there a high demand for household water filters?		Yes
√	If water quality is perceived as good, demand for household water filters may be low. Conversely, demand might vary based on specific water issues; for instance, in areas where salinity is a concern, filters addressing salinity may be more sought after than those targeting microbial contamination.	
Is access to water easy?		**Yes**
√	If water availability is limited or scarce, the effort required to use household water filters may not out-weigh the perceived benefits, resulting in low user acceptance. In such cases, consider improving access to water first.	
Are people in this area stable inhabitants?		**Yes**
√	If residents are likely to leave the area soon, investments in the study setup may not yield informative outcomes, or you may risk losing the study altogether.	

If you cannot answer YES to all the outlined criteria or if you are unsure about them, it is advisable to plan your baseline survey separately from the rest of the study and first confirm that you have selected the right study location and participants. You may also want to consider choosing a different study location if necessary.

Sample size calculation

To determine the number of households for your study, start by deciding how many groups you will compare. This decision shapes the selection process for households.

The decision on the number of groups to compare:

The sample size is determined by the number of comparisons you intend to make. Are you assessing user acceptance of one filter? Comparing different filters? Or comparing a group of filter users to a control group without filters? These decisions dictate the number of groups and households in your study. Refer to Table 15 to determine the number of groups based on your choices. For instance, if you're testing one filter against a group without filters, you'd have 2 comparison groups in the example provided.

Table 15 Number of groups for testing filter

Number of filters	Number of comparison groups	Example
I want to test 1 filter	1	Yes, I want to test 1 filter: 1 group
I want to test 2 filters	2	
I want to include a control group without a filter		
Yes	+ 1	Yes: +1 group
No	+ 0	

Sample size calculations

If your study follows the idea of assessing user's acceptance and preferences of filters, it is not necessary to do a sophisticated calculation of sample sizes. The calculation of sample size also depends on how the data analysis will be done. If you follow the methods described in this guideline, a group size of 50 households per group would be ideal. If this is impossible according to your study area, you can still reduce the group size to 40 households.

If you plan to conduct a scientific study which produces scientifically sound results, you should consider diving more into this topic. Under the resource section, you will find a useful online tool for sample size calculations.

Random selection of households

If your study focuses on assessing user acceptance and preferences of filters, conducting a sophisticated calculation of sample sizes may not be necessary. The ideal group size, following the methods outlined in this guideline, is 50 households per group. However, if this is not feasible in your study area, you can reduce the group size to 40 households. For scientific studies aiming to produce scientifically sound results, further exploration of this topic is recommended. Refer to the resource section for an online tool to assist with sample size calculations.

Options for random selection of households

Lottery box	Write the names or assigned numbers of all eligible households on a paper. Put all the papers in a lottery box and mix and blindly draw the required number of names from the lottery box.
Random route sampling	The selection of households is done on the ground: your staff starts in the middle of the target community and spreads into different directions. Every second/third/fourth household is selected, depending on the size of the community and the number of households you need in your sample. Make sure to cover the whole area of the community and do not leave out specific areas (e.g., those that are at the edge of the community). In case your staff reaches the boundaries of a community, a pen can be spun until it points to a direction within the community, and the data collector continues this way.

References

For scientific sample size calculation: Dhand, N. K., & Khatkar, M. S. (2014). Statulator: An online statistical calculator. Sample Size Calculator for Comparing Two Independent Means. Accessed 17 July 2020 at http://statulator.com/SampleSize/ss2M.html

L.4 Study approvals

Required	Optional	Group	Detailed protocol/questionnaire	
X		Logistics and preparation	Template of a consent form	
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X				

For your study, it is mandatory to comply with ethical standards, especially if you are dealing with vulnerable groups of society. Depending on your context and study area, there might be several institutions or focal points where you need to present your study proposal and seek ethical approval.

This chapter wants to draw your attention to the importance of taking time for careful consideration of ethical aspects throughout all steps of study implementation. It is structured in three parts: i) the discussion of common ethical standards, ii) the short insight into the Research Ethics Tool provided by Elrha/The Humanitarian Innovation Fund and iii) shortly discuss the need of institutional ethical approvals.

Ethical standards

When working with vulnerable groups within the society, it is crucial to include certain considerations in the planning process of your study. Table 16 lists ethical principles if dealing with vulnerable people and especially when experimenting with emerging technologies. This list and content are quoted from the Humanitarian Innovation Fund (https://higuide.elrha.org/toolkits/get-started/principles-and-ethics/).

Table 16 List of ethical principles when dealing with vulnerable population. Adapted from Humanitarian Innovation Fund`s Research ethics tool: https://higuide.elrha.org/toolkits/get-started/principles-and-ethics/

Compliance	your study should comply with international ethical standards and should be approved by an ethics review committee
Humanitarian Purpose	your study should serve the needs of the participants and should adhere to basic humanitarian principles, such as impartiality.
Do No Harm	none of your study components should lead to any harm for any involved stakeholders. This requires careful pre-assessment of potential risks within the specific context.
Responsiveness	if required according to the needs of involved participants, the study should be able to be adjusted to adhere to ethical standards.
Informed Consent	the participation in your study must be voluntary and the decision to take part must be taken on an informed basis. The participant always has the right to stop participation. For a template of an informed consent sheet, see supporting materials.
Justice	your study should treat all participants equally, independently from their age, gender, physical wellbeing or any other characteristic.

The Research Ethics Tool (Humanitarian Innovation Fund, r2hc, Elrha)

This chapter is based on the guidelines, standards and tools provided by the Elrha (https://higuide.elrha.org/toolkits/get-started/principles-and-ethics/,https://www.elrha.org/wp-content/uploads/2015/01/ELRHA-Interactive-Flipcards-F3.pdf). The following list only gives a short inside into the Research Ethics Tool and is adapted from it.

Planning the study: ask yourself, why you want to conduct the study and why you decided to conduct the study in this specific area/community? Reflect on the questions on how you decided to use certain methodologies and how these might be perceived by the participating community. Carefully evaluate anticipated benefits but also the potential risks related to your study for participants. Reflect on your measures how you ensure confidentiality and privacy and how you plan to ethically obtain and store the collected information. Those aspects related to information of study participants need to be clarified to the participants in an information sheet to which they can give their informed consent to participate. Finally, before starting the study, you might need to obtain ethical approvals from different institutions, such as your own organizational ethics committee, the research ethics committee or from local leaders or governmental bodies.

During implementation: think of the implementation phase and how all involved stakeholders can address any evolving and unforeseen ethical issues and how could you possibly manage required adaptations in your study plan?

At the end of the study: think of how you disseminate and share the findings of your study. Who will have access and how? Reflect on what went well and what could be improved regarding your study implementation and also regarding study outcomes. Ideally, your study results are accessible freely and online. You can use online platforms such as Ridie (https://ridie.3ieimpact.org/index.php).

Institutional ethical approval

It is recommended to seek ethical clearance from an institutional ethics review committee. The committee will help you to adhere to ethical standards and not oversee any critical point that might be connected with your study methodology. To achieve ethical clearance, you will have to check with the requirements of the individual body. Most probably your application for ethical clearance needs to entail the purpose of your study, your detailed methodology (including selection criteria for participants, the description of the filter to test, etc.). You will need to discuss how you plan to adhere to the above-listed ethical standards. A good guideline for this section will be to answer the questions provided in the Research Ethics Tool provided by Elrha/The Humanitarian Innovation Fund. You should also provide all study protocols and tools that you plan to administer. This means that the study needs to be well-developed before you apply for ethical clearance.

Considerations

Adherence to ethical standards is mandatory and should not be neglected. This also requires to plan enough time for developing tools, planning each step of the study and performing a careful risk-analysis before the start of the study. The process of receiving ethical clearance of one or several institutions might take time and be iterative and involve several rounds of feedback and adaptations of your study protocols.

Resources

Research Ethics Tool provided by Elrha/The Humanitarian Innovation Fund:
https://www.elrha.org/wp-content/uploads/2015/01/ELRHA-Interactive-Flipcards-F3.pdf
https://www.elrha.org/researchdatabase/r2hc-ethics-framework-2-0/

Principles and Ethics described by the Humanitarian Innovation Fund: https://higuide.elrha.org/toolkits/get-started/principles-and-ethics/

L.5 Data management

Required	Optional	Group L		Detailed protocol/questionnaire
X		Logistics and preparation		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X	X	X	X	X

For a filter evaluation project, a data management system needs to be established to keep track of the monitoring campaign, including questionnaires and technical measurements completed and planned, ensure the data are protected from disclosure and manipulation, as well as to prevent data loss and enable data transfer between partners.

Background

Most laboratories use data management systems, which enable keeping track of samples and experiments, prevent loss of data, fraud or disclose of protected data and - for certified labs – assure compliance with specific standards such as GMP or ISO 17025. Special data management software is available, which are widely used by laboratories and projects. However, for a relatively small filter evaluation project, the data management system can be established using software and processes already known to all partners including local staff, such as excel tables and document sharing spaces. For questionnaires (interviews, obervations), using mobile phone based systems such as ODK, KoboToolbox or others has certain advantages, in terms of data quality and rapid data collection and transfer.

Description

Basic principles any data management system needs to follow include but not limited to:

- Ensure primary data is secured and protected in its original form and digitalized copy.
- Identify any personal or sensitive data, anonymize data and store any personal or sensitive data i.e. information identifying households (Names, phone numbers, GPS coordinates, consent forms) separately from the data, possibly offline and protected. Define when the personal or sensitive data (i.e. data identifying households, photo and video materials) should be deleted and who is responsible. Map different types of data and communication channel which can be used for its storage and transfer.
- Ensure primary and primary anonymized data is protected from manipulation. Primary data files should always be stored as files with disabled changes protected by a password. All paper-based data should be filed in folders and digitalized. Manual transfer to excel templates should be accompanied with a photo of the original paper sheet or equipment (e.g. agar plate with CFU count visible on it) stored in the same excel file or folder, with the date and name identifying the sample.
- Protect and limit access to primary data but allow easy access to primary anonymized data. If using online data-sharing platforms, ensure data transfer is encrypted, the access is limited to a defined list of people and further sharing of data is not possible without permission and password. Use protected data sharing space offered by organisations (Universities, NGOs) and avoid private solutions (dropbox, google drive) whenever possible.
- Ensure data consistency. Use always the same templates for all monitoring campaigns, do not modify any questions in questionnaires and ensure the data sets can be integrated, use the same units throughout the whole data set. Identify and set name tags used for storing and exporting data.
- Prevent data manipulation and fraud and control data quality. During the study, basic rules to ensure data has been collected properly include distribution of responsibilities between different team members (e.g. persons collecting data in the field give their mobile phones for data transfer to other team members), collection of GPS coordinates, track of consumables and supplies spent and used during the monitoring campaign. Appointment of a person in charge of data quality control as well as quality control visits into the field by team supervisors can reduce the risk of data fraud. All members of the

team should be aware of the measures taken in case misconduct or data fraud is detected, zero-tolerance policy and clear responsibilities and processes in place to address misconduct and data fraud. The clear processes to report data fraud must be established and protect the person who raised concerns. Photo documentation of the results (e.g. photos of the plates after counting colony forming units), as well as regular checks, are helpful. Open communication culture as well as a positive attitude to mistakes can reduce the risk of data fraud as well.

- Ensure data is available in time to all project partners. Set deadlines and ensure that all anonymized primary data is uploaded by these deadlines or otherwise, all partners are notified of a delay and its reasons and a new deadline is set.

- Ensure that any analysis of the anonymized primary data is done in a file stored under a new name tag which can be clearly distinguished from the primary anonymized data.

Resources and materials

Computers, multiple external data storage hard drives, access to a server with sufficient level of protection, sim card with sufficient data on it to upload the filled questionnaires into the server also using mobile network, access to excel, photo camera or mobile phone with a high-quality photo camera with GPS tracking function, mobile phones for questionnaires with sufficient storage space.

Considerations

Ensure that everyone in the team is trained on data management and aware of the general data management principles including management of personal and sensitive data, photo and video materials, data transfer and storage through unprotected channels (private emails, WhatsUp, dropbox, etc.). Ensure that this applies also for visiting project partners, HQ or communication staff and third party visitors. Ensure that "culture of research" is developed and supported within the team. Ensure that supervisionrs are aware of the responisbiity to establish and implement quality control for data management to assure none of it is lost and data protection requirements are respected.

References

KoboToolbox: https://www.kobotoolbox.org/

ODK (Open Data Kit): https://opendatakit.org/

L.6 Field Laboratory management

Required	Optional	Group L	Detailed protocol/questionnaire	
X		Logistics and preparation		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X		X	X	X

Installing and running a field laboratory for water quality analysis in a non-dedicated environment requires preparation and planning. Two major considerations are assuring the safety of all staff working in the laboratory zones embedded in the office space and the office, as well as ensure the proper and reproducible working process in the laboratory.

Background

To perform analytical work, specifically microbiological work with reproducible results with appropriate quality, it is important to introduce and maintain robust processes and create an adequate environment. Laboratory space can be in principle set up in office space when tap water and power supply or gas cooking stove are available on spot or at a short distance.

Description

<u>Team and responsibilities</u>

The process starts with setting up a team and training responsible people to ensure they understand their roles and responsibility, which includes based general management and workflow organisation tasks also safety and quality control. Depending on the number of samples, and workload, it might be important to share responsibilities between team members, with a dedicated responsible person for one or few processes. The processes can include microbial water quality analysis, cleaning and sterilization of the equipment, waste management, maintenance, data recording and transfer. For each of these or other required processes, a standardized operation process (SOP) has to be developed, established and made available for the person responsible but also any other person working in the zone. Ideally, the person responsible for one process overseas also the need for infrastructure, consumables etc. to perform this process and required quality control procedures. This person is also the main contact person, and the name and contact information such as phone number should be accessible and visible to all team members. The person responsible for the entire laboratory space needs to be aware of all SOPs and ensure quality control. A schedule for regular training lessons needs to be established and implemented.

<u>Infrastructure</u>

The laboratory space can be set up basically in any office space, but if possible, a closed room with good ventilation should be preferred. Availability of power supply and running water is an advantage, although basic microbial testing can be done also without it. The laboratory space has to be structured with dedicated zones for different processes and purposes, such as microbial water quality tests, equipment sterilization, cleaning, waste management, storage, and "office work" for data recording and transfer. The purpose of creating zones is to avoid cross-contamination and mixing of samples, as well as ensure the required safety level for all involved staff. The role of each zone needs to be marked and understandable for each person working in the laboratory space and the office it is embedded in. The visibility of the zones is important, e.q. coloured labels on the door or the floor will help to identify the zones and possible safety precautions required. Tables and other equipment (gas stove, pots, refrigerator, towels, pens, etc.) used in the laboratory zones should not be used for any other purposes.

<u>Daily management and organisation</u>

To organize the workload a working schedule is essential. The lab manager should do the organisation of the workload at least once per week. To ensure a proper information flow, it is useful to inform all the lab staff / involved persons by periodical team meetings. The experiment/analysis has to be performed according to the corresponding SOP. Each test/experiment has to be documented in a laboratory journal positioned in the laboratory zone. This journal is not personal but is used by everyone who is performing the SOP and should never leave the laboratory. A defined format for the data collection in a laboratory journal is strongly recommended. It should be clear who performed which task, the date and time the tasks were performed and any further relevant information. Once a day, the lab manager or another responsible person should proof the results and the documentation, and ideally sign the lab journal daily. The laboratory journal is a primary data (see L5) and needs to be archived also after the data have been transferred into electronic format.

Quality control / Quality assurance

Equipment and method tests are recommended to be done periodically. At least once per day, 1-3 blank samples with mineral bottled water, and when possible a standard sample (sample with known content, such as containing bacteria used in integrity test) should be analysed. Critical samples should always be measured in duplicates, and once a day, a measurement of a triplicate sample is required.

In case the results show variation exceeding 20% for microbial analysis, or blanks are contaminated with cells, all analysis should be stopped and the contamination reported to the responsible person. This or another equally qualified person aware of the SOP should be involved, and all steps critically analysed to detect and eliminate the source of contamination. The samples need to be stored in the refrigerator during this time and tested as soon as the problem is identified and eliminated. All samples need to be stored and only disposed of after the data in the laboratory journal have been signed by the responsible person.

Training

To ensure a constant and adequate quality of labwork including technical issues a continuous optimisation and training system has to be implemented. Ideally, a training matrix has to drown up and each training has to be documented.

Maintenance

Infrastructure might need periodical maintenance according to the specific supplier and quality requirements. To cover all necessary maintenance work and quality tests it is necessary to plan the activities in a calendar (hardcopy or electronically). The person who is doing the tests/Maintenance work, the time of execution, and according to which SOP it is implemented should be visible.

Waste Management

Any laboratory activity leads to generation of waste and no activity should begin unless there is a plan how to handle waste generated. The best way to manage laboratory waste is to prevent it generation as much as possible. The waste generated needs to be sorted in at least three categroies – general waste, waste presenting chemical hazard and waste presenting biological hazard. The water quality analysis required for evaluation of filters in field produces mostly two types of waste: general waste as well as waste presenting biological hazard. The information sheets T1 and T2 as well as corresponding protocols include Waste Management section which needs to be considered while setting up the methods.

Resources and materials

- Folder with SOP (hardcopy/electronically)
- Marking tape
- Workbench / Safety workbench/office bench
- Lab equipment (e.q. funnel, pipettes, disinfection material, incubator)
- Personal protective equipment if required by SOPs (e.q. safety goggles, gloves, lab coat)
- Access to Excel and Server used for data management (see L5)

Considerations

When setting up the laboratory space with staff without prior laboratory experience, a re-organisation might be required after some time, after the processes are clear and implemented by all staff. Thus, the zone concept should be revisited and considered to optimize the workflow. Data fraud and research misconduct is unfortunately a reality in many laboratories. This might happen for many reasons, such as high workloads, lack of understanding of the project goals and objectives, tendency to report good results only, fear to report mistakes, laziness, lack of ownership, conflicts with management or many others. At least two people must share the responsibilities and are capable of doing all work to ensure there is no information and knowhow loss as well as to reduce the risk of data fraud or misconduct. The clear processes to report data fraud must be established and protect the person who raised concerns. A project manager should always be aware of the main steps of the analysis and be able to control and verify the results. Photo documentation of the results (e.g. photos of the plates after counting colony forming units), as well as regular checks, are helpful. Open communication culture as well as a positive attitude to mistakes can reduce the risk of data fraud as well.

Waste management is often neglected and no activity in the lab should be started unless there is a clear plan for managing waste for each method implemented.

L.7 Team training

Required	Optional	Group L		Detailed protocol/questionnaire
X		Logistics and preparation		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X	X	X	X	X

Training and capacity development are fundamental components of any WASH project, and a filter evaluation project is no exception. The background, capacity, ability, workload, experiences, expectations, as well as attitude and motivation of the field WASH team, will define the objectives and the scope of training, as well as the need for regular follow-up trainings.

Background

The attitude and motivation of the team are pivotal for the success of any project. If project objectives are unclear or if the team feels overwhelmed and sees the project as additional work, it's crucial to engage in discussions with the entire team to identify and address problems and concerns. While it's considered best practice to involve the field team in project development and planning from the outset, this doesn't always happen in reality.

The primary goal of training is to ensure the team comprehends the objectives, understands the methods, familiarizes themselves with project documentation and manuals, and defines responsibilities. Additionally, training should address logistics, infrastructure, materials, consumables, and the employment and training of volunteers or additional staff. Workflows can be developed, timelines revisited and adjusted to reflect local limitations and context, and reporting mechanisms established during training sessions.

Training can be conducted over multiple days, but it's essential to ensure the presence and awareness of all team members regarding their responsibilities and tasks. It's also important to have all necessary hardware (filters, lab space, consumables for analysis, mobile phones with installed software) readily available. Whenever possible, avoid relying solely on PowerPoint presentations and opt for a hands-on approach to training.

Description

Table 17 summarizes the major steps of the training.

Table 17 Training steps

Define and discuss the objectives of the training	Discuss the expectations of the team and your own. Set and discuss learning goals and expected outcomes
Define and discuss overall objectives of the project	Provide an overview of the background of the project, research questions, general project activities, timeline and deliverables.
Define and discuss the objectives of the field study	Explain and discuss how the objectives of the field study contribute to the overall project goals, what are drawbacks and limitations
Introduce the methodology and methodology documentation	Discuss in detail all steps of the methodology, ask questions and assure that all steps are understood. Introduce the manual and use it during the training.

Introduce the filters	Explain the working principle of filters. Provide hardware (filters) and let team members install, operate and maintain the filter as they would be community members (role game). Ensure that all team members are participating in the practical part. Assign tasks or roles if this is not the case.
Define, discuss, re-think and agree on the timeline	Discuss and define the project timeline and planned number of monitoring visits (see table 2). Discuss if there are any limitations and how the team perceives the timeline. Discuss if any holidays, events, etc. might cause delays. Reconsider the timeline with the team and create a timeline together in a participatory process. Assure that not only the team leader speaks.
Introduce the specific methods and clarify responsibilities and workflow	Explain the methods in general. The team might have preferences or be organized in the way to take responsibility for different methods. Clarify with the team and record the responsibilities on a whiteboard or sheet. For each task, there should be a leader, and at least one other responsible person. Together with the team, build and visualize the workflows.
Explain methods to responsible team members	Train the responsible team members but assure that the rest of the team is involved and participating in the training. The specific topics include but not limited to: • Logistics, filter distribution and organization (general aspects, as well as sections L and D) • Technical data collection and analysis (section T) • User acceptance evaluation methods (Section U) • Data management and quality control (L.5.) • Reporting and communication channels Check that all consumables are available, the software is installed, questionnaires are uploaded, etc. Use videos or create videos of the complex methods (with the agreement of the team).
Revisit timeline	Discuss the timeline and assure that all changes required by the team due to a better understanding of methods and tasks are implemented.
Establish communication	Discuss and establish communication channels. Assure that all team members understand which communication channel can be used for which information and aware of ethical concerns and regulations regarding disclosure of sensitive information (e.g. photos of the households sent over WhatsApp is a no go). Map data types and communication channels.
Summarize	Revisit your learning goals, and summarize the main points
Arrange for follow up	Set up the time and define objectives for a follow-up training.

Resources and materials

Personal meeting or series of online trainings (ensure good quality internet connection), manual, all consumables, software, hardware required (use checklists in the resources and materials sections for all information sheets).

Considerations

Training is typically conducted before a project begins, ideally during a personal field visit. However, the vast amount of information and the limited time available for training often result in an overload for team members. To mitigate this, it's important to allocate sufficient time for training, incorporate enough breaks, and encourage social interactions whenever possible. During training, the practical aspects should be led by team members, utilizing manuals, protocols, or videos as guidance. It's essential to avoid demonstrations that are not immediately followed by hands-on practice to ensure effective learning.

D Distribution and user training

Section D addresses the interactions with the users concerning delivery of filters (D1), training on operation and maintenance of the filters (D2), as well as follow up discussion regarding the responsibilities and strategy to deal with damage or failure of products after the end of the study (D3).

D.1	Filter distribution
D.2	User training
D.3	Follow-up briefing

D.1 Filter distribution

Required	Optional	Group	Detailed protocol/questionnaire	
X		Filter and context pre-evaluation		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
		X		

Filters are distributed to each household one by one followed by a non-participatory observation of the assembly and operation, microbial water quality sampling, integrity test, monitoring questionnaire to capture first impressions and experiences as well as extensive training on operation and maintenance of the filter.

Background

Filter distribution is an important step of the study. Sufficient time needs to be planned for this step to avoid hurry resulting in poor training of the users and poor quality of the collected data. Reserve days need to be planned into the schedule in case some of the users are not at home. The appropriate vehicle should be used for transporting the filters to households. The filters should be fixed in the vehicle to reduce risk of damage to housing, packaging or filter elements.

Description

Plan how many households you can visit during one day and in which area depending on the distance, traffic, and state of roads. For the introduction of the filters, you would require about 1 hour per household. If multiple filters are begin evaluated in the study, check which filters are assigned to which households and make them ready, with filter IDs visible on the filter housing and packaging. Introduce yourself without waiting for the respondent to ask questions before you start. Remind the user about the study set up. Confirm that users are aware that the filters are part of a study and they gave consent to be visited by a monitoring team as well as answer questions.

Please deliver the filter to the household. Check that the household ID number corresponds to the filter ID number assigned. Do not unpack the filter - hand filter over to the household as provided by the manufacturer or assembled in the office. For the filters without integrated housing - provide buckets or jerry cans additionally but without any explanation. Do not fix taps, candles etc. beforehand. Provide also any materials provided by the manufacturer together with the filter. This step is usually followed by a non-participatory observation of the use (see U4).

Resources and materials

Filters, permanent marker, possibly water if users are likely to have a water shortage in the household, mobile phones with uploaded questionnaires, hand-sanitiser, equipment required for water sampling (see section T).

Considerations

When user expectations do not address by the design of the filter, all concerns should be discussed. Users have a right to drop out of the study any time, and should not be put under pressure to accept the filter if they do not want it. When only one filter is evaluated during the study, one filter could be carried out and shown to users before they sign consent forms. This can however interfere with the non-participatory observation of the assembly of the filter, as users would know how the filter should look like. Both factors need to be discussed with the team. Once the decision is taken, it should be implemented in all households.

D.2 User training

Required	Optional	Group	Detailed protocol/questionnaire	
X		Filter and context pre-evaluation		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
		X	X	

Users should be trained on assembly, operation and maintenance of the filters to assure that they understand how the filter works and what is required to operate and maintain it correctly. Training should be done after non-participatory observation of use and operation (see U4) during the introduction visit. Follow up training proved to be very efficient during first filter monitoring to ensure that users operate the filter correctly, get all questions answered and concerns addressed.

Background

Training of users on operation and maintenance of filters usually follows the operation and maintenance (O&M) guidelines or the manual provided by manufacturers. If possible, the users who are finally responsible for operation and maintenance of the filter (often women) should be trained on its use actively, while other household members should be possibly present and support the main user in assembly, O&M.

Description

Any supporting information provided by the manufacturers should be translated into the local language before the study. It is usually an advantage when the filter assembly, O&M can be explained by pictograms without using words. Instructions printed on paper are likely to get lost, and printings directly on filter housing or water buckets and jerry cans should be preferred whenever possible.

The training usually includes three major steps:

- Control of the correct assembly and leakage of the filter element by tightening of the filter elements sealings
- Demonstration of the correct operation of the filter. After the user has observed the operation, she should try to do it on her own, till she can obtain a sufficient amount of water. Any questions at this stage should be answered by the trainer, and misunderstandings explained. Users who understand the principle of operation of the filter are likely to do fewer mistakes in its operation.
- Demonstration of the maintenance of the filter. Also, in this case, the user should try to implement and test the maintenance procedure on her own. The trainer should explain what materials can be sued for cleaning the filter, the major risks related to recontamination of the clean water tank. Whenever available, attention must be paid to pictograms and drawings on the filter or housing explaining the major steps.

Users need to receive clear instructions on what to do in case of the damage of the filter and provided with the phone number of a contact person. At the end of the training, users are handed in the sheets which they can use to record daily use of the filter for filter use estimation (see T4.)

Resources and materials

Functional filter, water if not available or limited in the household, printed instructions.

Considerations

It is important to ensure that the trainer understands the functionality and operation of the filter. Training of trainers on operation and maintenance should be by manufacturers whenever possible followed by a detailed discussion and documentation of experiences.

D.3 Follow up briefing and wrap-up

Required	Optional	Group	Detailed protocol/questionnaire	
X		Filter and context pre-evaluation		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X	X			X

An exit strategy is required after the filter evaluation study. This exit strategy needs to address the responsibilities concerning maintenance, reporting of damage, potential replacement of the products, provision or/and access to consumables or hardware as well as alternative water treatment strategies if filters fail. The communication of the exit study, leaving sufficient time to address concerns and answer questions is crucial at the end of the study.

Background

Users should be allowed to keep and use the filters after the evaluation study is completed if they want it and there are no concerns related to filter performance or ability of the users to operate and maintain the filters properly. If this is not possible, alternatives strategies for water treatment should be introduced and discussed. If users decide to keep the filter, they need to have a strategy on how to deal with damage and breakdown of the products. They also need to-know where to buy spare parts or consumables and who to contact in case of any questions. If the filter can be replaced with the same or alternative product, users need to know where to find it and at what costs.

Description

Table 18 summarizes major steps and considerations.

Table 18 – Major considerations for follow-up briefing and wrap-up

Steps	When	Activities
Prepare the exit strategy	Preparation phase	Decide • If users can keep the filters • Who provides support after the study is over and how is it financed • What are alternative products if filters are not available on the local market • If locally available spare parts can be used • What additional information users might require after the study • What alternative technologies or concepts can be used beyond water filters
Communicate the exit strategy	General introduction of the study and baseline data collection	Communicate to the users what will happen with the filter after the study is over if • The filter performs well and is well accepted • The filter performance is poor or it is not accepted Discuss and assure the users understand the exit strategy before they sign the consent form for the study.
Define users who want to keep the filters	Final data collection	Ask if a user wants to keep the filters. If so, • Check the conditions of the filter. Check for leakage or damage. Replace any damaged parts, and maintain the filter using the maintenance guideline provided by the manufacturer. • Provide information about who provides support after the end of the study. Share contact phone number. • If filters can be bought locally, share contact information of service centre or next shop. If not, share information for alternative products or spare parts (e.g. taps) which can be used instead. • Discuss the steps required to deal with the most common damages. Provide any printed or online materials if available. • If consumables or replacing of elements is required, discuss and provide information on the frequency of change or indicators. • Inform and discuss possible alternatives to filter • Allow enough time to address concerns and answer questions. If you do not know the answer, clarify it afterwards and follow up with a phone call.

Steps	When	Activities
Define users who do not want to keep the filters	Final data collection	Ask if a user wants to keep the filters. If not, • Clarify the reasons • Inform and discuss possible alternatives to filter • Collect the filter
Collect and record any communications	1-2 years after the study	Keep record on any calls, reported damages, and strategies people use to deal with problems
Organise follow up visit	After at least 1 year after the end of the study	Make a follow up visit and collect information using standard monitoring questionnaire and technical performance evaluation.

Resources and materials

Filter operation and maintenance printed instructions. Spare parts if applicable. Information related to supply chain for filters. Template for recording which filters are kept and their condition.

Considerations

Since funding might not be available after the study it might be difficult to assure the quality support after the study. Especially for products which do not have an established supply chain in the country, the after study support might be very limited. If possible, some resources should be kept to assure support for at least 1 year after the end of the study. The support should focus on helping users to help themselves as filed visits might be difficult or impossible.

T Technical performance evaluation

T section addresses the technical performance evaluation of the filters including microbial water quality assessment using indicator organisms (T1), filter integrity evaluation using spiking of probiotic bacteria (T2), evaluation of filtration flow rate (T4), reported, observed and measured filter use (T5), filter robustness and durability (T6), as well as measurement of general water quality parameters such as turbidity, conductivity, pH, dissolved oxygen and colour (T3).

T.1	Microbial water quality
T.2	Filter integrity
T.3	Filtration flow rate
T.4	Filter use
T.5	Robustness and durability
T.6	General water quality parameters

T.1 Microbial water quality

<table>
<tr><td>Required</td><td>Optional</td><td>Group</td><td colspan="2">Detailed protocol/questionnaire</td></tr>
<tr><td>X</td><td></td><td>Technical performance</td><td colspan="2">Annex P1</td></tr>
<tr><td colspan="5">Applicable to:</td></tr>
<tr><td>Preparation</td><td>Baseline</td><td>Introduction visit</td><td>Monitoring</td><td>Final data collection</td></tr>
<tr><td>X</td><td></td><td>X</td><td>X</td><td>X</td></tr>
</table>

Microbiological water testing involves testing for indicator organisms as a sign of potential faecal contamination rather than testing for specific pathogens. Testing samples before filtration, after filtration and at the outlet tap of the filter (which might be directly after filtration or after storage water container) provides information on the reduction of microbial contamination by the filter compared to raw water. This combines filtration performance of the filter as well as possible re-contamination occurring on the "clean side" of the filter element, in the storage container or at the tap.

Background

Traditionally, indicator organisms were defined as microorganisms which presence in water samples can be related to the probable presence of pathogenic organisms (disease-causing organisms). Today, it is recognized that there is no direct correlation between numbers of any indicator and enteric pathogen. Commonly, three groups of indicators are used for different needs summarized in the Table 19.

Table 19 Overview oft he indicator microorganisms and their characzeristics (adapted from WHO, https://www.who.int/publications/i/item/924154533X

Group	Definition	Examples
Process indicators	A group of organisms that demonstrates the efficacy of a process	Total heterotrophic bacteria, total coliforms
Faecal indicators	A group of organisms that indicates the presence of faecal contamination and infers the presence of pathogens	Escherichia coli (E. coli), thermotolerant coliforms, Enterococci
Index and model organisms	A group/or species indicative of pathogen presence and behaviour, which can be used a models	E. coli as an index for Salmonella and F-RNA coliphages as models of human enteric viruses

E.coli is currently considered to be the most appropriate group of coliforms to indicate faecal pollution from humans and warm-blooded animals. However, thermotolerant coliforms and sometimes Enterococci are commonly used as well.

Description

The quantification of the indicator microorganisms such as E.coli, thermotolerant coliforms or Enterococci in samples can be done in a local certified lab for water quality analysis. Alternatively, an implementing organisation can conduct bacterial water quality analysis using the ready-made field test kits. Usually, the use of kits requires only limited training and no special additional infrastructure. There is a variety of test kits available on the market. These test kits utilize one of the three approaches:

- Presence-absence test does not provide quantitative information, but change colour in case microbial contamination has been detected. They are not well suitable for filter evaluation projects.

- Most probable Number tests are semi-quantitative. The user fills the sample in a set of already prepared plastic bags or tubes and adds a nutrient solution. After incubation, lasting between 12-48 hours depending on the kit and temperature, the colour change indicates the number of positive samples which can be converted after in the estimation of the concentration of bacteria using statistical method.

- Culture media-based test with or without membrane filtration. These tests are the most quantitatively accurate. When used with membrane filtration, a 100 ml sample is collected and filtered through a membrane disk filter with a pore size of 0.45µm. The membrane disk filter is after placed on a culture media and incubated for 24 hours at 36-37 degrees. The colonies grow on the media and change their appearance (usually colour). User can count colonies to determine how many colony-forming units were present in the 100 ml sample. When source water is considered contaminated, instead of 100 ml sample, 1 ml sample can be placed directly on the plate containing culture media. In this case, the final number needs to be corrected by factor 100 to account for the change of volume.

The most probable number and culture media based tests can be used for filter evaluation. Culture media based tests are usually preferred as as are often cheaper and provide more accurate results in field conditions. Presence-absence test does not provide sufficient information to draw any conclusions about the filter performance or recontamination and should not be used.

The tests can be done by the implementing organisation directly when there is space available to establish a basic field laboratory (see L6) and conusmables can be shipped or bought locally. Alternaitvely, sample processing and analysis can be outsourced to a local water laboratory or University. In this case, it is important to discuss and agree on the method, timeline and quality control measures.

Independently on the method used, the following steps will be required when samples are done by the implementer. If the sampes are processed by the local laboratory the implementer needs still to prepare samplie collection:

Preparation	Prepare a sufficient number of the sterile containers (glass, plastics bottles or sterile sampling bags) for sample collection and number them using permanent marker or a sticker at least in two places. If efforts to require to collect samples are high and involve long travel, unsecure environment or limited access, it is recommended to collect multiple samples and store then cooled to minimize loss of data and enable repetition of the measurements if needed. Prepare a cool box containing crashed ice or cooling elements of the appropriate size to accommodate all samples.
Sampling collection and transport	Always disinfect your hands with a hand sanitiser or an alcohol swab before taking samples. The first 100 ml of water should be discarded and the sample was taken without closing the tap in the between. When there is not enough water in the raw or the clean water tanks of the filters, ask the user to refill the filter. Samples need to be collected into sterile containers. The sample size is defined by the method used as well as the sampling protocol (e.g. necessity of triplicate measurements for each sample or only for selected samples). Collected samples need to be stored cooled, when possible at 4 °C and processed within 24 hours. Overheating, exposure to sunlight or UV light and freezing cause damage of the microorganisms in the sample and should be prevented.
Sample processing	The exact protocol provided by the manufacturer of the test kit needs to be followed. When culture media based tests are used in combination with membrane filtration, it might be necessary to plate also 1 ml sample directly without membrane filtration when the E.coli counts are expected to be high, i.e. in raw water samples. All equipment which comes in contact with the sample (filtration funnel or set, pipettes, tweezers) need to be kept sterile. In the field conditions, alcohol, open flame or boiling water are commonly used.

Incubation	Incubation should be conducted according to the information provided by the test kit manufacturer. Usually, incubation at 34-37 °C during at least 24 hours would be required. In some cases, manufactures of the test kits provide strategies to overcome data loss due to improper incubation due to power cuts or temperatures lower than required. This can include an extension of the incubation period for the duration of the power cut up to 36-48 hours. Carrying samples in the pockets or a body belt for incubation using body temperature can be done in exceptional cases, but is not recommended.
Counting and data recording	Most of the test kits rely on the manual counting of colonies, fields or points, the results need to be transferred manually into an electronic table (usually excel table). See data management sheet.
Disposal of waste	Used bacterial medium plates always should be disposed of as biohazardous material, because potentially pathogenic microorganisms can grow and replicate on the plates. If there are no safe hazardous waste disposal system in place, used plates need to be disinfected with chlorine or thermally (see Safe disposal section of the P1 protocol). After that the can be disposed of as solid waste.

Establishing reliable quality control procedures would help to increase the quality of data and is a must. The exact quality control procedure would depend on the number and type of samples, test kit used and the capacity. The minimal requirements for quality control include:

- at least two blank samples per sampling day. Blank samples mean sampling water which does not contain any microbial contamination in the field following the same steps as for the samples. Usually, bottled water or previously boiled and cooled water can be used as blank.
- Multiple samples (at least 3) taken from the same sampling point at least twice per day if multiple samples from each point are not possible for logistical or capacity reasons.
- At least 1 positive sample per sampling day. Positive sample means a water sample which contains E.coli bacteria. Under field conditions, this can be a sample taken from a toilet or untreated water source with a high probability of contamination.

The measurements need to be repeated if blank samples are contaminated with E.coli, or the positive control shows negative result.

Resources and material

Test kit for detection of indicator microorganisms	Microbial water quality test kit or its elements. For plating method, this includes: e.g. Delagua Test Kit or Compact Dry Plates EC, Vacuum membrane filtration device, Sterile membrane filters 0.45µm, Device for generating vacuum (vacuum pump, hand vacuum pump of the syringe)
Incubator	Field incubator capable to hold 36-37 °C over 24 hours. If field incubators are not available, egg hatching incubators can be tested
Sample bottles or bag	Sterile bottles or plastic bags such as Whirl Pak® should be used. Bottles or plastic bags can be re-used by cleaning properly and sterilizing with water vapour or hot water.
Sample cooling	Coolbox with ice packs or cooling elements or crashed ice
Equipment sterilization	Testing equipment can be sterilized by immersing it for 3-10 min in boiling water or by cleaning it with alcohol. If stainless steel equipment is used, it can be also sterilized over open flame or by flaming methanol in it.
Basic laboratory space and supplies	Table not used for any other purposes, power supply (grid, solar, car-batteries), hand sanitizer, permanent marker, paper block or electronic device to record results.

Data analysis and visualization

Assure that all data is summarized in the excel table using the same units. Covert all numbers into one unit if required (e.g. CFU/100 ml) considering the sample volume. Usually, the data is presented in the graphical form which shows:

Actual numbers	The graph shows actual colony counts or most probably the number for raw water, filtered water and stored water. When the difference between raw water and filtered water exceed factor 10, the logarithmic scale might be useful. In this case, all 0 counts need to be replaced with 0.5.
Log-removal values	The log reduction values (also called Log removal values or LRV) are commonly used to calculate and visualize the magnitude of change of bacterial numbers due to a process (e.g. filtration, disinfection). Log reduction is calculated using the formula: Log reduction = Log10(A)- Log10(B) where A is the colony count in raw water, and B is the colony count in the filtered water. We should consider that both raw water and filtered water will influence the LRV value, meaning that when raw water has low counts, the LRV will be low, which can lead to misinterpretation of the filter removal performance.
Number of samples per type in each risk category	This method shows the number of samples with a result in a defined range. The ranges need to be defined and can indicate the risk of the presence of pathogenic microorganisms in a water sample. For example, following risk categories can be used for E.coli: 0 CFU/100ml (low risk), 1-10 CFU/100ml (medium risk), 11-100 CFU/100 ml (high risk); >101 CFU/100 ml (very high risk). This method is useful when raw water has many 0 or very low values or recontamination of water is observed and need to be visualized.

The data analysed in all three or any other way finally need to be interpreted to answer if

- Treated water corresponds to the local water quality guidelines for E.coli and is likely to be safe to drink;
- Recontamination of water in the storage tank is observed;
- The filter is functional and/or to which extent water the filter improves the quality of water compared to raw water with and without considering recontamination.

Considerations

Low concentration of indicator microorganisms in raw water makes evaluation of the filter performance difficult or impossible. Nevertheless, the testing would provide information if recontamination occurred in the system or not and if the water is likely to be safe in general. Presence of free chlorine in the raw water will influence the results leading to lower numbers or false-negative results. Thus, the free chlorine should be measured. This can be done by simple DPD based tests such as pool tester or test strips. In case the free chlorine is detected or likely to be detected, Sodium thiosulphate containing sampling bottles or sampling bags should be used to remove free chlorine from the water samples. Some test kits enable testing E.coli together with Total Coliforms using the same media. In such cases, the data need to be interpreted carefully considering the conditions. Coliforms are a heterogeneous group of organisms, many of which are not of faecal origin. Although useful as a model organism e.g. for detection of the efficacy of chlorination, the presence of coliforms in water filters is a poor indicator to evaluate microbial removal performance of filters. The reason for that is that many coliforms can multiply in a warm environment and may colonize the clean side of the filter or water storage containers, and persist in the filter over a long period of time. This behaviour is not common for most human pathogenic organisms, and therefore any correlations should be avoided.

References

World Health Organisation (2001). Water quality: Guidelines, standards and health, Chapter 13: Indicators of microbial water quality, https://www.who.int/publications/i/item/924154533X

Constructing low cost mobile incubator: https://www.jove.com/t/58443/construction-low-cost-mobile-incubator-for-field-laboratory

T.2 Filter integrity

Required	Optional	Group	Detailed protocol/questionnaire	
X		Technical performance	Annex P2	
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X		X	X	X

Filter integrity testing is important when the presence of the indicator microorganisms in raw water is low or varies considerably during the study and for different users. The integrity testing can be done by spiking non-pathogenic microorganisms in raw water at high concentrations and detecting these organisms in raw water and filtered water. The magnitude of reduction indicates the efficiency of water treatment disregarding the impact of recontamination and helps to detect any damage to the filter.

Background

The integrity of the filter in the field can be compromised by incorrect operation and maintenance, failure to install the filter correctly or manufacturing quality control problems. Common integrity problems include open or loosely tightened rubber or silicon sealing, mechanical damage of the filter elements not visible to users (micro-cracks, pinholes, broken fibres) or cracks in plastics between raw water and a clean water tanks in "two buckets" systems. Some manufacturers provide particles (usually clay particles), which can be used to spike water and measure turbidity or observe colour or cloudiness variations.

This method is useful to detect severe leakages but might fail to detect small damages or poorly sealed connections. Particles might interact with organic matter in water or adsorb on plastics and filter material, which would make the results unclear. Usually, microbial water quality measurements using indicator organisms would provide clearer results. This measurement is sufficient when concentrations of indicator bacteria in raw water are high and relatively constant over time and hygienic conditions in households are generally good. However, when the presence of the indicator microorganisms (e.g. E.coli) in raw water is low, varies strongly between locations and in time, or there is a severe re-contamination issue in or after the filter, integrity problems with the filter cannot be identified by measuring indicator microorganisms in raw and filtered water. For this, a method based on spiking of non-pathogenic, pro-biotic microorganisms at high concentrations and measuring their removal by the filter is a reliable and relatively easy to implement option.

Description

Filter integrity test methodology includes spiking probiotic indicator bacteria (Enterococci or E.coli) in raw water in collecting samples of raw and filtered water, which are subsequently analysed using plating method suitable for testing the spiked indicator organisms.

The method includes a preparation phase based on the identification and pre-testing of the concentrations required for spiking and dilution rates during the measurements to enable detecting at least 4-Log removal.

The following general steps will be required:

General preparation for integrity testing	Identify the probiotic microorganisms available (Enterococci, E.coli) as well as the suitable detection method. We have applied Bioflorin® combined with Nissui® Compact Dry Plates ETC in multiple studies. However, other probiotic microorganisms and products can be used as well. Estimate the dilution rate required based on the volume of the filter tested, the number of cells contained in one pill, capsule or tab used, and the detection limit of the method you use and test it. Usually 1 capsule is dissolved in 1 L of water by opening the capsule and emptying its content in water, or crashing the tab or pill and mixing for 3-5 min. A defined volume of this stock solution is added into the filter. Based on the pre-testing, develop a detailed protocol for the field. P2 provides an example of such protocol.

Preparation for sampling	Prepare the solution used for spiking shortly before use using bottled, groundwater or previously boiled and cooled tap water (assure water is not chlorinated). Do not store it longer than 12 hours. Prepare a sufficient number of the sterile containers (glass, plastics bottles or sterile sampling bags) for sample collection and number them using permanent marker or a sticker at least in two places. If efforts to require to collect samples are high and involve long travel, unsecure environment or limited access, it is recommended to collect multiple samples and store then cooled to minimize loss of data and enable repetition of the measurements if needed. Prepare a cool box containing crashed ice or cooling elements of the appropriate size to accommodate all samples.
Sampling collection and transport	Always disinfect your hands with a hand sanitiser or an alcohol swab before taking samples. The first 100 ml of water should be discarded and the sample taken without closing the tap in the between. When there is not enough water in the raw or the clean water tanks of the filters, ask the user to refill the filter. Samples need to be collected into sterile containers. The sample size is defined by the method used as well as the sampling protocol (e.g. necessity of triplicate measurements for each sample or only for selected samples). Collected samples need to be stored cooled, when possible at 4 °C and processed within 24 hours. For integrity test, always take clean water samples before you take raw water samples and store clean water samples in different coolboxes or in different closed plastic bags in one cool box. This will reduce the risk of cross-contamination. Overheating, exposure to sunlight or UV light and freezing cause damage of the microorganisms in the sample and should be prevented.
Sample processing	Exact protocol provided by the manufacturer of the test kit needs to be followed. When culture media based tests are used in combination with membrane filtration, it might be necessary to plate also 0.1ml or 1 ml sample directly without membrane filtration when the Spiked bacteria counts are expected to be high, i.e. in raw water samples. All equipment which comes in contact with the sample (filtration funnel or set, pipettes, twizzers) need to be kept sterile. In field conditions, alcohol, open flame or boiling water are commonly used.
Incubation	Incubation should be conducted according to the information provided by the test kit manufacturer. Usually incubation at 34-37 °C during at least 24 hours would be required. In some cases, manufactures of the test kits provide strategies to overcome data loss due to improper incubation due to power cuts or temperatures lower than required. This can include extension of the incubation period for the duration of the power cut up to 36-48 hours. Carrying samples in the pockets or a body belt for incubation using body temperature can be done in exceptional cases, but is not recommended.
Counting and data recording	Manual counting of colonies on the plates would be required. If the number of counts on the plate exceed the detection limit (usually 150-300 CFU/plate), than this needs to be indicated in the data. If the conts are so high, it is impossible to count, the data should be recorded anyway as too many to count or by a number agreed in advance (e.g. 999 or 301 CFU/plate). Counts exceeding the detection limit can still be useful for data analysis, but repetition of the measurement with a proper dilution of the sample should be done whenever possible. The results need to be transferred manually into an electronic table (usually excel table). See data management sheet.
Disposal of waste	Used bacterial medium plates always should be disposed as biohazardous material, because potentially pathogenic microorganisms can grow and replicate on the plates. If there are no safe hazardous waste disposal system in place, used plates need to be disinfected with chlorine or thermally (see Safe disposal section of the P1 protocol). After that the can be disposed as solid waste.

Establishing reliable quality control procedures would help to increase the quality of data and is a must. The exact quality control procedure would depend on the number and type of samples, test kit used and the capacity. The minimal requirements for quality control include:

- at least two blank samples per sampling day. Blank samples mean sampling water, that does not contain any microbial contamination in the field following the same steps as for the samples. Usually, bottled water or previously boiled and cooled water can be used as blank.

- Multiple samples (at least 3) taken from the same sampling point at least twice per day if multiple samples from each point are not possible for logistical or capacity reasons.

- Positive samples for all raw water samples containing spiked microorganisms and which are in the range of detection of the method used. This means the number of cells counted on the plate does not exceed the specific detection limit for plating (usually 150-300 CFU/plate). If this is the case, dilution of raw water before testing is required.

The measurements need to be repeated if blank samples are contaminated with spiked microorganisms, or the positive control shows negative result.

Resources and materials

Pro-biotic microorganism for spiking	Pro-biotic Enterococci or E.coli can be used. The stability of the microorganisms needs to be tested. Bioflorin® showed to be well suitable with around 800\`000-2\`000\`000 cells probiotic Enterococci per capsule.
Test kit for detection of indicator microorganisms	Microbial water quality test kit or its elements specific for the microorganisms used for spiking. For Enterococci this can be Nissui® Compact Dry Plates ETC from Hyserve®, Vacuum membrane filtration device, Sterile membrane filters 0.45µm, Device for generating vacuum (vacuum pump, hand vacuum pump of the syringe).
Incubator	Field incubator capable to hold 36-37 °C over 24 hours. If field incubators are not available, egg hatching incubators can be tested.
Sample bottles or bag	Sterile bottles or plastic bags such as Whirl Pak® should be used. Bottles or plastic bags can be re-used by cleaning properly and sterilizing with water vapour or hot water. If chlorine is likely to be present in water, sodium thiosulfate tabs might be required to remove chlorine.
Sample cooling	Coolbox with ice packs or cooling elements or crushed ice
Equipment sterilization	Testing equipment can be sterilized by immersing it for 3-10 min in boiling water or by cleaning it with alcohol. If stainless steel equipment is used, it can be also sterilized over an open flame or by flaming methanol in it.
Basic laboratory space and supplies	Table not used for any other purposes, power supply (grid, solar, car-batteries), hand sanitiser, permanent marker, paper block or electronic device to record results.

Data analysis and visualization

Assure that all data is summarized in the excel table using the same units. Covert all numbers into one unit if required (e.g. CFU/100 ml) considering the sample volume. Usually, the data is presented in the graphical form which shows:

Log-removal values	The log reduction values (also called Log removal values or LRV) are commonly used to calculate and visualize the magnitude of change of bacterial numbers due to a process (e.g. filtration, disinfection). Log reduction is calculated using the formula: Log reduction = $Log_{10}(A)$- $Log_{10}(B)$ where A is the colony count in raw water, and B is the colony count in the filtered water. We should consider that both raw water and filtered water will influence the LRV value, meaning that when raw water has low counts, the LRV will be low, which can lead to misinterpretation of the filter removal performance.

The data analysed needs to be interpreted to answer if the filter is functional and to what extend compared to laboratory values.

To estimate the performance of the filter, the LRV values suggested by WHO (see Table 20) could be used as an indication of the acceptable performance. Filters showing less than 2-Log reduction for indicator bacteria should be tested again and repaired or replaced.

Table 20 Performance classification for housheold water treatment and safe storage based on removal of bacteria, viruses and protozoa proposed by WHO*

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

* https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/water-safety-and-quality/household-water-treatment-and-safe-storage

Considerations

Concentrations of the probiotic bacteria added to raw water should be chosen so, it is possible to detect them within the detection limit of the method. Depending on the method used, this could be e.g. 150-300 CFU/ plate. It might be necessary to dilute raw water before plating it, which can be done with bottled water. 1 ml samples applied directly to the plate without filtration can be considered as well. Usually, a pre-test would be required to define the raw water concentration, which would allow detection of at least 4-Log removal. Presence of free chlorine in the raw water will influence the results leading to lower numbers or false-negative results. Thus, the free chlorine should be measured if it is likely to be present in raw water. This can be done by simple DPD based tests such as pool tester or test strips. In case the free chlorine is detected or likely to be detected, Sodium thiosulphate containing sampling bottles or sampling bags should be used to remove free chlorine from the water samples.

T.3 Flow rate

Required	Optional	Group	Detailed protocol/questionnaire	
X		Technical performance	Annex P3	
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X		X	X	X

Filtration flow rate is an important parameter to evaluate filter performance. User acceptance of filters will likely relate to the volume of water filter can treat per day as well as the volume of water available at specific peak times. Flowrate is a typical design parameter for the filter. Commonly used units are Liters per hour or litres per minute.

Background

The flow rate of a filter is influenced by various factors, including the properties of the filtration element such as surface area, material permeability (e.g., ceramics, membrane), and pressure, which can be hydrostatic (water level difference) or generated by a hand pump. Temperature and water conductivity also have a minor impact on flow rate. Filters can be categorized as gravity-driven filters, which operate based on the pressure difference between the raw water tank and filter outlet, and pressure-driven filters, which rely on a manual pump. During operation, the presence of organic matter and particles can lead to a decrease in flow rate over time due to the clogging of the filtration element in gravity-driven filters. Cleaning or backwashing can fully restore the flow rate when clogging is reversible. However, chemical cleaning may be necessary to address irreversible clogging, or the flow rate may not be recoverable at all. In filters operated by a pump, the flow rate typically remains constant or only slightly decreases, while the pressure or effort required for pumping may increase due to clogging. Monitoring the flow rate in such filters can be more challenging compared to gravity-driven systems, as both the flow rate and pressure will fluctuate, and installing a pressure gauge in the filter may be impractical.

Description

For gravity-driven filters, such as two-bucket, one-bucket, or syphon systems, the flow rate can be measured by filtering a defined volume of water (e.g., 0.5 L) and timing the filtration process with a stopwatch. Alternatively, measuring the volume of water filtered within a set time interval, typically around 2-5 minutes, can also be used. In gravity-driven filters, the flow rate directly correlates with the water level in the raw water tank. Therefore, it's crucial to standardize the water level for all measurements and keep it consistent throughout. Flow rate measurements should ideally be taken when the filter is full. However, it's important to consider the availability of water, especially in dry areas where households may not have sufficient water or may be unwilling to fill the filters to the required level. Flow rate measurements should only be conducted after all water samples for microbial water quality analysis have been taken.

For syphon filters, or if a syphon is unintentionally created in the filter, it's essential to control the water level between the raw water tank and the outlet of the filter. Syphon tubes should not run dry or partly dry during measurement to maintain consistent pressure in the system and ensure accurate results.

In filters operated by manual pumping, measuring flow rate is less straightforward, as flow rate is likely to remain constant despite clogging (resulting in increased pumping effort). When it's not possible to measure the pressure generated by the pump due to design constraints, an alternative approach is to measure the water collected during a set number of pump strokes or the maximum volume of water generated during intensive pumping over 1 minute. Consistency is key, so the same person should conduct the measurements whenever possible to minimize uncertainty due to variations in manually applied pumping pressure.

If backflushing or cleaning is required regularly, it's important to record whether the filter has been backflushed on the day of measurement. At least three measurements for each filter at a time are recommended to account for variations and minimize errors.

Resources and materials

Stopwatch graduated cylinder or scale, and book for recording.

Data analysis and visualization

The measured data should be recorded in the field. Using mobilephone based data collection such as KoboToolbox or ODK is advisable. It´s crucial to compare the filtration flow rate over time for the new filters distributed in the field and during specific periods of operation. Therefore, the flow rate should be visualized for each filter against the duration of its operation. Data can be aggregated for a specific filter type for each measurement day and visualized using box plots when comparing multiple filters to each other. This visualization method allows for easy comparison of flow rates across different filters and highlights any trends or variations over time.

Considerations

Water quality, operation and maintenance frequency and quality, and the type of filter will significantly impact the flow rate. Damage to the filter or leakages can lead to an increase in flow rate. If the flow rate exceeds the values obtained for the new filter, the filter should be inspected for leakage. In the event of clogging, users should be retrained on the proper operation and maintenance procedures.

T.4 Filter use

Required	Optional	Group	Detailed protocol/questionnaire	
X		Technical performance	Annex P4	
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X		X	X	X

Filter use is a critical parameter for understanding user acceptance as it directly impacts flow rate and filter performance. Unused filters are less likely to clog and perform effectively. However, measuring filter use can be challenging as it is an indirect parameter. In filter evaluation studies, filter use can be monitored through reported and observed methods. Reported filter use relies on data provided by users, while observed filter use is estimated based on various indicators such as water availability in the filter and its location. When financial resources permit and regulations allow, data loggers and pressure or flow sensors can be employed to accurately monitor actual filter usage.

Background

Whenever feasible, data on reported, observed, and actual (measured) usage should be collected. Presently, numerous new developments focus on measuring usage in household filters through sensors. While many of these devices and sensors are still in pilot testing, they hold significant potential. Tables 21 and 22 offer an overview of the background, distinctions, and descriptions for reported, observed, and measured usage.

Table 21 Reported, observed and measured use – background of the measurements

Use	Method	Background
Reported use	Use recorded and reported by users	Users record the number of fillings of the filter per day on sheets of paper.
Observed use	Use estimated based on the set of indicators and questions	Implementer observes and records the location of the filter, its general status including the presence of water in the filter (in all filter storage tanks) and cleanliness, using a checklist. Observation is followed by questions regarding the frequency of use of the filter, water containers used to fill in the filter, time of the day, etc.
Actual (measured) use	Use measured by pressure or flow rate sensors logging or transferring data.	The most accurate measurement of usage would involve measuring the flow rate of the filter. However, currently, there are no commercially available low-cost flowmeters suitable for very low hydrostatic pressures typically observed in gravity-driven filters. Standard low-cost water meters have too much resistance to be utilized in such scenarios, but there are a few more expensive options available. Other methods which can be used to measure actual use: • Pressure sensors to measure hydrostatic pressure variations due to filling in filters and using water (e.g. Solinst Levelloggers) • Sensors to record the opening/closing of the taps. If these methods are used, calibration is required to assure that data can be separated from the "noise" (e.g. children playing with taps, changes in atmospheric pressure, etc.).

Description

Table 22 Reported, observed and measured use – methods description

Use	Method	Description
Reported use	Use recorded and reported by users	Users get sheets of paper with dates and are asked and trained to record each filling of the filter with a mark on the paper as well as the volume of the water-filled in (by recording the number of fillings done by a certain container positioned next to filter). In some cases, containers for filling filters (e.g. 2-5 L jags) are distributed as well. The implementer makes the photo of the sheet during monitoring visit and transfers data manually into excel. Data can be collected for each date, or without recording of the date for a certain defined period.
Observed use	Use estimated based on the set of indicators and questions	The monitoring questionnaire (see U5) includes the questions and observation checklist used to estimate the observed use of the filters.
Actual (measured) use	Use measured by pressure or flow rate sensors logging or transferring data.	The sensors are placed in the filters and users are informed about the sensors. When water level sensors (such as Solinst® or Omega® level loggers) are used, they need to be programmed beforehand to collect data at specific time intervals (e.g. every 5-10 min). Frequent time intervals will use the available storage space in the logger very soon, and will also detect water level fluctuations during filling, very rare measurements might result in overseeing of the filling events. Some pressure loggers need to be corrected for fluctuations in atmospheric pressure, meaning that a one logger recording atmospheric pressure needs to be placed and secured in the area. When the temperature of raw water differs considerably from ambient temperature (over 5 °C), low cost data logging temperature sensors can be used to detect use as well (e.g. i-buttons®). If senosrs are not waterproof, they might be placed in rubber balloons or gloves and tightened on top after releasing air. The data needs to be read-out regularly. It is important to synchronise starting time and measurement intervals of different sensors to simplify data analysis.

Resources and materials

Questionnaire pre-installed on the mobile phone, book or printed paper sheets with pens to be distributed to households, sensors, loggers and data transfer equipment.

Data analysis and visualization

Reported use data is collected during the field visit. Usually, a photo of the sheet used for recording by households should be done with the GPS of the camera on, and the time of the photo is recorded in the field book together with the study ID of the household. The sheet should have the Study household ID. This would simplify the identification and allocation of photos to the right households.

Filter use might change in time and therefore visualization of data on filter use in time using box plots is advisable. Use data can be also used to calculate the study dropout rate.

Considerations

Users tend to overestimate the use of the filters for different reasons. Non-users might refuse to report that they are not using the filter. For this, observed use should be always analysed in parallel to reported use for consistency. When use is measured with sensors, reported and observed use data can be collected in parallel and consistency of the data evaluated. In some locations, using sensors for data collection might require special approval from authorities or ethics committee. Users might refuse using electronic sensors in some conflict zones in fear of being under surveillance.

T.5 Robustness and durability

Required	Optional	Group	Detailed protocol/questionnaire	
X		Technical performance		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X		X	X	X

Durability is a filter feature that indicates the ability of the filter to withstand the impact of environmental factors as well as incorrect user and maintenance during the whole supply chain, including shipment, distribution, assembly and use. Robustness indicates the consistency of performance of the filter across different settings and conditions.

Background

Durability and robustness of the filter depend on

Filter related features	The general production quality of the filter, design of the filter, number and quality of moving parts, the materials used for filter production and their quality, the packaging quality
Environment and context	Environmental conditions: temperature, humidity, dust exposure during transport, storage, distribution and use; source water quality Household conditions: exposure to sunlight, conditions of water storage containers, quality of the surface filter is placed on, the necessity to move filter within the household, space available, etc. Users: care is given to filter in general, understanding and implementation of O&M procedures, handling taps and moving parts, spilling water during filling

Durability and robustness relate directly to each other, as less durable products are likely to show higher variability in different settings and environmental conditions. The most reliable indicator for durability is the number of filters damaged during the study at each stage of the supply chain.

For robustness, the variability of the performance regarding flowrate and quality of filtered water depending on water quality and context (environmental, hygienic conditions in households, frequency of maintenance) should be analysed.

Description

Assessing durability using filter damage as an indicator. The number of filters damaged during logistics and after each phase of the evaluation project should be recorded. For each damaged filter, the part damaged, the severity of the damage, potential reason (when known) and if the filter can be or cannot be repaired should be recorded. Below few examples are summarized. Table 23 can be adapted depending on the filter design and context.

Table 23 Filter damage checklist

Phase	What is damaged	Can the damage be repaired?
• Preparation (incl. transport, storage) • Introduction visit (distribution, assembly and first use) • Monitoring • Final data collection	• Filter housing • Filter core element (membrane, ceramic candle) • Tap • Pump • Handle	• Yes – by user • Yes – by the implementer • Yes – involves procurement of new parts • No

Reasons for damage	Action done	
• Handling by the transport company • Bad roads • Lack of maintenance • Filter fell off the support structure/ table • Playing or misuse of parts (pump, taps) • Exposure to sunlight, dust • Leakage/failure of the core element	• Filter is repaired • Filter is replaced • The filter is removed without replacement	

Assessing robustness using flowrate, filter integrity and user information as an indicator. The flow rate and integrity of a filter are influenced by its usage and its ability to withstand environmental conditions and operational challenges. In real-world settings, the variation in filter integrity and flow rate among different filters is typically higher compared to controlled laboratory conditions. To visualize the flow rate and integrity assessment results for each monitoring campaign, box plots (or box and whisker diagrams) are effective tools. These plots effectively display the data dispersion and identify outliers, as explained in the data analysis and visualization section. A large interquartile range (IQR), long whiskers, and numerous outliers suggest significant data dispersion. This indicates lower robustness of the filters. To compare different monitoring campaigns, areas or filters, the visual illustration can be very powerful to understand the dispersion.

Resources and materials

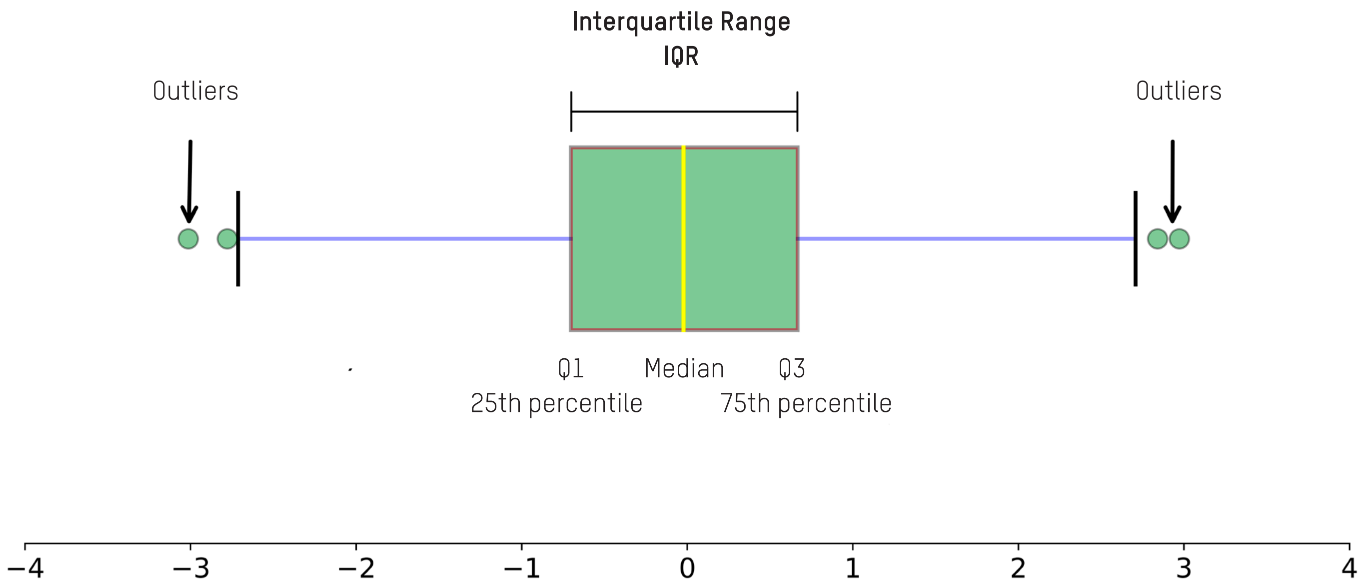
Data collected through filter use (see T5), flowrate measurements (see T.4.) and integrity test (see T2), and access to excel or data analysis software with integrated function to create box plots easily such as SigmaPlot, Mathlab, R.

Data analysis and visualization

Filter damage – the standard "stacked column" charts can be useful to visualize the proportion of the filters which had damage compared to the entire number of filters and type of damage.

Robustness – box plot with whiskers (Figure 3) can be used to illustrate the dispersion and outliers. The box plot is built using the 5 main values retrieved from data: median, Q1, Q3, Minumum and Maximum as shown on the image below.

Figure 3 – Box and whiskers plot *



*Adapted from https://towardsdatascience.com/understanding-boxplots-5e2df7bcbd51

- The median – is the middle value in a data set that has been arranged in numerical order so that exactly half the data is above the median and half is below it. So, the median divides the data into two equal sets.
- The low quartile (Q1) - is the value of the middle of the first set, where 25% of the values are smaller than Q1 and 75% are larger
- The upper quartile (Q3) - is the value of the middle of the second set, where 75% of the values are smaller than Q3 and 25% are larger.
- The difference between Q3 and Q1 will give the Interquartile Range (IQR), which thus, describes where the bulk of data lies, illustrating the middle 50% of the data values.
- "Minimum" value shows the furthest data value which is within one and a half IQR of the lower end of the box.
- "Maximum" value shows the furthest data value which is within one and a half IQR of the upper end of the box.
- Outliers are those data values which are larger than the "maximum" or smaller than the "minimum" value.

Considerations

Filters that remain unused are likely to exhibit higher flow rates and integrity. Therefore, when estimating robustness, data should only be analyzed for filters that are used at least once a week, while disregarding the data for filters that are not in regular use. Certain types of damage, like a broken tap or tube, may not directly affect the overall performance of the filter. If such damage is frequently observed, it may be advisable to consider replacing the damaged components with locally available products.

T.6 General water quality parameters

Required	Optional	Group	Detailed protocol/questionnaire	
	X	Technical performance		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X		X	X	X

General physico-chemical water quality parameters encompass turbidity, conductivity, temperature, dissolved oxygen, pH, and color. Turbidity serves as a useful metric for assessing filter performance and understanding the influence of water quality on flow rate and maintenance needs. Other parameters like conductivity, temperature, dissolved oxygen, pH, and color don't offer direct insights into filter performance. However, they serve as valuable indicators for gauging the acceptance of water sources and filtration, and for detecting issues related to biological regrowth in water storage tanks, both pre- and post-filtration.

Table 24 Background information

Parameter, Units	Background and description of the parameter
Turbidity NTU (Nephelometric Turbidity Units), FTU (Formazin Turbidity Units)	Turbidity in water results from the presence of fine organic and inorganic solids. Its presence impacts the acceptability of water to consumers and affects the performance of disinfection technologies. Turbidity often indicates potential filter clogging, with waters high in turbidity expected to have a higher clogging potential, particularly for ceramic and biosand filters. However, for membrane filters, which undergo regular backflushing, turbidity from inorganic particles like clay doesn't necessarily affect filtration rate irreversibly. Only when combined with organic matter does high turbidity lead to irreversible filter clogging. In surface waters, increased turbidity may correlate with higher organic matter content, such as after flooding, serving as an indication of potential clogging. While reducing turbidity through filtration is a straightforward measure of filter performance, it should not be relied upon alone without microbial water quality measurements.

Parameter, Units	Background and description of the parameter
Temperature °C	The temperature of raw water reflects climatic conditions and storage methods (above or underground, covered vs. uncovered). It can influence water acceptance, with households often preferring chilled water over ambient temperature. Temperature significantly affects physico-chemical processes like solubility of compounds, pH, conductivity, and biological processes. For biological processes, a 10 °C rise in water temperature doubles the rate of these processes. In warm climates where water temperatures exceed 30 °C in storage tanks, biological regrowth on the clean side of filters may occur, posing a challenge not seen in lab settings. This can lead to increased Coliform levels in both raw and clean water tanks, unrelated to filter performance. Temperature measurements are valuable in filter evaluation studies to assess the risk of biological regrowth and filter usage. Differences of 2 °C or more between raw water and ambient temperature indicate filter use, while differences exceeding 5 °C warrant the use of low-cost temperature loggers to monitor filter usage.
Conductivity µS/cm	Conductivity measures a water sample's ability to conduct electric current. It reflects the sample's ionic content, which correlates with dissolved solids concentration. While conductivity itself isn't directly relevant for filter evaluation, it provides a useful estimate of dissolved solids content. For many surface waters, conductivity multiplied by 2/3 approximates the Total Dissolved Solids (TDS) in milligrams per liter (mg/l). TDS can vary significantly among different water sources within the same area (e.g., rainwater, surface water, groundwater, tap water), indicating the primary water source or changes in sources that could affect filter performance and microbial water quality. It's crucial to consider the relationship between conductivity and temperature, with conductivity increasing by approximately 2% per degree Celsius rise in temperature. Users may reject water sources with a conductivity exceeding 1000 µS/cm considering them as salty. Also, users may expect filter to reduce salinity of water, that is not the case for most of the filters (except reverse osmosis-based filters).
pH	By definition, pH is the negative logarithm of the hydrogen ion concentration of a solution and it is thus a measure of whether the liquid is acid or alkaline. The pH scale ranges from 0 (very acid) to 14 (very alkaline). The range of natural pH in freshwaters extends from around 4.5, for acid, peaty upland waters, to over 10.0 in waters where there is the intense photosynthetic activity by algae. However, the most frequently encountered range is 6.5-8.0. In waters with low dissolved solids, which consequently have a low buffering capacity (i.e. low internal resistance to pH change), changes in pH induced by external causes may be quite dramatic. Extremes of pH can affect the palatability of water, cause a severe corrosive effect and affect the efficiency of disinfection with chlorine, metal solubility or ammonia toxicity. There is no health hazard from pH, except that extreme values will show excessive acidity/alkalinity, with organoleptic consequences and cause corrosion of metal parts. Filtration usually does not have any effect on the pH of water. pH monitoring however can be useful when different water sources are used with varying pH in the filter evaluation study.
Dissolved Oxygen mg/l 02	Dissolved oxygen levels are occasionally monitored in water sources with high organic content. Oxygen's importance in filters is primarily sensory, as low dissolved oxygen levels can lead to taste and odor issues in water. The risk of oxygen depletion causing taste and odor problems is higher in source waters with significant organic matter content, particularly when raw water tanks are infrequently cleaned of sediments. The solubility of oxygen in water decreases as temperature rises, exacerbating the issue in warmer climates. Therefore, warm climates may experience intensified taste and odor problems due to reduced oxygen solubility.

Parameter, Units	Background and description of the parameter
Color mg/l Pt/Co [mg/l Hazen]	Natural colour usually reflects the presence of complex organic molecules derived from organic (humic) matter such as peat, leaves, branches, etc. Its effect can be enhanced by the presence of suspended matter. Sometimes natural colour may arise from the presence of colloidal iron/manganese. Objections to high colour are generally on aesthetic grounds rather than on the basis of a health hazard. Consumers might be reluctant to drink water, however safe, which has a yellowish-brown colour. Depending on the nature of the colour, different filters will reduce it to a certain extent. Organic matter is one of the major foulants for membrane and ceramic filters, leading to clogging, thus monitoring and recording of color for surface water sources might be useful during filter evaluation projects where surface water is the major water source.

Description

Turbidity, temperature, dissolved oxygen, and color are prone to change during the transportation and storage of water. Therefore, it's essential to measure all these general water parameters directly in filters using portable equipment. Multimeters equipped with specific electrodes for conductivity, dissolved oxygen, and pH are available from field testing equipment providers. However, it's crucial to regularly calibrate electrode-based systems according to the manufacturer's instructions to ensure reliable measurements. Low-cost systems, including conductivity and pH "pens" and electrodes that can be connected to mobile phones, are also available. However, their precision and robustness can vary significantly and should be evaluated beforehand. pH can also be estimated using pH strips or comparators, that might be sufficient. Turbidity is typically measured using a portable turbidity meter (nephelometer) or a glass turbidity tube, depending on available resources and required precision. For turbidity levels below 5 NTU, turbidity tubes are unreliable, and electronic turbidity meters should be used. The cost of electronic turbidity meters has decreased significantly in recent years, with reliable battery-powered devices available for around 300 USD.

Color is measured by comparing the observed color to a defined scale using a comparator, usually in the form of cells, cards, or disks. Temperature can be measured using a separate thermometer, although most multimeters and turbidity meters have internal temperature measurement capabilities. Low-cost temperature loggers can be used to monitor and record temperature over time.

Resources and materials

Single devices, or a multimeter for pH, Dissolved Oxygen and Conductivity including calibration solutions and power supply system (batteries or researchable), Turbidity meter (calibration solutions and power supply is required for electronic devices) or turbidity tube, Comparator for colour measurement. Beakers for taking samples might be practical in some cases.

Data analysis and visualization

Water quality parameters are measured in raw water and filtered water and the data are shown in absolute values. Visualization of data in percentage of removal should be avoided, when there is a high variation in raw water or filtered water values, or filtered water values are very low (e.g. > 1 NTU for turbidity).

Considerations

Turbidity in the clean water tank serves as an indicator of filter failure or leakage. Moreover, turbidity reduction is commonly used to demonstrate filter efficiency, serving as a persuasive marketing tool to convince users and implementers of the filter's performance. However, it's important to note that turbidity particles are much larger than bacteria and viruses. Therefore, while turbidity reduction may indicate improved water quality, it doesn't necessarily guarantee a sufficient reduction in bacteria and viruses.

In essence, the presence of turbidity signals potential filter malfunction, severe contamination or bacterial regrowth, while its absence doesn't definitively confirm that the filter is fully functional in terms of microbial contamination.

U User perception and attitude assessment

User perceptions, attitudes, and acceptance of household filters in general or a specific product largely determine whether the product will be used consistently and correctly. Section U proposes a set of methods used during the filed study at its different phases to measure and understand user perceptions, attitudes and acceptance.

This chapter introduces the objectives and structure of the baseline survey (U1), explains how mobile phones can be used for data collection using KoboToolbox or ODK open-source data collection systems (U2), and describes the RANAS approach to systematic behaviour change to better understand user behaviours related to water treatment (U3). The distribution and assembly of the filters are supported by a non-participatory observation of filter assembly and operation (U4), followed by a general monitoring questionnaire (U5). Qualitative methods such as focus group discussions (U6) and co-design workshops (U7) are suggested as optional tools to better understand users` motivations and preferences as well as their ideas and suggestions for optimization. Finally, willingness to pay (U8) can be evaluated in situations where selling filters and development of a market-based supply chain is of interest.

U.1.1 Baseline survey

Required	Optional	Group	Detailed protocol/questionnaire	
X		User acceptance	Annex BL questionnaire	
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
X	X			

The baseline survey is one of the key elements of any filter evaluation study. The baseline survey takes place before participants receive their filters. The information collected here is later compared to information collected in the final data collection to assess change.

Before conducting the baseline survey, several steps need to be considered beforehand and planning enough time for preparation is essential. This sheet takes you through the different steps and refers to other documents within this guideline, where additional information can be found.

Steps of the study

The study, as outlined in this guideline, involves four distinct steps: a preparation phase, the baseline survey, the implementation phase, and a final data collection. It is important to consider the whole set-up from the start and plan accordingly. Notably, the questions in the baseline questionnaire will be repeated in the final data collection, allowing to record and analyse changes in the perceptions and attitudes of participants. For this pre-post comparison, it is essential to interview the same people at baseline and final data collection. To connect the datapoints for each individual, you need to know who is who and give every participant a unique ID (see section participants ID below).

Ethical considerations

The set-up of the study has to follow ethical considerations. It is important to obtain informed consent of participants before the study. Ideally, people sign/thumb-print their consent on a consent sheet, according to the requirements stated in your ethical approval of the study. A template for an informed consent sheet is provided by WHO and can be found in supplementary information or online (see references).

Selection of study participants

The selection of participants is discussed in more detail in L3. As soon as you have selected the list of study participants, you can continue by assigning them unique IDs.

Participant ID

To compare baseline and final data collection, you have to know which interview data belongs to which participant. Ensuring ethical standards, often requires keeping the names of your study participants separately from their answers. We recommend to prepare a list with the names (and if required phone numbers) of all study participants and assign each one a unique study-ID. This list is confidential and will be stored separately from the responses to the surveys (see L5). Enumerators only enter the unique ID number into the questionnaires. The confidential list may look like this:

Participant's ID	Name	Village name	Phone Number
BL1	YY	XX	+33 45 000 0000
BL2	ZZ	MM	+33 45 000 0001

Logistical set-up

Think of the timing of the interviews: when are participants at home and have time to answer your questions? How much time does one interview take and how many interviews can be done in one day? How many days do you need then to complete all interviews? Plan accordingly for time needed for the survey, number of enumerators needed, transportation, and if necessary, accommodation. If you collect data by using electronic devices, you have to plan for local storage capacity to save the data, internet connection to transfer the data, and battery charging.

Preparation of the questionnaires

Have a close look at the provided questionnaire and adapt the questions to your specific context if needed. You might need to translate the questions into the local dialect. Also, already think of the final data collection: questions should not need to be changed later, so that they can be compared.

Data collection using electronic devices

Sheet L5 introducing the set-up and application of electronic data collection and data management.

Training of enumerators

Schedule time for your staff to be trained on the questionnaire items and translations, conduct a pre-test with some households, and discuss possible challenges. Your team needs to know about the assignment of participants' IDs and its importance for the final data collection. Include a session introducing the project background and the goal of the survey. Also, plan for role plays, discussion of interviewing techniques, and ethical considerations.

During the training, each item of the questionnaire needs to be discussed to ensure everyone knows what the question wants to assess and why. Participants also need to agree on one translation of the questions and ensure that questions are always asked in the same way. The questions have different answer scales. Enumerators should be aware of the different question types as discussed in U12

Interviewing ethics and techniques

There are some common Dos and Don'ts for data collection. Practice interviewing techniques in role plays during the training: enumerators can learning from each other how to treat, for example, someone who is in a hurry or very hesitant. Here is a list of Dos and Don'ts, but you may think further and include more points according to your cultural/religious context:

- You must remain absolutely NEUTRAL about the content of the interview and in your reactions to the respondent's answers.
- Do not assume any answer he/she might give. If you do not get the answer, just probe.
- You must not under ANY circumstances talk about the respondent's private information to any third person, not even within the team.
- Each response must be directly recorded in the questionnaire. Don't do it afterwards, your memory will certainly fail you.
- If you receive irrelevant or complicated answers, do not break in too suddenly but listen to what the respondent wants to say and then lead him/her back to the original question.
- Treat all your respondents with kindness and respect: use appropriate language, keep a comfortable distance to your respondent, keep eye-contact if appropriate.
- Do not judge anything your respondent tells you, there are no good or bad answers.
- Conduct the interview in a private and quiet place and respect the participant's personal privacy by not causing them any unnecessary personal embarrassment or discomfort.

Pre-testing questionnaires

A part of training your staff is pre-testing the survey instruments. For the pre-testing, choose a location and households that are as similar as possible to the "real" study population, but is located somewhat away. Let each enumerator conduct 1-2 interviews, observe as many interviews as possible, and afterwards discuss any flaws or insecurities. Based on the pre-test, you may adapt the instruments were needed to help your staff to deliver high-quality data and achieve the best results for your study.

Supervision of data collection in the field

The data quality is very important for the outcome of your study. If data is not trustworthy, the results you might get are corrupted. Therefore, plan for quality management. Discuss the importance of high data quality already during the training and make sure to provide constant support during data collection. You might want to plan for (uncommunicated) visits during the data collection, check the incoming data regularly on any mistakes or misunderstandings. Include regular debriefings to have a constant exchange with your team and can detect any problems early.

Resources

- Informed consent sheet, mobile phones with pre-installed questionnaires, a set-up server for saving the data

Considerations

The preparation of the baseline survey is crucial to achieve high data quality and ensure sound and reliable results. However, unforeseen challenges or issues raised by stakeholders involved may come up during the process. You should plan for some extra time to be able to adapt your strategy and schedule if needed.

Table 25 Checklist for baseline survey

Checklist baseline survey	√
Questionnaire items adapted to my context	
List of participants or selection method defined	
Participant IDs defined and distributed	
Questionnaire programmed and uploaded	
Electronic devices prepared	
Data saving schedule and strategy designed	
Training of enumerators planned and conducted	
Questionnaire pretested and adapted where needed	
Survey logistics (transport, accommodation) planned	
Data quality management set up	

References

Template for informed consent form by WHO

https://www.who.int/groups/research-ethics-review-committee/guidelines-on-submitting-research-proposals-for-ethics-review/templates-for-informed-consent-forms

U.1.2 Baseline questionnaire

Required	Optional	Group	Detailed protocol/questionnaire	
X		User acceptance	Annex BL questionnaire	
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
	X			

The baseline questionnaire is the tool used during the baseline survey and contains a set of questions to be asked to the participants of the study. Some important considerations need to be addressed before using the baseline questionnaire, such as a careful translation and adaptation to the local context.

In this section, the different questionnaire components are discussed. If you want to measure behaviour change towards the use of household water filters as well as related motivators and barriers within your study, consider using the RANAS questionnaire (U3.1 and U3.2) as part of your baseline survey.

Questionnaire content

Section A: General information

This section collects information concerning the respondent and his/her household. The reasons why this information is relevant are twofold. First, the acceptance and use of the filters might differ due to gender, age groups, different household sizes, or other household characteristics. Second, for the follow-up survey, it is necessary to identify households and the corresponding household member that are part of your study. Therefore, you will need information about your respondent. Please adapt the collected data about your respondents to your needs and context

Section B: Information on WASH practices

If participants have received other information than provided by your organization, this might either support or conflict with the willingness to use the household water filters and their acceptance. Knowledge about the exact content of provided information helps to close gaps or complement information when needed.

Section C: Access to water

Questions about the access and availability of water allows an understanding of the context related to using household water filters. Questions about satisfaction with water quality and water availability allow assessing changes in those parameters after the use of household water filters

Section D: Collection and storage of drinking water

This section asks about the handling of drinking water within the household, helping to assess the safety of the water chain from the source to the consumer. It contains questions about which container is used for collecting water and how this container is cleaned.

Section E: Current water treatment practice

To know what the target audience already knows and which practices for water treatment are already in use, this section assesses key features about current water treatment practices and the existing knowledge.

Section F: Water filters

This section asks for the acceptance and preferences of potential users for household water filters as well as their willingness to pay for a household filter. This will help to plan the selection of household water filters for the trial. By assessing preferences in the baseline survey, the results of the follow-up survey can be compared and changes identified.

Section G: Observation of handwashing and sanitation facilities

In a short observation checklist, access to handwashing and sanitation facilities is assessed and functionality indicated. This information helps to cross-check data that is collected on the functionality of household water filters.

Optional:

Section H: Emergency context

This section assesses information on the emergency context. If this does not apply to your working context, you may just delete this part from the questionnaire. The information helps you to plan the survey and decide on the project set-up and timelines if, for example, people are prone to leave the area again.

Different answer and response styles

Table 26 summarizes different types of questions.

Table 26 Types of question and answers in baseline questionnaire

Example of a question	Question type	Answer type
C4: Do you need to pay for your drinking water? 0= No, 1= Yes	Yes or No question	Only one choice possible
How satisfied are you with the following aspects regarding your current water supply? – C6: Quality. 0=not at all satisfied to 4= very satisfied	Rating question: enumerator reads the answer options out and respondent chooses one option	Only one choice on a 5-point scale possible
D2: What kind of water storage do you use to store water outside the house? 1= Jerry cans (10-50 L), 2= Containers 50 – 500L, 3= On-ground or elevated tank 500 - 1000L, 4= On-ground or elevated tank/ cistern > 1000L, 5= Underground cistern, 99= Other	Open question: answer options are not read to the respondent. Enumerator ticks the options that are mentioned by the respondent.	Multiple choices possible. If the answer is not pre-coded use "other" and specify further.

Note: for the rating questions, the different answer options should be chosen so that they follow a clear increasing sequence. In the questionnaire provided in this guideline you will find 5-point scales with e.g., 0 = not at all easy 1 = somewhat easy, 2 = rather easy, 3 = easy and 4 = very easy.

Resources and materials

The baseline questionnaire needs to be uploaded to the mobile phones and a system to manage the collected data established (e.g. server).

Data analysis

After the final data collection (the endline), the information from the baseline survey is compared to the information collected in the endline. The data analysis depends on the question type. For questions with multiple answer options (example in Table 27), percentages of individuals of your sample who mentioned certain answer options are calculated. Then, the two time points are compared.

Table 27 Example of data analysis for questions with multiple answer options

C1: Which main water source do you currently use to collect water for drinking and cooking?	Baseline	Endline	Change
Piped water in the village	20%*	19%	-1%
Rainwater harvesting from roof	5%	35%	+20%
Rainwater harvesting from surface run-off	15%	16%	-1%

*to calculate percentages, count the number of times this option was mentioned and relate this figure to the whole sample size (=100/ XX (sample size)/ YY (times mentioned))

Interpretation: for the example above, people experienced a decrease in access to piped water supply in the village by 1% but increased their rainwater harvesting from roofs by 20%. The harvesting of run-off rainwater from surfaces has decreased very little, by 1%. To judge whether a change has been considerable or too small, depending on your context, you might want to consider changes above 20% as considerable.

For questions requiring a rating on a scale (example in Table 28), the mean value are calculated and compared between baseline and endline.

Table 28 Example of data analysis for questions with rating on a scale

C6: How satisfied are you with the following aspects regarding your current water supply? Water quality	Baseline	Endline	Change (Endline – Baseline value)
Mean value	2.3*	4.5	2.2

*to calculate mean values, sum up all values from all respondents and divide this value by the number of participants (=sum(all values)/XX (sample size)).

Interpretation: The satisfaction of participants concerning water quality has strongly increased compared to the baseline survey, by 2.2 points on a scale from 1 (not at all satisfied) to 5 (very much satisfied). We recom-mend to consider any changes below 0.5 scale points as not relevant.

In order to make the results easier to understand and to see where the largest changes have happened, you may visualize the data by using grouped bar charts.

Considerations

To collect high-quality data, it is important that everyone who is dealing with the questionnaire has understood every item. This means that he/she is aware of what the question wants to assess and why. This is also true for the participants – therefore, a careful translation is needed and questions must meet the specifics of the study context.

U.2 Use of mobile phones for data collection

<table>
<tr><td>Required</td><td>Optional</td><td>Group</td><td colspan="2">Detailed protocol/questionnaire</td></tr>
<tr><td>X</td><td></td><td>User acceptance</td><td colspan="2"></td></tr>
<tr><td colspan="5">Applicable to:</td></tr>
<tr><td>Preparation</td><td>Baseline</td><td>Introduction visit</td><td>Monitoring</td><td>Final data collection</td></tr>
<tr><td></td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
</table>

Collecting data with mobile devices is convenient as data is immediately saved and does not need to be transferred from paper sheets into digital versions. This saves time and reduces the number of mistakes. There are many different tools for digital data collection: KoboToolbox and ODK, for example, are very common in the WASH sector. KoboToolbox is free of charge for up to 5000 submissions per month. This guideline focuses on KoboToolbox, but the questionnaires that are developed for KoboToolbox can also be used in ODK.

Introduction of KoboToolbox

Information is taken from the official homepage of OCHA services and can be accessed online via https://www.kobotoolbox.org/. You can also find detailed instructions on how to set up the questionnaires and on data collection on this page.

- KoboToolbox is a free open-source tool for mobile data collection, available to all. It allows you to collect data in the field using mobile devices such as mobile phones or tablets. It also allows you to collect data using paper-pencil or computers.
- KoboToolbox is being continuously improved and optimized, particularly for the use of humanitarian actors in emergencies and difficult field environments to support needs assessments, monitoring and other data collection activities.
- The adaptation of KoboToolbox for humanitarian use was a joint initiative between OCHA, Harvard Humanitarian Initiative (HHI) and the International Rescue Committee (IRC).

Questionnaires

The questionnaires that are provided in this guideline are all ready for upload and use in KoboToolbox or ODK. However, if you want to adapt questions and change the questionnaires, feel free to do so. There are extensive guidelines on programming KoboToolbox questionnaires at https://support.kobotoolbox.org/.

Setting up a KoboCollect Server

- Register and sign-up at https://www.kobotoolbox.org/sign-up/. Choose either the global or European KoboToolbox server when creating your account. You can also get in touch with them for a private server.
- Note that the servers have different URLs: https://kf.kobotoolbox.org (global server) or https://eu.kobotoolbox.org/ (European server).
- Once logged in, create a new project and upload the questionnaire. The questionnaire has to be deployed

Data saving and upload

- Install the Kobo or ODK Collect App.
- Under "add project" you have to enter the server URL and your login data of your KoboToolbox account.
- On the home screen go to "get blank form". Choose the right form for your interviews, select and download. Only now you can go to "fill blank form" where the form will open and you can start the interview.
- If you mistakenly chose one option, you can undo so by holding the option for a while
- Make sure to always save each interview properly by clicking "save form and exit". The box saying "mark form as finalized" should be selected at the end of the interview. You can find the finalized interviews in the folder "finalized forms" on the home screen. After you have collected all interviews for one day, open this folder, select all interviews and "send finalized forms". They will be automatically uploaded to the server and saved. For this upload, you will need an internet connection.
- The data can then be viewed and downloaded in your KoboToolbox account.

Table 29 Checklist for mobile phone based data collection

Checklist electronic data collection	√
Date and time: make sure that all mobile devices are set to the correct time and date	
Tool: make sure that all devices use the correct form (questionnaire) for data collection	
Battery: always use a fully charged device so that no data is lost or you have to stop an interview while on-go-ing, always carry a power bank as a back-up	
You can adapt the brightness of the device if you work in sunlight and this also saves battery	

Considerations

It is recommended that at least one person in the project management team is familiar with KoboToolbox or ODK to help set up the questionnaires and the server, train the enumerators and trouble shoot. If this is not the case, an online course or training on how to use one of the tools might be necessary prior the study. It is also recommended to try all steps with invented or old data before actual data is collected to check that all processes work correctly and are understood by the team.

References

KoboToolbox is available at https://www.kobotoolbox.org/

U.3.1 The RANAS aproach to systematic behaviour change

Required	Optional	Group	Detailed protocol/questionnaire	
	X	User acceptance		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
	X			

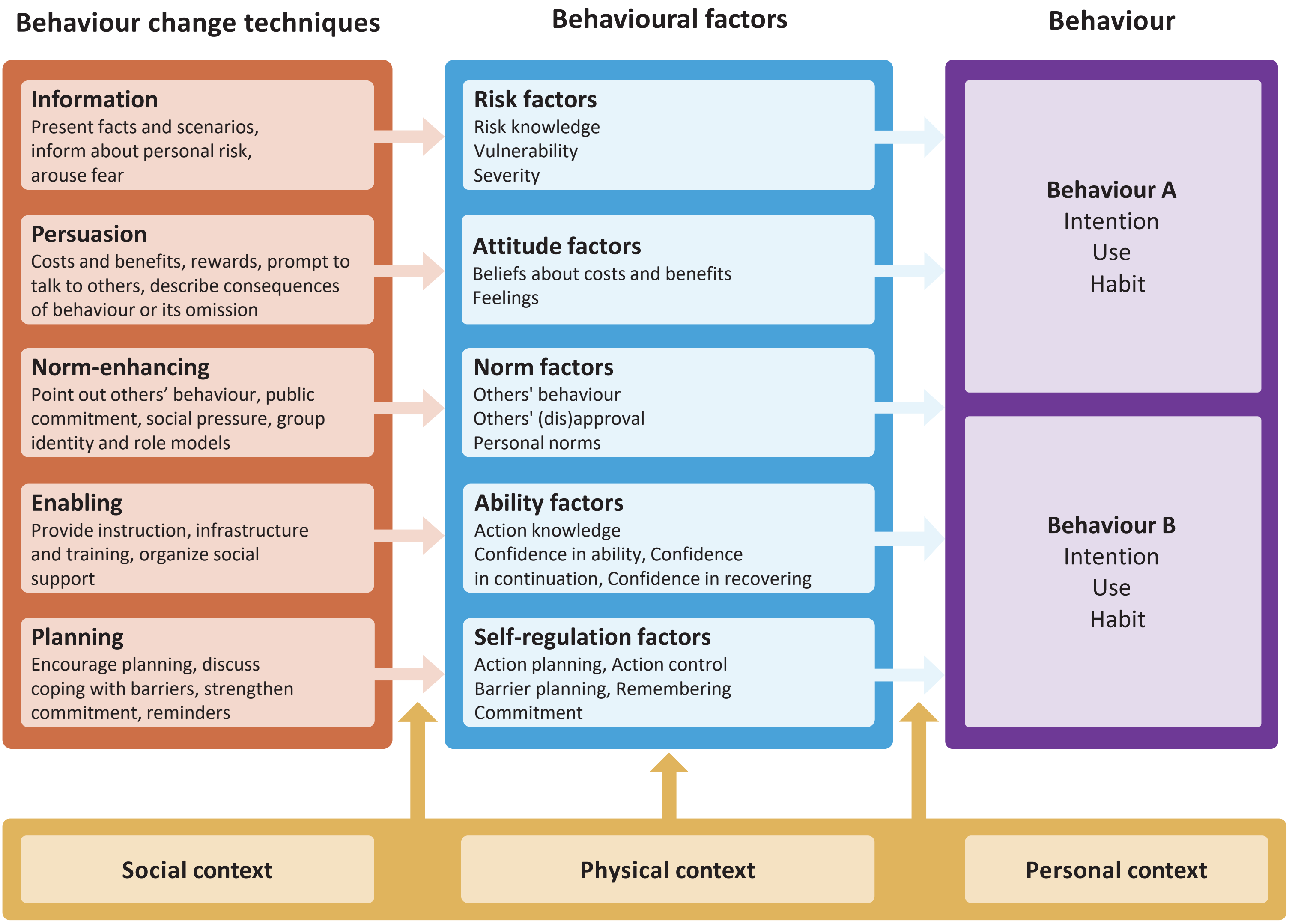
Incorporating behaviour change into your study enables the development of population-tailored and data-driven interventions. These interventions enhance the acceptance and use of household water filters. RANAS, an acronym for Risks, Attitudes, Norms, Abilities, and Self-regulation, describes a theoretical model of psychosocial drivers influencing a target behaviour. This model serves as the foundation for the practical RANAS approach, consisting of six sequential steps detailed in this chapter.

This chapter provides an overview of both the theoretical RANAS model and its practical application. For readers keen on more in-depth information, the RANAS approach with many details and practical tips is available online (https://ranas.ch/ranas-approach/).

The RANAS model of behaviour change consists of five core factor blocks (blue boxes, Figure 4). These represent the mindset of users – their thoughts, attitudes, and beliefs related to a new target behaviour, such as the consistent use of household water filters. These behavioural factors steer human behaviour and must align with the desired target behaviour(s) (e.g., target behaviour A: users consistently using household filters, target behaviour B: users consume only bottled water, purple boxes).

Understanding which of the behavioural factors steer the target behaviour allows for the direct targeting of exactly those beliefs, emotions, and motivations through specific behaviour change techniques (BCTs, brown boxes). The entire model is contextualized within the users' environment, including personal context (e.g., age, gender, income), social context (e.g., cultural norms), and physical context (e.g., water availability, infrastructure) that either facilitate or impede the adoption of new behaviours.

Figure 4 – The RANAS model of behaviour change



The behavioural factors of the RANAS model

This section describes the behavioural factors within the RANAS model in more detail. A nuanced understanding of these factors is crucial for effectively conducting the RANAS questionnaire and select behavior change techniques based on the results. The following table 28 is retrieved from the original RANAS methods fact sheet and can also be found online (Ranas, 2023).

Table 30 Defintions of behavioural factors

Behavioural factor	Definition
Risk factors: represent a person's understanding and awareness of the (health) risk.	
Factual knowledge	A person's knowledge about a disease's causes and (personal) consequences and its preventive measures or about the impact of environmental issues.
Vulnerability	A person's estimate of the probability of contracting a disease or of being affected by an environmental issue.
Severity	A person's assessment of the seriousness of a disease or environmental issue and of the significance of its consequences.
Attitude factors: represent a person's positive or negative stance towards a behaviour.	
Beliefs about costs and benefits	A person's beliefs about monetary and non-monetary costs (time, effort etc.) and benefits (lower medical costs, improved health) of a behaviour, including social benefits (higher status, appreciation by others).
Feelings	A person's emotions (joy, pride, disgust etc.) which arise when thinking of a behaviour or its consequences or when practicing the behaviour.
Norm factors: represent the perceived social pressure towards a behaviour.	
Others' behaviour	A person's observation and awareness of others' behaviour.
Others' (dis)approval	A person's perceptions if the behaviour is approved or disapproved by relatives, friends, or neighbours. This includes the awareness of institutional norms, i.e. the dos and don'ts expressed by recognized authorities such as village, tribe, or religious leaders, and other institutions.
Personal norms	A person's beliefs about what is right or wrong, according to their personal values.
Ability factors: represent a person's confidence in their ability to practice a behaviour.	
Action knowledge	A person's knowledge of how to execute the behaviour.
Confidence in ability	A person's perceived ability to practice a behaviour.
Confidence in continuation	A person's perceived ability to practice a behaviour if obstacles arise.
Confidence in recovering	A person's perceived ability to continue the behaviour after disruptions.
Self-regulation factors: represent a person's attempts to plan and self-monitor a behaviour and to manage conflicting goals and distracting cues.	
Action planning	The extent of a person's attempts to plan when, where, and how to execute the behaviour.
Action control	The extent of a person's attempts to self-monitor a behaviour by continuously evaluating and correcting the ongoing behaviour toward a behavioural goal.
Barrier planning	The extent of a person's attempts to plan to overcome barriers which would impede the behaviour.
Remembering	A person's perceived ease of remembering to practice the new behaviour in key situations.
Commitment	The commitment a person feels to practicing a behaviour.

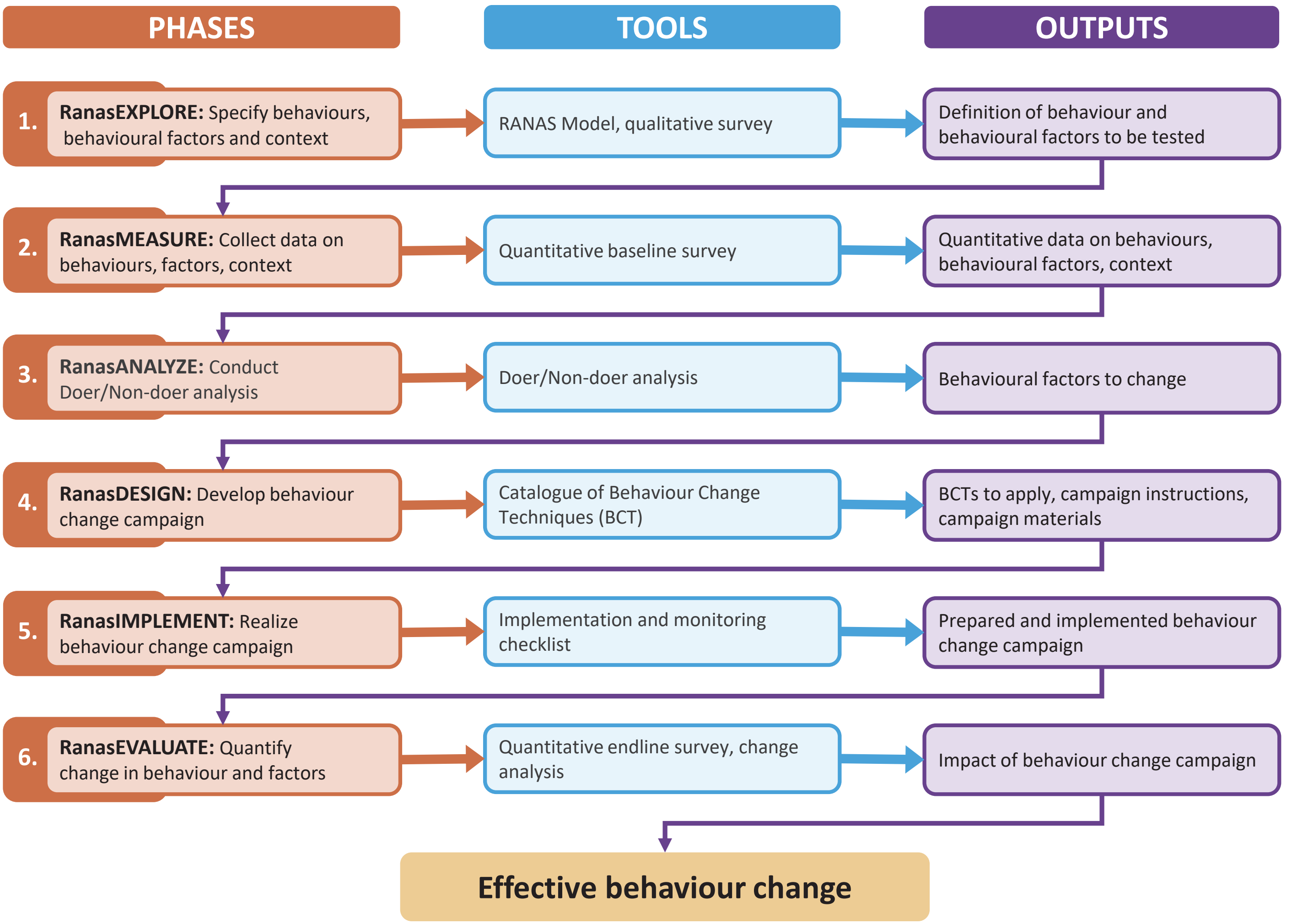
The six phases of the RANAS approach

The RANAS approach to systematic behaviour change describes a standardised way on how to use the RANAS model in a practical setting.

1. RanasEXPLORE: Specify behaviours, factors and context
2. RanasMEASURE: Collect data on behaviours, factors and context
3. RanasANALYZE : Conduct Doer/Non-doer analysis
4. RanasDESIGN: Develop behaviour change campaign
5. RanasIMPLEMENT: Realize behaviour change campaign
6. RanasEVALUATE: Quantify change in behaviours and factors

This section describes the six phases in more detail and provides a step-by-step to develop, implement and evaluate a behaviour change intervention. The following Figure and Table is retrieved from the original RANAS methods fact sheet and can also be found online (Ranas, 2023).

Figure 5 – The six phases of the RANAS approach



Phase 1: RanasEXPLORE: Specify behaviours, factors and context

First, the exact behaviours to be changed and the specific population group to be targeted are defined – who exactly should change which behaviour. Then, information is collected on behavioural and contextual factors that might influence the target behaviour, for example, with qualitative interviews or focus group discussions with various stakeholders at different levels and the target population. The results are then used to adapt the RANAS model for the specific project. The RANAS model integrates leading theories of behaviour change and findings of environmental and health psychology (see Fact Sheet on the RANAS model). By using it to classify and organize the potential behavioural and context factors, it is ensured that all important factors are considered.

Example: *During the qualitative interview, a few respondents mention that they are uncertain of how to collect sufficient water for using the household water filter. They mentioned that integrating water collection into the daily routines poses a considerable challenge.*

Phase 2: RanasMEASURE: Collect data on behaviours, factors and context

A quantitative questionnaire to measure the behaviour and the behavioural factors and a protocol to conduct observations of the target behaviour are developed. Data are collected from people who perform the behaviour (doers) and people who do not perform the behaviour (non-doers).

Example: *In the quantitative questionnaire we pick up the specific issues found in the qualitative interviews. We now ask each person, how strongly collecting enough water is perceived as a barrier and ask for possible solutions (factor "barrier planning" factor from the Self-regulation factor block.*

Phase 3: RanasANALYZE : Conduct Doer/Non-doer analysis

A Doer/Non-Doer analysis is conducted to identify the behavioural factors steering the target behaviour. Responses of doers are compared to the responses of non-doers. Large differences in the responses between doers and non-doers of certain behavioural factors show that these critically steer the behaviour and should be addressed through behaviour change techniques (BCTs) to change the behaviour.

Example: *We may find in the data that collecting enough water is a recurring challenge shared by many of the non-doers and may also learn that a recurring solution proposed by these non-doers involves the practice of collecting water multiple times a day and incorporating this task into their daily routines.*

Phase 4: RanasDESIGN: Develop behaviour change campaign

BCTs corresponding to the identified behavioural factors in the previous phase are selected for application in the behaviour change campaign from the RANAS catalogue of BCTs (see: Methods Fact Sheet: The RANAS Behaviour Change Techniques (BCTs), Ranas, 2023). It contains information about existing evidence from environmental and health psychology. The BCTs have to be adapted to the local context and suitable communication channels have to be selected. Those constitute the mode of delivery of the BCTs. Together, the BCTs and the communication channels form a behaviour change campaign.

Example: *Recognizing the importance of addressing "barrier planning," we select BCT 30: Prompt coping with barriers. Our approach involves personalized household visits to discuss water collection times and identify individual solutions of integrating water collection into the person's daily routines. Likewise, other challenges are discussed. To reinforce the intervention, we jointly fill out a paper of potential barriers and corresponding individual solutions that is then left at the household as a reminder.*

Phase 5: RanasIMPLEMENT: Realize behaviour change campaign

An intensive training of all implementers and detailed checklists that display the steps of the behaviour change campaign are required for implementation, monitoring and continued improvement of the campaign.

Example: *A supervisor accompanies the implementers during pre-test household visits, observes the interaction and gives feedback.*

Phase 6: RanasEVALUATE: Quantify change in behaviours and factors

Using the same tools as in the baseline (phase 2), the behaviour and the behavioural factors are measured again with a questionnaire and observations. Ideally, a comparison group should be evaluated to control for intervention-independent changes in behaviour and behavioural factors.

The behaviour change strategies have been effective when the before-after differences in behaviour and behavioural factors are larger for the population that received the campaign than for the comparison group. The results can be used to refine the campaign if necessary and to justify upscaling to similar areas as the campaign has shown to effectively change the target behaviour.

Example: *The analysis of the behaviour shows us that roughly 60% have changed and now consistently use clean and safe water for drinking and cooking at home. The analysis of the behavioural factors reveals that the change took place due to stronger barrier planning skills and that obtaining enough water is now not perceived as a problem anymore. Additionally, we learn that they liked the intervention. Some people remained non-doers and we now can adapt our interventions to also target their needs.*

References

More information and practical information on the RANAS model and approach can be assessed online:

- The RANAS approach containing all steps and many examples: https://ranas.ch/ranas-approach/
- Ranas (2023). Methods Fact Sheet: The RANAS approach to systematic behaviour change. Zurich, Switzerland. https://ranas.ch/wp-content/uploads/2023/08/Methods-Fact-Sheet-1-RANAS-approach.pdf
- Ranas (2023). Methods Fact Sheet: The RANAS model of behaviour change. Zurich, Switzerland. https://ranas.ch/wp-content/uploads/2023/08/Methods-fact-sheet-2-RANAS-model.pdf
- Ranas (2023). Methods Fact Sheet: The RANAS behavioural factors. Zurich, Switzerland. https://ranas.ch/wp-content/uploads/2023/08/Methods-Fact-Sheet-3-RANAS-behavioural-factors.pdf
- Ranas (2023). Methods Fact Sheet: The RANAS Behaviour Change Techniques (BCTs). Zurich,
- Switzerland. https://ranas.ch/wp-content/uploads/2023/08/Methods-Fact-Sheet-4-RANAS-behaviour-change-techniques.pdf

Mosler, H.-J. (2012). A systematic approach to behavior change interventions for the water and sanitation sector in developing countries: a conceptual model, a review, and a guideline. International Journal of Environmental Health Research, 1–19.

Contzen, N., Kollmann, J., Mosler, H.-J. (2023). The importance of user acceptance, support, and behaviour change for the implementation of decentralised water technologies, Nature Water, https://doi.org/10.1038/s44221-022-00015-y.

U.3.2 The RANAS questionnaire on acceptance and use of household water filters

Required	Optional	Group	Detailed protocol/questionnaire	
	X	User acceptance	Annex RANAS questionnaire, Annex FD	
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
	X			

Once you decide to apply the RANAS approach, you will first need to collect information about users' preferences, reasons for or against filter usage, motivators and barriers. Conducting individual questionnaires is recommended for this purpose. Subsequently, the acquired data can be translated into population-targeted, data-driven behaviour change interventions to address the specific needs of your population.

Assessing RANAS factors

The questions assessing the RANAS behavioural factors cannot be answered by yes or no. Most often, they ask for a rating on a scale: "How much do you like the taste of the filtered water?" (for the factor feelings). So, participants are requested to provide an answer that ranks between 0 = I don't like the taste at all to 4 = I extremely like the taste. This detailed scale is crucial because changes in behavioural factors can be very subtle, shifting from a slight preference (I like the taste a little) to a stronger preference (I quite like the taste). These small differences could already be very important, because they may explain why someone is using a filter and someone else doesn't. Therefore, the differentiation between the various response options of the scales is very important and needs to be discussed during interviewer training.

Qualitative pre-survey

To identify the relevant feelings for filter use in your context, the barriers that people usually face, and the solutions some doers use to overcome those barriers, a qualitative pre-study is recommended. This helps to refine the RANAS questionnaire by filling the gaps in the questions (see RANAS questionnaire in supplementing information). Annex FD provides a qualitative interview guideline that can be used with 5-10 individuals in a first step. The gathered information can then be used for the quantitative questionnaire.

Quantitative questionnaire on the use of household water filters and related psychosocial factors.

The questionnaire consists of two parts. The first part contains the assessment of the behaviour itself to later distinguish between people who consistently use household water filters (doers) to those who don't (non-doers). The second part entails the questions assessing psychosocial factors according to the RANAS model.

Behaviour assessment of household water treatment

Table 31 Example questions to measure behavioural outcomes

Example questions to measure behavioural outcomes		
Behavioural outcome	**Example question**	**Response scale**
Behaviour (frequency)	How much of your household's drinking water is treated?	0 = Almost none; 1 = Less than half; 2 = About half; 3 = More than half; 4 = Almost all
Intention	How strongly do you intend to treat all your drinking water?	0 = Not strongly; 1 = A little strongly; 2 = Strongly; 3 = Quite strongly; 4 = Very strongly
Habit (automaticity)	How much do you feel that you treat your drinking water automatically?	0 = Not automatically; 1 = A little automatically; 2 = Automatically; 3 = Quite automatically; 4 = Very automatically

Assessment of psychosocial factors related to using household water filters

The following table offers examples to assess the RANAS behavioural factors related to using household water filters. Where questions are marked with an asterisk and parts are written in italics, input from the qualitative survey is needed or questions should be cross-checked with information gathered during qualitative interviews.

Table 32 Example questions to measure behavioural factors

Example questions to measure behavioural factors		
Behavioural factor	**Question example**	**Response scale**
Factual knowledge	I will present to you some potential causes of diarrhoea. Could you please tell me for each whether it is a cause or not? 1. Water contaminated by bacteria 2. Mosquito bite 3. Spicy food 4. Raw water	A = Yes; B = No. Each correct answer is awarded one point. The scale is constructed by adding up the points.
Vulnerability	How high do you feel is the risk that you contract diarrhoea?	0 = No risk; 1 = A little risk; 2 = A risk; 3 = Quite a risk; 4 = A high risk
Severity	Imagine you contracted diarrhoea, how severe would be the impact on your daily life?	0 = Not severe; 1 = A little severe; 2 = Severe; 3 = Quite severe; 4 = Very severe
Beliefs about costs and benefits (effort)*	How <u>effortful</u> do you think is it to only use water from your household water filter?	0 = Not effortful; 1 = A little effortful; 2 = Effortful; 3 = Quite effortful; 4 = Very effortful
Beliefs about costs and benefits (time)*	How <u>time-consuming</u> do you think is it to only drink water from your household water filter?	0 = Not time-consuming; 1 = A little time-consuming; 2 = Time-consuming; 3 = Quite time-consuming; 4 = Very time-consuming
Beliefs about costs and benefits (health)	How certain are you that drinking water from your household water filter prevents you from getting diarrhoea?	0 = Not certain; 1 = A little certain; 2 = Certain; 3 = Quite certain; 4 = Very certain
Feelings (behaviour)*	How much do you <u>like to use your household water filter</u>?	0 = Don't like it; 1 = Like it a little; 2 = Like it; 3 = Quite like it; 4 = Like it a lot
Feelings (taste)*	How much do you <u>like the taste of the water</u> provided by your household water filter?	0 = Don't like it; 1 = Like it a little; 2 = Like it; 3 = Quite like it; 4 = Like it a lot

Example questions to measure behavioural factors		
Others' behaviour	How many people in your community filter all their drinking water?	0 = (Almost) nobody; 1 = Some of them; 2 = Half of them; 3 = Most of them; 4 = (Almost) all of them
Others' (dis)approval	People who are important to you, how much do they approve that you use a household water filter for all drinking water?	0 = Disapprove a lot; 1 = Disapprove; 2 = Neither approve nor disapprove; 3 = Approve; 4 = Approve a lot
Personal importance	How strongly do you feel an obligation to yourself to use a household water filter for all drinking water?	0 = Not obliged; 1 = A little obliged; 2 = Obliged; 3 = Quite obliged; 4 = Very obliged
How-to-do knowledge	What are the steps for the correct use of your household water filter?	No answer options are provided. Each mentioned critical step of using the household water filter is awarded one point.
Confidence in performance	How confident are you that you can always drink water from your household water filter?	0 = Not confident; 1 = A little confident; 2 = Confident; 3 = Quite confident; 4 = Very confident
Confidence in continuation*	How confident are you that you can continuously use your household water filter even though you have to spend a substantial amount of time for doing so?	0 = Not confident; 1 = A little confident; 2 = Confident; 3 = Quite confident; 4 = Very confident
Confidence in recovering*	Imagine you have stopped using your household water filter for several days, for example, because it needed to be cleaned. How confident are you that you would start using your household water filter again?	0 = Not confident; 1 = A little confident; 2 = Confident; 3 = Quite confident; 4 = Very confident
Action planning	Do you have a plan when during the course of your day to fill your household water filter? If yes: Could you please specify the point in time?	No answer options are provided. Answers will be classified into "specific plans" (e.g. after breakfast; at 9 am) and "unspecific/ no plans" (e.g. in the morning).
Action control	How much do you pay attention to only drink water from your household water filter?	0 = Pay no attention; 1 = Pay a little attention; 2 = Pay attention; 3 = Quite pay attention; 4 = Pay much attention
Barrier planning	Do you have a plan for how you can treat all your drinking water even if your household water filter is not functional?	No answer options are provided. Answers will be classified into "correct plan" (e.g. I'll boil the water) and "incorrect/no plan" (e.g. I'll drink raw water).
Remembering/ forgetting	How often does it happen that you forget to use the water from your household water filter?	0 = (Almost) never (0%); 1 = Seldom (25%); 2 = Sometimes (50%); 3 = Often (75%); 4 = (Almost) always (100%)
Commitment	How important is it for you only use water from your household water filter?	0 = Not important; 1 = A little important; 2 = Important; 3 = Quite important; 4 = Very important

Considerations

The administration of the RANAS questionnaire needs careful training as well as an understanding of the RANAS approach and the meaning of the different behavioural factors. Make sure to include enough time for training your enumerators into your project schedule. The training should contain a theoretical part, role plays to identify ambiguities, and a pre-test to get a feeling for how much time is needed.

References

More information can be found on https://ranas.ch/ranas-approach/

Ranas (2023). Methods Fact Sheet: The RANAS model of behaviour change. Zurich, Switzerland. https://ranas.ch/wp-content/uploads/2023/08/Methods-fact-sheet-2-RANAS-model.pdf

Ranas (2023). Methods Fact Sheet: The RANAS behavioural factors. Zurich, Switzerland. https://ranas.ch/wp-content/uploads/2023/08/Methods-Fact-Sheet-3-RANAS-behavioural-factors.pdf

U.4 Non-participatory observation

Required	Optional	Group	Detailed protocol/questionnaire	
X		User acceptance	Annex Observation checklist	
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
		X		

During the introduction visit, the participants receive the filter and printed instruction for assembly, operation and maintenance of the filter. Ideally, the instructions are easy to understand, e.g. in form of pictograms, so that users do not need additional support from outside. To understand whether this is the case, a non-participatory observation of the filter assembly is conducted without any further support or training. Training on filter installation, operation and maintenance is conducted afterwards.

Background

The goal of the observation is to evaluate whether the filter is self-explaining and can be assembled and operated without external support and training. The results will also help to define if incorrect installation might lead to any malfunction of the filter. Thus, the non-participatory observation aims to understand the ease, simplicity, challenges, problems experienced by users as well as assess possible health risks during

- assembling the filter (fixing filter elements and taps into the filter, connecting the filter parts, placing the filter in the bucket, priming (removing air of the system if needed), etc.)
- the first use of the filter (filling in water, waiting for water)
- handling of treated water (collecting water, use of external containers, bottles, cups)

while only using the written instructions provided by the manufacturers and no support from the trainers.

Description

Observation follows the steps below:

1	Inform the user that he/she can now install the filter and you would just observe him/her during this procedure and that you will take notes. Users are allowed to ask for help from family members or other community members, but not from the observers. Please assure that the user is aware that she /he can keep the filter even if assembled incorrectly and there are no other implications of the incorrect actions concerning the filter.
2	Hand over the filter.
3	Ask the user to assemble and install the filter where it is supposed to be used. Try not to provide suggestions even when you see a strange behaviour or you are approached directly. Interact only if you are convinced that the filter can be damaged.
4	Additionally, use a stopwatch to record the time the user needs to assemble the filter.

5	Fill out the observation checklist on your electronic device.
6	Stop observation if • the filter is assembled correctly • the filter is assembled incorrectly but the user says that he/she has done it • the user does not know how to proceed and stopped trying, shows signs of frustration and actively requires help. In such a case you can first suggest asking someone else for help.
7	Confirm with the user that he/she is done with assembling the filter or ultimately requires help and stop recording only if the answer is yes.
8	In case the filter is assembled incorrectly, explain the problem and fix it. If the filter is assembled correctly - proof the tightness of candles etc. if need.
9	Check with the user that there is untreated water and ask to use the filter. In case there is no water, ask the user to go to the source together with you and collect some. If the source is not reachable in an acceptable timeframe or there are other reasons which prevent you or the user from going to the source, use water you brought with you.
10	Start observation of the use of the filter. Fill out the observation checklist on your phone.
11	Interact with the user when • the user tends to drink water which is not treated (the wrong hose used, etc.) • the user finds that it takes too long - encourage to wait
12	Stop observation when • the user has drunk the first glass of water • there is no water coming out of the filter or filter is obviously non-functional
13	Ask the user how he/she will clean the filter. Encourage to use the information materials provided with the filter if any.
14	Ask to demonstrate this to you and observe the behaviour.
15	Stop recording when the user • has finished the cleaning process (either in accordance with instructions or wrong or partially wrong) • does not know how to do it and does not receive help from anyone

Resources

- KoboToolbox form: Observation checklist

Considerations

In some cases, it might be interesting to do a video recorded observation to analyse or explain the possible challenges better to the manufacturers and implementers not present during the observation. However, the team has to apply for ethical approval to do this well in advance and the recorded users would have to be properly informed and sign a consent form.

Table 33 Checklist for the observation

Checklist for the observation	√
Have the filter and according to instructions ready	
Make sure to have the observation checklist on your device	
Bring a stopwatch or your mobile phone to take the time	
Bring water in case water is unavailable to test the filter	
Make sure that you know how to assemble the filter correctly, and you have tested it before	

U.5 Monitoring questionnaire

<table>
<tr><td>Required</td><td>Optional</td><td>Group</td><td colspan="2">Detailed protocol/questionnaire</td></tr>
<tr><td>X</td><td></td><td>User acceptance</td><td colspan="2">Annex Monitoring questionnaire</td></tr>
<tr><td colspan="5">Applicable to:</td></tr>
<tr><td>Preparation</td><td>Baseline</td><td>Introduction visit</td><td>Monitoring</td><td>Final data collection</td></tr>
<tr><td></td><td></td><td></td><td>X</td><td></td></tr>
</table>

After the baseline survey and the distribution of household filters, participants are expected to start using the filters and integrate the use in their daily routines. Monitoring visits help to assess information on functionality, use and acceptance of the filter. This information again helps to better guide your decision at the end of the study regarding the suitability of the tested filter to your specific context.

The initial monitoring data can be gathered during the introductory visit (see D1). Subsequently, it is advisable to conduct at least one monitoring visit before the final one, which can also coincide with the last data collection session. Each monitoring visit has four sections: i) Observation of filter use, ii) Interview on use and acceptance, iii) Self-recorded use of the filter (see T4), and iv) General water quality parameters (see T6). The last section assessing the general water quality parameters is optional.

Observation of filter use

The observation questions are part of the monitoring questionnaire. First, the filter functionality and cleanliness as well as other water containers that might exist are observed and information is then entered into the questionnaire. During the training of your staff make sure that everyone has the same understanding of the questions, even for the observation. For example, the perception of cleanliness might vary among your team members. To gain a common understanding you can use pictures or conduct mock observations and discuss the outcomes together.

Interview on filter use and acceptance

The questionnaire contains questions about ease of use and cleaning the filter as well as questions about users like the taste of the filtered water and anything participants negatively or positively comment about the filter.

Self-records

As described in T5, participants get sheets of paper with dates and are asked to record each filling of the filter with a mark on the paper along with the volume of water filled in. These sheets are copied to the questionnaire during the monitoring visit. If more feasible, a picture can be taken and data entered after the visit.

General water quality parameters

In sheet T3, the parameters and their measurement are described. The assessment is done during the monitoring visit to measure the functionality of the filter and quality of the filtered water. The assessment of these is optional (the questions will not appear in the questionnaire if not selected). The parameters that can be assessed are: flow rate (ml/s), turbidity (NTU/FTU), temperature (°C), conductivity (µS/cm), pH, dissolved oxygen (mg/l 02), and color (mg/l Pt/Co [mg/l Hazen]).

The questionnaire contains an item that assesses the number of the monitoring visit. Enter here whether this is your first, second, third, etc. monitoring visit.

Resources

- Trained data collectors need to have functional electronic devices and the KoboToolbox/ODK monitoring questionnaire downloaded on it.
- Testing equipment depending on the selection of water quality parameters to test.

Considerations

Besides the baseline survey, the introduction visit and the final data collection, the monitoring is another important source of information. To be able to connect all sources of information of one household, make sure to always repeat the same study participant ID which you assigned to the household in the baseline survey. You might want to consider to write the participant ID on the filter if possible.

U.6 Focus Group Discussion (FGD)

Required	Optional	Group	Detailed protocol/questionnaire	
	X	User acceptance		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
				X

A Focus Group Discussion (FGD) is a participatory and interactive tool for collecting information from the study participants. They are invited to share their experiences about the study and the use of the filters as well as their preferences and attitudes. The FGDs should be conducted for different groups (e.g., men and women) in order to enable everybody to express their opinions frankly.

The FDG allows getting in-depth information about the experiences, preferences and attitudes of the study participants. Two characteristics are crucial for an FDG: a) there is a moderator who facilitates the discussion and keeps the overview and b) every participant should get his/her space to share his/her opinion. Therefore, FDGs are structured and well-organized, but participatory and interactive. The facilitator needs to be aware that participants may not share the same opinion and that different participants (e.g., women) may feel uncomfortable to share their views in front of others. A careful planning process is mandatory before conducting an FDG. The following section offers different tools and checklists for this process, but a lot of resources are available online if other information should be preferred. A collection of online resources is provided below.

Selection of participants

Select participants that have been part of the study and invite them to the planned FGD. If you feel this is necessary, you can plan for different groups:

- Adult women
- Adult men
- Religious leaders/village leaders/elders
- Adolescents

Depending on the size of your sample, you can either invite all study participants or do a random selection among study participants. Make sure that no one feels excluded or that preference is given to certain individuals and their opinions. Usually, the size of an FGD ranges from 6-12 participants. But also smaller groups are informative and fine. The advantage of smaller groups is that participants have more time to share their opinions.

Drafting a list of questions

Part of the preparation process is to draft a list of questions that serve as guidance for the moderator of the FGD. The questions that are discussed with the participants should be open and no questions that can be answered with yes/no. A possible collection might be:

√ What were your experiences with using the filter(s)?

√ What did you like or dislike about the filter(s) that you received?

√ How do you evaluate the different features of the filter(s)?

√ How do you evaluate the flow rate, design, capacity and water quality of the filter(s)?

√ What would you like to change about the filter(s)?

√ Which filter would you prefer? Why?

√ How did your family members react to the filter? What do your neigbours say?

Operational preparation

√ Preparation of a list of questions

√ Ask for the permission with village leaders to conduct FGDs

√ Train moderators and minute takers

- √ Arrange for a venue which is easily accessible for everyone
- √ If you want to record the session: informed consent sheets, video/audio recorders (with extra batteries)
- √ Organize invitation of participants
- √ Plan timing according to the schedules of your target group
- √ Plan for an appropriate kind of incentive for their voluntary participation

Facilitating FGDs

The moderator plays a crucial role during the facilitation of an FGD. He/She needs to

- √ Ensure that the discussion follows the developed guideline and answers the previously defined questions
- √ Make sure that the discussion is inclusive and balanced
- √ Avoid dominating the discussion and expressing his/her opinion or judgements
- √ Be open, alert, encouraging and enabling.

Theoretically, the moderator should be able to establish a group dynamic where participants discuss the guiding topics among themselves.

Usually, an FGD contains these steps (Dawson, Manderson, and Tallo 1993):

- √ Use an "ice-breaker", e.g. a round of introduction, a prayer or even a game.
- √ Explain the topic of the whole study and the specific purpose of this FGD
- √ Start the discussion and use the list of questions as guidance, but ideally just as inputs that encourage the discussion. No need to follow the order of the questions.
- √ Thank participants and say good-bye.

Data analysis

You can either use the notes taken by your staff or the video/audio recordings to later recapitulate the process and discussion. Make sure that you don't let yourself guide by your interest but by the content of the discussion.

- √ List all information that answer the questions of your list.
- √ Group the information according to topics.
- √ Check whether the information is different for different sub-groups (men, women, leaders, etc.).
- √ Also critically analyse your individual impression of the discussion and your thoughts that evolved during the process or when doing the analysis.

After you have achieved a synthesis of the discussion, try to find a structure for the results. This might look like this:

- √ Mentioned advantages/disadvantages of the filter overall
- √ Mentioned feedback on different features (flow rate, design, water quality, capacity, etc.)
- √ Preferences for filters (divided by groups)
- √ Feedback on the further development of the filter (divided by groups)

Considerations

The main goal of an FGD is to create a space where participants can honestly share their experiences and opinions concerning the use of the filters. This might sound easier than it is, so careful preparation and training of staff are important, as well as planning enough time both for preparation and facilitation. Finally, the check-lists, questions and resources provided here shall only serve for inspiration and can be adapted and further extended.

References

This document is strongly based on the guidance of the Swiss Tropical and Public Health Institute (link) https://www.swisstph.ch/fileadmin/user_upload/SwissTPH/Topics/Society_and_Health/Focus_Group_Discussion_Manual_van_Eeuwijk_Angehrn_Swiss_TPH_2017_2.pdf

U.7 Co-design workshop

Required	Optional	Group	Detailed protocol/questionnaire	
	X	User acceptance		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
				X

The co-design workshop aims at collecting experiences of users after the study. Their feedback on the different features of the filter will help to make improvements and eventually ensure better acceptance and uptake of the filter. This is especially important if manufacturers want to adapt the design of their filter to local contexts and if parts of the filters are produced on local markets. Co-designing as a concept wants to give voice to people and shape a democratic and collective process to achieve user-centred designs.

Planning the co-design workshop

Participants

Think of who are the users of the filters and who else might be relevant stakeholders to share their opinion on the filter's design. Make sure to include representatives of all stakeholder groups (manufacturers, users, designers) and give them a voice equally (similar to the focus group discussions).

Time and place

Plan according to the schedules of your target group and choose a conveniently accessible location where everyone has easy access and feels comfortable to share their views. You can think of an appro-priate time-frame for your workshop, usually not more than 2 hours.

Facilitator(s)

The role of the facilitator(s) is crucial. They have the responsibility to create an environment where all participants feel free to share their opinion and experiences. Following is a list of recommendations:

- Encourage equal participation
- Take visible notes (if applicable)
- Be neutral
- Let people develop their individual solutions, but try to converge diverse ideas into a common idea in the end

Define the goal and the agenda of the workshop

Think about the goals of the workshop and plan activities accordingly. You could, for example, structure the workshop into sharing of experiences (e.g., by demonstration) and sharing ideas for improvements, needs and visions.

Implementation of the co-design workshop

Many of the existing different participatory activities can help to collect ideas and create solutions for challenges that users had experienced while testing the filters. Have a look at the existing resources to find activities that best fit your context. Usually, a co-design workshop consists of three phases (also see https://de.slideshare.net/user-spots/codesign-workshop):

Opening: an explanation of the goal of the workshop, the introduction of all participants, opening the field by presenting the findings of your study and the questions that are related to it

Example: *participants include filter manufacturers, designers and users that have been part of the study. In the first step, everyone is introduced and people can say what they expect from this workshop. Then the study results regarding one (or more) filters are presented: users overall have been satisfied with the filter but rate the design and ease of cleaning of the container very low. The goal of this workshop, therefore, is to i) verify if those are the relevant aspects that need to be discussed, ii) discuss possible solutions and alternatives and iii) rate the discussed alternatives to emphasize one option which then can be handed over to manufacturers and are realistic to be produced.*

Shaping: creating ideas or solutions to challenges, users have faced during the study

Example: *ideas of improving the design are collected by letting participants draw their ideal filter on a large piece of paper and present their work in smaller groups. Important aspects are noted down. Regarding the cleaning of the container, users and manufacturers discuss in small groups what the needs are and how they could be considered. Each group presents only one solution to the entire group.*

Evaluation: users rate the discussed solutions and related advantages and disadvantages

Example: *several different ideas of how to adapt the design and the container for better cleaning have been presented. All options are presented to the group and everyone receives 3 post-its they use to rate their preferred options. The options with the most votes are discussed again by the entire group regarding advantages and disadvantages.*

Data analysis

All notes and drawings, pictures taken of produced outputs serve as a data basis for the evaluation of the results of the co-design workshop. It is required to carefully evaluate all materials. Also, check the data analysis presented for focus group discussions (U6) that is very similar to the analysis of co-design workshops. The product of the co-design workshop should be a list with ideas to improve the filters and their advantages and disadvantages. The list should be approved by all participants to ensure feasibility (manufacturers) and acceptability (users). The list should be used in the decision-making process along with other data to discuss how potential changes can improve performance or acceptance.

Considerations

It might be difficult to get all stakeholders to participate in the co-design workshop. However, without, for example, including manufacturers or local producers the ideas produced by users of how to improve filters might not be incorporated by producers or they are impossible to be implemented. On the other side, without the experiences of users, the ideas that are created in a co-design workshop will most probably not meet users' needs and wishes and not lead to user acceptance.

References

https://medium.com/@gyngyifekete/designing-a-co-design-workshop-7686eaf4bf0f

https://de.slideshare.net/userspots/codesign-workshop

http://www.cocreate.training/wp-content/uploads/2019/03/co-design_handbook_FINAL.pdf

U.8 Assessment of willingness to pay

Required	Optional	Group	Detailed protocol/questionnaire	
	X	User acceptance		
Applicable to:				
Preparation	Baseline	Introduction visit	Monitoring	Final data collection
		X		X

The concept of willingness to pay (WTP) is mainly an economic tool to measure the perceived value of a product. WTP, however, is not a fix and constant value but depends on different parameters, such as income, context and availability of connected resources (e.g., water).

For the context of evaluating the acceptance of household water filters, the perceived economic value and the possibility and willingness to pay for distributed filters is of interest. Of course, this only accounts for contexts where users can invest in filters. In acute emergency responses where filters might be distributed for free, willingness to pay might not be of interest. If, however, the filters are planned to be locally produced and available on local markets, the value serves as an indicator of how likely the filters will be accepted and bought by end-users.

Assessing willingness to pay

Both, in the baseline questionnaire and the extended list of the final data collection, include questions that assess the willingness/ability to pay for the water filters. In the baseline questionnaire, question F2 (How much would you be willing to pay for a household water filter?) generally asks for the willingness to pay for any filter not related to the one which will be tested in the study. The value given can be related to the price users have to pay for their current water supply system (question C9) and to their current monthly income (question A10). In the extended list of the final data collection, the question about willingness to pay is repeated but this time related to the water filter the household has received (FE6: How much would you be willing to pay for your filter?). If two (or more) filters have been provided and tested, users will be asked which one they would rather buy (FG15: If you would need to decide to purchase one of the two filters. Which one would you rather buy?) and how much they would be willing to pay for it (FG16: How much would you be willing to pay for your preferred filter?)

If in your study, the willingness to pay is not of interest, the questions can be removed from the questionnaire before data collection.

Data analysis

As mentioned above, the willingness to pay is not necessarily a fixed value but may alter and depends on different parameters. For example, users after having used the filter might evaluate the value much higher as previously because they have liked the use and features of the filter. The amount they are willing to pay for the filter might increase. If the value decreases, this is a sign of low acceptance of the filter. To make this type of analysis, the value from the baseline and the value from the final data collection are compared. If there is interest in evaluating changes in willingness to pay, the values should be deducted from each other to either see decrease or increase.

References

https://cenrep.ncsu.edu/2020/06/04/willingness-to-pay-for-in-home-water-filtration-in-rural-northern-ghana/

https://hal.archives-ouvertes.fr/hal-00522828/document

U.9 Follow-Up survey

<table>
<tr><td>Required</td><td>Optional</td><td>Group</td><td colspan="2">Detailed protocol/questionnaire</td></tr>
<tr><td>X</td><td></td><td>User acceptance</td><td colspan="2">Annex Follow-Up questionnaire</td></tr>
<tr><td colspan="5">Applicable to:</td></tr>
<tr><td>Preparation</td><td>Baseline</td><td>Introduction visit</td><td>Monitoring</td><td>Final data collection</td></tr>
<tr><td></td><td></td><td></td><td></td><td>X</td></tr>
</table>

The last step of the data collection phase is the follow-up survey to allow to compare baseline and endline data and show changes that can be attributed to the filter. This requires the administration of the monitoring questionnaire as well as the extended list. There are several optional components to the final data collection, such as the RANAS questionnaire (U3.2), focus group discussions (sheet U6), co-design workshops (U7), or the assessment of the willingness to pay (U8).

Some of the questions from the final data collection questionnaire (extended list) are the same as in the baseline questionnaire to be able to compare and evaluate changes achieved by the distribution of the filters. This is the reason why questions should not be changed or only changed in both questionnaires (baseline and extended list).

Adaptation of the questionnaire to the study set-up

If your study set-up contains the comparison of two (or more) different filters, you need to adapt the questionnaire accordingly. The template comprises a section which requests households to rate and compare two different filters they have received. If your study does not entail the comparison of two filters, you can either leave the questionnaire as it is and instruct your data collectors to always choose "no" for the following question: Did households receive different filters that shall be compared? If you want to avoid possible confusions, you can also delete this part of the questionnaire before data collection.

Components of the final data collection

Depending on the goal of the study, it might be useful to further include other components apart from the monitoring questionnaire and the extended list. If more in-depth and qualitative information is needed, the inclusion of focus group discussions is helpful. This helps in particular when study results are unexpected and need more clarification. A co-design workshop is particularly recommended when manufac-turers have an intention to further optimize their products for the local context, or filters are partly pro-duced locally (e.g. local housing is used).

Resources

Trained staff and carefully planned tools for the data collection are needed, as well as the allocation of resources for logistics. The questionnaires need to be downloaded to mobile phones and pre-tested before the data collection.

Considerations

Regarding the logistical set-up, the training of the data collectors as well as any ethical considerations, please refer to other sheets in this guideline. It is very important for all phases of the data collection to always enter the same household ID which was assigned at the beginning of the project and, if possible, also interview the same respondent throughout the whole process. This is particularly important for the final data collection. Always make sure to keep the names of the respondents separate to the questionnaire information to keep privacy and anonymity.

References

M. Peter and M. Harter (2021) Selecting household water filters in emergencies: a manual for field evaluation, University of Applied Sciences and Arts Northwestern Switzerland, Muttenz, Switzerland.