



# Household Water Filter Evaluation Ahmedabad, India

Comprehensive Initiative on Technology Evaluation at MIT  
Product Evaluation Report, Fall 2015



CITE Evaluation Lead Susan Murcott demonstrates water sampling procedures to Assistant Team Coordinator Shrikant Brahmhatt in Adalaj on the first day of field work. Credit: Jason Knuston



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## Introduction

The Comprehensive Initiative on Technology Evaluation (CITE) at MIT was created in 2012 and is the first-ever program dedicated to developing methods for product evaluation in global development. CITE is led by an interdisciplinary team at MIT, and draws upon diverse expertise to evaluate products and develop a deep understanding of what makes different products successful in emerging markets. Our evaluations provide evidence for data-driven decision-making by development workers, donors, manufacturers, suppliers, and consumers themselves.

In summer 2014, a CITE research team evaluated household water filters available on the market in Ahmedabad, India. The team worked closely with students and faculty at local universities to assess water filter products' *suitability*—how well do filters perform their intended purpose, *scalability*—how well do the filters' supply chain effectively reach consumers, and *sustainability*—are the filters used correctly, consistently, and continuously by users over time.

The findings of that research are presented here in CITE's second product evaluation report organized by the three categories of water filter that CITE found on the Ahmedabad market. From least costly to most costly, the water filter categories include:

**Conventional particle filters:** These water filters remove particles in the size range of 5 - 1,000 microns from water. Particles in this size range include contaminants such as dirt, sand, pollen, and some bacteria. In Ahmedabad, CITE found widespread use of two types of conventional particle filters—cloth and *jali*<sup>1</sup> mesh, both of which are commonly used by Ahmedabad's poorest families, households living on less than \$4 a day.<sup>2</sup> CITE observed that some households use either cloth or *jali* filters, while others use cloth and *jali* mesh together, one after the other on the same water.

**Gravity non-electric filters:** These filters mainly operate in the microfiltration or ultrafiltration range, meaning they can remove particles much smaller than the cloth and *jali* mesh filters, including all bacteria, protozoa, and viruses. The gravity non-electric water filter category typically includes a variety of manual fill and gravity-driven filters.

**Reverse osmosis water filters:** These filters are a popular choice for middle and high-income consumers in Ahmedabad, offering major performance advantages over both conventional particle filters and gravity non-electric filters. Reverse osmosis filters remove all viruses, bacteria, metal ions, aqueous salts, and more.

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<sup>1</sup> *Jali*, in Hindi, means a perforated material (e.g. cloth, stone, metal) or lattice screen.

<sup>2</sup> For the purposes of this study, CITE defines “the poor” as households living on less than \$4 a day who are classified as India’s “economically weaker section” and households living on about \$8.50 a day who are classified as India’s “lower-income group.” This definition is based on a policy set by India’s Ministry of Housing and Urban Poverty Alleviation.

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## How to Use This Report

This report contains comparative rating charts and key findings based on a year of rigorous research and analysis done by CITE's multidisciplinary team at MIT, both in the lab and in the field. Key findings are organized by the three categories of water filters that the CITE team studied in Ahmedabad, India and the Consumer Reports labs in Yonkers, New York as well as a fourth section on crosscutting findings.

1. **Conventional particle filters,**
2. **Gravity non-electric filters, and**
3. **Reverse osmosis filters.**

The findings of this report are especially applicable for the following audiences:

- **Entrepreneurs** looking for an opportunity to improve upon or create new household water filter products for Indian consumers;
- **Manufacturers, suppliers, and retailers** seeking to better understand consumer preferences, use patterns, and needs;
- **Development practitioners**, especially donor agencies and individuals responsible for procurement who may be interested in purchasing large quantities of household water filters for their programs in India;
- **Government officials** seeking to better address water quality and treatment issues in and around Ahmedabad, India through policy and education;
- **Consumers** in Ahmedabad specifically, and India more generally.

Readers who would like to explore CITE's findings in greater depth are welcome to read the detailed suitability, scalability, and sustainability reports referenced in this comprehensive report.



Eshita Dayani and Jonars Spielberg from MIT CITE interview a local resident about his water quality and water filter usage in Ahmedabad, India. Photo Credit: Sydney Beasley

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## Background & Problem Statement

In India, 76 million people lack access to an improved drinking water source.<sup>3</sup> Without clean drinking water, these 76 million are at heightened risk for water-borne diseases like diarrhea, typhoid, and cholera, which significantly contribute to mortality rates.<sup>4</sup> UNICEF estimates that 2,000 children under the age of five die every day from diarrheal diseases around the world, and of that number, about 1,800 deaths are linked to water, sanitation and hygiene.<sup>5</sup> And as in many other countries, India's poor are much more likely to be affected by unsafe drinking water than those who are financially better off.

Household water filters—if used correctly, consistently, and continuously—could serve as a stopgap solution for communities with unimproved and improved water supplies. In many parts of India, water filters are already playing this role at scale, including in Ahmedabad, a city of six million people in northwest India where CITE conducted its research in June 2014.

Ahmedabad is an interesting case because the Ahmedabad Municipal Corporation, a local government body responsible for providing civic infrastructure, has made notable strides to provide clean water to its residents. In some of Ahmedabad's poorest communities, piped water is often supplied for free. Additionally, about 88% of people in urban Gujarat, the state where Ahmedabad is located, treat their drinking water.<sup>6</sup>

Despite these efforts, improved water sources are not always safe.<sup>7</sup> Water safety can be compromised by storage in contaminated vessels or other unhygienic handling practices in the home; and piped water can face a number of challenges, requiring frequent repair and maintenance, springing leaks, or experiencing pump failures and electrical outages. A number of studies have linked interruptions of water supply to outbreaks of cholera and other waterborne diseases,<sup>8</sup> and CITE identified at least one cholera outbreak in a community with piped water while conducting this study in Ahmedabad.<sup>9</sup>

In Ahmedabad, where the water supply is a complex mix of surface water and groundwater, mixed in different proportions at different times, CITE found that water parameters like the level of hardness, residual chlorine, and total dissolved solids<sup>10</sup> often exceed the acceptable limit set by India's Standard Requirement.<sup>11</sup> *E.coli* was detected in 19% of surface water samples and 68% of groundwater samples, while total coliform was detected in 36% in surface water samples and 81% of groundwater samples.<sup>12</sup>

The water situation in Ahmedabad is such that residents often have very little knowledge about the quality

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<sup>3</sup> An "improved water source" is defined by the WHO and UNICEF Joint Monitoring Programme as "a water source that, by nature of its construction or through active intervention, adequately protects the source from outside contamination, particularly fecal matter."

<sup>4</sup> WHO/UNICEF/JMP, 2015.

<sup>5</sup> UNICEF, 2013.

<sup>6</sup> "Drinking Water, Sanitation, Hygiene, and Housing Condition in India." National Sample Survey Office, 2012.

<sup>7</sup> "Why 'Improved' Water Sources Are Not Always Safe." Bulletin of WHO, 2014.

<sup>8</sup> "Why 'Improved' Water Sources Are Not Always Safe." Bulletin of WHO, 2014.

<sup>9</sup> "Household Water Filter Evaluation, Suitability—India." CITE, 2015.

<sup>10</sup> Total dissolved solids is a term used to describe inorganic salts and small organic matter found in water that can affect its taste.

<sup>11</sup> India's "Standard Requirement" for water is determined by the Bureau of Indian Standards, a government body responsible for consumer protection at the national level.

<sup>12</sup> "Household Water Filter Evaluation, Suitability—India." CITE, 2015.

of their water<sup>13</sup> and few opportunities to learn more. Household water filters could serve as a useful frontline tool in ensuring safe drinking water. But having a wide variety of filters on the Ahmedabad market makes it very difficult for consumers to ascertain what works and what does not. CITE identified over 100 models of household water filters in the Ahmedabad market alone.

Furthermore, many of Ahmedabad's poorest families use conventional particle filters, such as *jali* mesh or cloth, that CITE found ineffective at removing harmful elements such as *E.coli* and total coliform.<sup>14</sup> There are several water filters on the market that are effective, but may not be affordable for or available to consumers. This creates a gap—and inadvertently, an opportunity—in the household water filter market for a product that is both effective *and* affordable.

## Findings at a Glance

The following are some of the high-level findings from the CITE water filter evaluation organized by category of filter. Descriptions of each filter category as well as the detailed findings associated with each category are explained in detail later in the report.

### Conventional Particle Water Filters

- Ahmedabad's poor know very little about their water quality as they have no means to test it. Most of Ahmedabad's poor use conventional particle filters such as cloth and *jali* mesh filters, and have little information about other, better performing water filters that might be affordable at their income level.
- Conventional particle water filters including cloth and *jali* mesh are extremely low-cost and widely available, but ineffective at removing turbidity<sup>15</sup> and *E.coli*. Furthermore, some *jali* mesh models actually contaminated previously clean water samples.

### Gravity Non-Electric Filters

- While the general effectiveness of gravity non-electric filters far surpasses that of cloth and *jali* mesh filters, the performance of gravity non-electric water filters varied widely by model when measuring flow rate, turbidity removal, lifetime, and *E.coli* removal.
- Three of the gravity non-electric filters evaluated by CITE could be an effective, affordable option for Ahmedabad's poorer households, but would need better financing mechanisms to make their upfront cost feasible for the poorest.
- Gravity non-electric filters are often difficult to find in rural areas outside of Ahmedabad where they may be needed most.

<sup>13</sup> "Household Water Filter Evaluation, Sustainability." CITE, 2015.

<sup>14</sup> "Household Water Filter Evaluation, Suitability—India." CITE, 2015.

<sup>15</sup> Turbidity is a measure of a liquid's clarity. Excessive turbidity in drinking water can be aesthetically unappealing, and can be a visual indicator of the microbial quality of the water.

## Reverse Osmosis Filters

- CITE’s lab testing shows reverse osmosis filters are the only category that can dramatically reduce total dissolved solids. Additionally, all of the reverse osmosis filters CITE tested greatly reduced turbidity and removed more than 99.99% *E.coli*.
- Recently introduced locally assembled non-branded Dolphin<sup>16</sup> filters are very popular in the Ahmedabad market. These Dolphin filters were just as effective as their branded counterparts at less than half the cost.
- Reverse osmosis systems waste 74 liters of water for every 26 liters they clean. This makes them unsustainable in water scarce regions like Ahmedabad and India more broadly.

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## Approach & Methodology

CITE employed a variety of methods to collect data for the water filter evaluation including lab and field tests of the water filter performance; surveys of water filter retailers and households in Ahmedabad; and semi-structured interviews with original equipment manufacturers and distributors in Ahmedabad and Gandhinagar. The complete list of methods appears in Table 1.

Each of CITE’s teams conducted a different aspect of overall water filter evaluation:

The **suitability team (S1)** evaluated the technical performance of the water filters and tested attributes like the ability to remove *E.coli*, turbidity, and total dissolved solids, among others.

The **scalability team (S2)** assessed the availability and affordability of the products as well as after-market requirements such as parts availability, maintenance plans and service experience. They also obtained information on sales volumes, inventories and product margins from distributors.

The **sustainability team (S3)** analyzed the social, economic, and usability factors that affect adoption such as user familiarity with the product, affordability, confidence in use, quality of instructions and training, and perceived benefits of using the filters.

All three teams have applied a weighted criteria methodology—similar to the method used by US *Consumer Reports*—to understand the suitability, scalability, and sustainability of different household water filters. A weighted criteria methodology identifies key aspects of the technology that are important to stakeholders (e.g. technical performance, cost, usability) and then identifies attributes that can be measured to calculate a score for each aspect. Weightings are applied to the attributes to reflect their relative contribution to the aspect score. The resulting weighted criteria matrix is then used to develop a series of comparative ratings charts.

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<sup>16</sup> CITE immediately identified a notable market share for non- or locally-branded products that are assembled by distributors and/or retailers from a combination of locally manufactured, India-manufactured and imported components. We combine this fragmented set of market players under a brand name that is commonly used by numerous local companies: Dolphin.

The analysis carried out and data collected by each team is summarized in Table 1 below.

**Table 1: Summary of 3S (suitability, scalability, and sustainability) methods used in the water filter evaluation**

	<b>Sample</b>	<b>Sample Selection</b>	<b>Method</b>	<b>Content of Evaluation</b>
<b>Suitability</b> <i>Consumer Reports</i> <i>Lab Testing</i>	15 water filters	Purposeful sample <sup>t1</sup> of models from market in Ahmedabad, India	Lab tests	<ul style="list-style-type: none"> <li>• Total Dissolved Solids</li> <li>• <i>E.coli</i></li> <li>• Turbidity</li> <li>• Flow rate</li> <li>• Percent recovery (RO filters)</li> <li>• Clogging/filter lifetime</li> </ul>
<b>Scalability</b>	108 water filter retailers	Stratified (by geography) purposeful cluster sample	Surveys	<ul style="list-style-type: none"> <li>• General business information</li> <li>• Availability of products</li> <li>• Affordability of products</li> <li>• After-market</li> <li>• Market potential</li> </ul>
	17 original equipment manufacturer and distributor representatives	Snowball sample <sup>t2</sup>	Semi-structured interviews	<ul style="list-style-type: none"> <li>• Sales volumes</li> <li>• Product margins</li> <li>• Inventory</li> <li>• Lead times</li> </ul>
<b>Sustainability</b>	264 households (146 gravity non-electric or reverse osmosis filter users, 84 cloth and/or jali mesh filter users & 34 non-users)	Purposeful sample	Surveys	<ul style="list-style-type: none"> <li>• Social factors such as prevalence/awareness of filters, social influence, endorsement</li> <li>• Economic factors such as affordability and availability</li> <li>• Perceived benefits</li> <li>• Usability factors such as confidence in use, instructions and training, and performance</li> </ul>

CITE used an assortment of purposeful sampling strategies to select research subjects and households for water testing. Researchers at the Indian Institute of Management-Ahmedabad and Indian Institute of Technology-Gandhinagar worked with the team to select the participants in a purposeful way. Distributors and original equipment manufacturers were identified through a snowball sampling strategy based on initial connections from customer service addresses, LinkedIn, and MIT alumni in Ahmedabad, India.

<sup>t1</sup> Purposeful sampling, also known as judgmental, selective or subjective sampling, is a type of non-probability sampling technique.

<sup>t2</sup> A snowball sample—a type of purposeful sampling—is a non-probability sampling technique where existing study subjects recruit future subjects from among their acquaintances.

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## Comparative Ratings Charts

CITE evaluated products holistically, conducting research both in the lab and the field. Research conducted in the lab is critical to verifying how well each product performs from a technical perspective, while research conducted in the field is crucial to understanding how product use plays out contextually with real people in real communities like Ahmedabad. CITE’s lab and fieldwork influence one another. Notably, CITE’s field work informed which water contaminants were common in Ahmedabad’s various water sources, and therefore necessary to test in the lab as well as which water filters were commonly found in the local market. CITE’s field work was also crucial in giving the research team a good understanding of Ahmedabad’s water supply and systems.

One of the key outputs of both lab and field research are comparative ratings charts (pg. 12, 15 and 18) that facilitate decision-making. While each comparative ratings chart analyzes the same three categories of water filters as the others, the unit of analysis for each is slightly different by necessity. In the lab, CITE evaluated suitability by looking at *models* in order to provide the most specific information possible for potential water filter buyers. From a scalability perspective, CITE looked at variability across *brands* to understand water filter supply chains at a more macro-level. And from a sustainability perspective, CITE looked at variability across *type*, the way actual consumers used and understood water filters. An example of type is pairing cloth and *jali* mesh filters, two filters that are commonly used together. Each of the charts is explained in detail later in this report.

### Lab Research

CITE’s lab research on water filters was conducted in a specially fitted lab<sup>17</sup> at *Consumer Reports* in Yonkers, New York. CITE’s field team first traveled to Ahmedabad to identify which water filters were available on the Ahmedabad market, and then shipped samples of the most widely available filters back to the United States for rigorous lab testing.

Each water filter was tested on a sub-set of WHO performance-based attributes chosen for their relevance to the water conditions found in Ahmedabad.

***E.coli* removal:** the percentage of *E.coli*<sup>18</sup> removed by each filter with 99.99% defined as “excellent,” 99.9% defined as “very good,” 99% defined as “good,” 90% defined as “fair,” and anything less as poor or unacceptable;

**Turbidity reduction:** the degree to which a filter could reduce turbidity starting at a given level of WHO recommended challenge water<sup>19</sup> with 80-100% defined as “excellent,” 60-80% defined as “very good,” 40-60% defined as “good,” 20-40% defined as “fair,” and anything less as poor or unacceptable;

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<sup>17</sup> Learn more about how CITE specially fitted equipment at the *Consumer Reports* lab by referencing “Household Water Filter Evaluation, Suitability—*Consumer Reports*.”

<sup>18</sup> According to the EPA, “the presence of *E. coli* in water is a strong indication of recent sewage or animal waste contamination. Sewage may contain many types of disease-causing organisms.”

<sup>19</sup> WHO, 2014.

**Total dissolved solids reduction:** the degree to which a filter could reduce total dissolved solids at the level of WHO recommended challenge water<sup>20</sup> with 80-100% defined as “excellent,” 60-80% defined as “very good,” 40-60% defined as “good,” 20-40% defined as “fair,” and anything less as poor or unacceptable;

**Clean water flow:** liters of clean water a filter produced each hour, with 8-10 liters/hour defined as “excellent,” 6-8 liters/hour defined as “very good,” 4-6 liters/hour defined as “good,” 2-4 liters/hour defined as “fair,” and anything less as poor or unacceptable;

**Percent recovery:** the percentage of clean water produced out of the total water poured into a filter<sup>21</sup>

**Lifetime:** a measure of how well the filter retains its flow rate of clean water over time with 24.75-31.25 lifetime days defined as “excellent,” 18.25-24.75 lifetime days defined as “very good,” 11.75-18.25 lifetime days defined as “good,” 5.25-11.75 lifetime days defined as “fair,” and anything less as poor or unacceptable;<sup>22</sup>

**Convenience:** a measure balancing the value added by features that facilitated water filtering (such as a pre-filter) and the value detracted by features that hindered water filtering such as water flow problems<sup>23</sup>

Based on these attributes, CITE developed a comparative ratings chart, which also indicates price of the filter in Ahmedabad as well as other features<sup>24</sup> products may offer to consumers. In this comparative ratings chart, features are not included in the overall score; instead they are included to provide more information about the water filter being assessed. The comparative ratings chart is provided in Table 2.

The comparative ratings chart follows three primary steps:

- 1) Rating:** CITE draws a linear relationship between a filter’s performance on an attribute and the rating assigned to that attribute. In other words, the better a filter performs on a specific attribute, the higher its rating on that attribute. For example, a filter’s turbidity removal ability is linearly converted to a rating score ranging from 0.50 (poor) to 5.49 (excellent).<sup>25</sup>
- 2) Weighting:** After giving each filter a rating score for its attributes, each attribute is weighed according to their importance<sup>26</sup>, to compute the overall score.
- 3) Score:** The overall score of a water filter model is scaled in a range between 0 and 100. The score of each filter model indicates the filter’s overall performance.

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<sup>20</sup> WHO, 2014.

<sup>21</sup> This measure was only applicable for reverse osmosis water filters, which produce brine, also known as wastewater.

<sup>22</sup> For gravity non-electric filters, end-of-life was defined as when the clean water flow rate fell below 1 liter/hr. For reverse osmosis filters, end-of-life was defined as when clean water flow rate fell below 100mL/min. Thus, filter lifetime measures how long a filter can retain its clean water flow rate.

<sup>23</sup> “Household Water Filter Evaluation, Suitability—*Consumer Reports*.” CITE, 2015.

<sup>24</sup> As defined by CITE, “features” are not central to the product identity or function, but may be commonly found in the product family.

<sup>25</sup> To learn more about CITE’s methodology for assigning ratings to attribute performance, reference “Household Water Filter Evaluation, Suitability—*Consumer Reports*.”

<sup>26</sup> The CITE team determined weightings based on how important an attribute was to the safety of the water. For example, *E.coli* removal was weighed more heavily than turbidity removal, which is often seen as more an aesthetic water characteristic.

CITE tested each filter using challenge test water as defined by the WHO, which requires introducing turbidity and total dissolved solids to base water.<sup>27</sup> CITE also created an *E.coli* solution and injector in order to efficiently test *E.coli* removal of filters tested in the lab.



Jason Knutson, a student at MIT and Mahesh Kumar, a student from IIT-Gandhinagar sample water from the Narmada Canal just outside Ahmedabad, India. Credit: Jenny Tanphanich

The overall results show the top performers in the product family. In addition, they show the “value for money,” i.e. the relative performance increase as a function of price. This allows those making decisions to balance the tradeoff between overall performance and price, as well as between the various attributes when making a purchasing decision. The user of the chart may choose to select a model by the highest overall score, or the score as a function of price, or by critical factors relating to their specific situation.<sup>28</sup>

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<sup>27</sup> To learn more about CITE’s creation of challenge water, reference “Household Water Filter Evaluation, Suitability—*Consumer Reports*.”

<sup>28</sup> What is not included in this chart is an assessment of strictly nontechnical factors or issues such as social and cultural acceptability of water filters, customer willingness to pay, ease of repair and maintenance, product durability, and accessibility of customer service by manufacturers. Because context is crucial in understanding these factors, they are instead informed by CITE’s field research, which you can read about in the next section of this report.



Table 2. Suitability Comparative Ratings Chart (based on lab testing)

Product Information					Product Attributes								Product Features			
Category	Model	Overall Score 0 to 100	Cost in Dollars [1]		E.Coli Removal	Turbidity Reduction	TDS Reduction [3]	Clean Water Flow		Percent Recovery [6]		Lifetime	Convenience	Pre-filter	Auto or natural shut off	Power or life Indicator
			Purchase	Operating [2]				Liters/Hr	Score	%	Score					
Reverse Osmosis	Clean Water Dolphin	90	\$98	\$369	●	●	●	14.5	●	27	◐	●	◐	●		
	Tata Swach Platina	88	\$233	\$668	●	●	●	14.0	●	31	◐	◐	●			
Gravity Non Electric	Eureka Forbes AquaSure Amrit	56	\$42	\$489	◐	●	-	4.00	●	-	-	◐	●	●	●	●
	Tata Swach Smart 1500 liters	53	\$20	\$252	◐	●	-	3.27	◐	-	-	◐	●	●	●	●
	Hindustan Lever PureIt Class 14L	52	\$17	\$537	◐	●	-	3.40	◐	-	-	○	◐	●	●	●
	Tata Swach Smart w. Silver NANO 3000 liters	51	\$17	\$537	◐	●	-	2.21	◐	-	-	◐	●			
	Prestige LifeStraw	51	\$50	\$135	◐	●	-	1.61	○	-	-	◐	◐	●		
	Kent Gold UF Membrane Filter	50	\$43	\$183	◐	●	-	3.10	◐	-	-	○	○	●	●	●
	Tata Swach Cristella Plus	47	\$17	\$537	○	◐	-	3.96	●	-	-	●	●	●	●	
	Espresso Stainless Steel Water Container [4]	43	-	-	◐	●	-	0.61	○	-	-	●	◐			
	Everpure Unbreakable [5]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Conventional Particle	Ratings for cloth and mesh filters were not generated because the lowest category "poor" did not capture the inadequacy of their performance and would skew the other ratings.															

Legend

- Excellent
- ◐ Very Good
- ◑ Good
- ◒ Fair
- Poor

Attribute Definitions

- E.coli removal: percentage of E.coli removed by the filter
- Turbidity reduction: percentage of turbidity removed by the filter
- Total dissolved solids reduction: percentage of total dissolved solids removed by the filters
- Clean water flow: liters of clean water a filter produced per hour
- Percent recovery: percentage of clean water produced out of total water poured into filter
- Lifetime: a measure of how well the filters retains its flow rate of clean water over time
- Convenience: a measure balancing value added by features that facilitate water filtering & value detracted by features that hinder water filtering

Notes

- Overall Score ranges from 0 to 100, with 0 as low and 100 as high.
- [1] – The exchange rate used for this calculation is 60 INR per USD.
- [2] – Operating cost is the total cost of ownership (TCO), which averages the initial purchase price plus the cost of the replacement parts for a household consuming 25 liters per day over the five-year lifetime of the device.
- [3] – Gravity non-electric filters as a product category are not designed to remove total dissolved solids.
- [4] – Multiple samples never met the minimum flow rate of 1 liters per minute
- [5] – There were significant leaks found in multiple samples of the Everpure Unbreakable, making the quality impossible to test.
- [6] – Percent recovery only applies to reverse osmosis filters which produce wastewater.

Although there are other kinds of water filters outside of the three categories that CITE evaluated, we intentionally limited ourselves to filters commonly found in the market and in homes in Ahmedabad, as opposed to specialty items such as water softeners, arsenic, fluoride, or mineral filters. We also limited our investigation only to filters, not to ultra-violet (UV) treatment, chemical disinfection products, or other non-filtration water treatment methods. CITE did not evaluate filters for the chemical contaminants arsenic or fluoride. This is for two reasons: first, arsenic and fluoride are not common in the Ahmedabad water supply, and thus would not be relevant to this study, and second, the World Health Organization deems infectious diseases caused by microbial contaminants to be the “most common and widespread health risk associated with drinking water.”<sup>29</sup> Therefore, we focused our research primarily on microbial contaminated water, as this most directly relates to health concerns in our target area.

It is possible that in the future, a CITE-style evaluation could be applied to these other household water treatment categories.

## **Field Research**

Context is crucial to each evaluation CITE conducts, and our water filter evaluation in Ahmedabad was no exception. CITE’s field research included a scalability and sustainability evaluation of all water filter categories.

### **Scalability**

CITE defines “scalability” as the capability of the supply chain to reach consumers, taking into account issues of supply chain configuration, manufacturing, distribution, sales channels, and after-market support.

Three key aspects characterize the scalability performance of an original equipment manufacturer supply chain for a product:

**Affordability:** the product’s total cost of ownership, combining initial purchase and ongoing maintenance, and availability of financing across the supply chain.

**Availability:** the product’s market presence and stock levels for consumer purchase.

**After-market:** the support system to maintain the product after purchase by the consumer, including service and repairs.

For each of these aspects, CITE studies key attributes as identified in Table 3 on the following page:

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<sup>29</sup> “Guidelines For Drinking Water Quality.” WHO, 2011.

**Table 3. Scalability Attributes**

	<b>Attribute</b>	<b>Ratings</b>
<b>Affordability</b>	Initial Investment	“Excellent” defined as a cost below 2,000 INR (US \$33.33)
	Total Cost of Ownership	“Excellent” defined as a cost below 219 INR (US \$3.65) per 1000 liters
	Financing	“Excellent” defined as a score above 80, with the score based on prevalence of monthly installments, other consumer credit & manufacturer credit to retailers
<b>Availability</b>	Selection Availability	“Excellent” defined as prevalence above 40%
	Shelf Availability	“Excellent” defined as above 16 days of inventory
	Rural Availability	“Excellent” defined as prevalence above 40%
<b>After-Market</b>	Parts Availability	“Excellent” defined as prevalence above 80%
	Maintenance Plans	“Excellent” defined as 40% or greater savings with a maintenance plan over individual part purchases
	Service Experience	“Excellent” defined as a score above 80, with the score based on prevalence of positive and negative feedback from retailer and user surveys

As illustrated in the Scalability Comparative Ratings Chart (Table 4), CITE combined values of the nine attributes in a weighted sum to determine the overall scalability score.

Attribute values are based on the empirical evidence collected by the team.<sup>30</sup> Weights, listed at the top of the table, are influenced by consumers and commercial providers’ preferences as understood by CITE’s market research in the field. The weights and scoring basis are provided for transparency.

Overall, affordability comprises 50% of the scalability score; with availability and after market support each contributing 25%. CITE decided total cost of ownership was the most important attribute for affordability since it captures all relevant costs; financing is a key factor in initial adoption and has a weight of 15%; initial investment is weighted only 5% since that value is also incorporated in the total cost of ownership. Selection and shelf availability for the device are equally weighted with parts availability. Rural availability has a lower weight since the urban market contributes more to scalability. After market attributes characterizing maintenance plan options and service experience are equally weighted.

<sup>30</sup> “Household Water Filter Evaluation, Scalability.” CITE, 2015.

Table 4. Scalability Comparative Ratings Chart

Product Information [1]			Affordability			Availability			Aftermarket		
Weighting			5%	30%	15%	10%	10%	5%	10%	7.5%	7.5%
Category	Brand	Scalability Score	Initial Investment	Total Cost of Ownership	Financing	Selection Availability	Shelf Availability	Rural Availability	Parts Availability	Maintenance Plans	Service Experience
Reverse Osmosis	Dolphin	70	●	●	●	●	●	●	●	●	●
	Kent	51	○	●	●	●	●	●	●	●	●
	Tata	46	○	○	●	●	●	●	○	●	●
	Eureka Forbes	45	○	●	●	●	●	●	●	●	●
Gravity Non Electric	Eureka Forbes	59	●	●	●	●	●	○	●	●	●
	Kent	55	●	●	●	●	●	○	●	○	●
	Tata	53	●	●	●	●	●	○	●	○	●
	HUL	48	●	●	●	●	●	○	●	○	●
	Prestige [2]	-	●	●	-	○	●	○	-	-	-

Legend

- Excellent
- Very Good
- Good
- Fair
- Poor

Attribute Definitions

Selection availability	measures market presence of the product in retail stores
Shelf availability	indicates likelihood that a consumer will be able to purchase a product when entering a store
Rural availability	percentage of retailers outside of the city that sell the product
Initial investment	maximum retail price
Total cost of ownership	initial investment plus the cost of replacement filters over the lifetime of the device
Financing	availability of consumer or retailer credit options for this product
Parts availability	ability to purchase replacement parts for this product when needed
Maintenance plans	added value that annual maintenance contracts offer compared with annual cost of
Service experience	consumers purchasing and installing components themselves based on survey data from retailers & consumers about their experience with warranty and service

Notes

- [1] – While all three CITE research teams studied the same three water filter categories, CITE’s scalability team drew its product samples from field visits to retail outlets, while suitability drew its product samples from field visits to households, so the two slightly differ.
- [2] – Prestige is included as a promising product even though it has a small sample size and insufficient data to conduct a complete evaluation. Prestige is new to the market and is only available in a small number of retail outlets.

## Sustainability

CITE defines “sustainability” as the social, economic, and usability factors that affect a user’s adoption of a product including user familiarity with the product, affordability, confidence in use, quality of instructions and trainings, and perceived benefits of using the filters. CITE evaluated the sustainability of different household water filters with respect to four key aspects: social, economic, perceived benefits, and usability. The output from this method is a comparative ratings chart (see Table 5).



Women in Ranoda, a village outside Ahmedabad, India demonstrate how to use a water test kit. Shortly after completing the water filter evaluation, CITE began work on a water test kit evaluation to be published in early 2016. Credit: Sydney Beasley

The four key aspects are defined as follows:

- **Social:** measures how well the technology fits the social norms practiced by the consumers.
- **Economic:** measures whether the user has access to the technology through retail or other outlets, and whether they are willing and able to pay for the initial and on-going costs associated with the technology.
- **Perceived benefits:** measures how well the technology fulfills the user’s expectations for meeting their needs.
- **Usability:** measures whether the users are confident that they can use the technology correctly in order to achieve the highest benefit, whether there is a structure in place that will teach them how to use and maintain it, and whether they trust that it will continue to operate well for as long as they expect.

To assess sustainability, water filters were again organized into three categories; however, conventional particle filters were broken down into three “types”: cloth alone, *jali* alone, and cloth and *jali* together while the reverse osmosis filters were broken down into two types: locally-assembled and branded, resulting in six category/type alternatives as shown in Table 5.

This distinction allowed CITE to capture variations among the expanded set of categories more accurately. It also reflects the way consumers use and understand different kinds of filters. For example, while cloth and *jali* mesh filters work in similar ways from a technical, or suitability perspective, some consumers use cloth and *jali* mesh filters together, a distinction that calls for an additional category when properly assessing the sustainability of a product.<sup>31</sup>

The six categories assessed from a sustainability perspective include cloth alone, *jali* mesh alone, cloth and *jali* together, gravity non-electric, locally assembled reverse osmosis, and branded reverse osmosis filters.

Table 5 indicates the comparative ratings chart for six filter categories, including the scores for all 11 attributes and the weightings for the attributes. The weightings used are directly influenced by the preferences of water filter users CITE surveyed in Ahmedabad.

The economic aspect is weighted most heavily due to the fact that the poorest households in Ahmedabad commonly expressed high cost as the major barrier to buying a water filter.<sup>32</sup>

It should be noted that not all attributes are relevant for all categories. Specifically, the health and time/money attributes were not calculated for the cloth and *jali* categories within the perceived benefits area, because the question posed, “Which features do you value most about your filter?” does not apply to cloth and *jali* filters that are extremely simple and do not include features.

Cloth and *jali* filters were also not scored on the instruction and training attribute of the usability area because these filters are not sold with included instructions and training manuals. Where attribute scores were not calculated, the higher-level key aspect scores were calculated using whichever scores were available, which influences the weighting for different categories.

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<sup>31</sup> “Household Water Filter Evaluation, Sustainability.” CITE, 2015.

<sup>32</sup> “Household Water Filter Evaluation, Sustainability.” CITE, 2015.

Table 5. Sustainability Comparative Ratings Chart

Product Information			Social			Economic	Perceived Benefits			Usability		
Conventional Particle Weightings			3.8%	3.8%	7.5%	50%	0.0%	0.0%	15.0%	6.0%	0.0%	14.0%
Reverse Osmosis/Gravity Non-Electric Weightings			3.8%	3.8%	7.5%	50%	3.0%	3.0%	9.0%	5.0%	5.0%	10.0%
Category	Type	Sustainability Score	Observability	Social Influence	Recommendability	Cost Barrier	Health	Convenience	Water Quality	Confidence In Use	Instructions & Training	Dependability
Conventional Particle	Cloth	77					-	-			-	
	Cloth and Jali	73					-	-			-	
	Jali	72					-	-			-	
Gravity Non Electric	Several Brands	62										
Reverse Osmosis	Local Assembly	57										
	Branded	37										

Legend

- Excellent
- Very Good
- Good
- Fair
- Poor

Attribute Definitions

Observability	Prevalence of use and awareness of filters
Social Influence	Impact of peers and the past on filter use
Recommendability	Endorsement of a filter based on personal use
Cost Barrier	Initial purchase cost relative to annual income
Health	Health as a value and reason to buy a filter
Convenience	Time and money values and reasons to buy a filter
Water Quality	Water quality as a value and reason to buy a filter
Confidence in Use	Faith in user's own ability to use a filter correctly
Instructions & Training	Type and diversity of support services for a filter
Dependability	The satisfactory performance of a filter over time

## Conventional Particle Water Filters

### How are they used?

India has a long history of cloth and mesh filtration. In 5th century BCE, Buddhist monks and nuns were allowed eight requisites as their personal property, the eighth of which was “a water strainer for removing impurities from drinking water.”<sup>33</sup> While Buddhism declined during the subsequent Muslim conquest of the Indian subcontinent, the cultural practice of filtering water with a cloth has been deeply established in India for at least 2,500 years. India also has a long tradition of cloth production with the capacity to produce cloths of every type, weave, and mesh size.

Today, cloth and *jali* mesh filters typically cost between INR30 (US \$0.50) to INR60 (US \$1.00) on the Ahmedabad market. The market for conventional particle filters is decentralized, making it almost impossible to draw specific, pointed conclusions about its supply chain. However, given their extremely low price and widespread availability at small shops and kiosks, CITE did not find any significant economic or supply chain barriers to scale. Apart from cloth and *jali* mesh filters, other types of conventional particle removal filters such as ceramic filters, biosand filters, and siphon filters were not found in the Ahmedabad market.



*These cloths, designed for Indian saris, are also commonly used as cloth water filters, often over top of “matka,” or clay water storage pots common in India.*



*Users also commonly attach pieces of cloth like this one to their water taps to serve as a water filter.*



*An example of a jali mesh water filter found on the Ahmedabad market.*

*Figure 1. Examples cloth and jali mesh water filters used in Ahmedabad, India.*

### Key findings

Despite the fact that cloth and *jali* mesh filters are low-cost, widely available, and commonly used by the poor, CITE found that these filters are not suitable for use as household water filters.

<sup>33</sup> “The Bhikkhus’ Rules: A Guide for Lay People,” 1999.

## Cloth filters

Cloth filters, made from locally produced sari cloth, had limited usefulness as a low-cost way to provide clean water. CITE's research team tested three kinds of cloth in the lab representing the "best," "medium," and "lowest," quality based on the tightness of their weave. CITE's research showed that while most users only use one or two layers of cloth to filter their water, some users fold their cloth four times which can improve the filter's effectiveness.

CITE's lab testing showed the following<sup>34</sup>:

- Using one layer of any cloth filter tested had no effect whatsoever on removing turbidity or bacteria from contaminated water.
- Folding the "best" cloth model eight times only reduced turbidity by 60%.
- In the lab, there was a positive correlation between the turbidity removal rate and the number of cloth filter layers. When the "best" cloth was folded eight layers, it could remove 60% of turbidity. Unfortunately, even the "best" cloth model folded eight times removed less than 20% of *E.coli* and had no notable impact on removing total dissolved solids.

## Jali mesh filters

*Jali* mesh filters proved even less effective than cloth filters at filtering water. CITE's research team tested five models of *jali* mesh in the lab, including Robin brand mesh, Robin Rimpi-99 mesh, Robin Big Boss mesh, AKASH JALDHARA mesh, and Marshal ZEBA mesh. When tested in the lab, CITE found that the best-performing *jali* mesh filter only reduced turbidity by 5% and had no effect on removing *E.coli*.<sup>35</sup> Further, when tested in the field, about 28% of cloth and 13% of *jali* mesh filters actually caused clean water entering the filter to become contaminated with total coliform.<sup>36 37</sup>

## Consumer awareness, knowledge & confidence

Coupled with the ineffectiveness of conventional particle filters on the Ahmedabad market, CITE found that, when asked what water filter brands and models they could name, not one of the users of cloth or *jali* mesh could name a water filter brand that was designed for their market segment.<sup>38</sup> When these users were able to recall a brand, they often stated that they were not willing or able to pay for it.

CITE also found that some cloth and *jali* mesh filter users had low confidence in their ability to use their water filter correctly. Of water filter users surveyed, nearly two-thirds of users who were not confident in their ability to clean their own water were cloth and *jali* filter users.

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<sup>34</sup> "Household Water Filter Evaluation, Suitability—*Consumer Reports*." CITE, 2015.

<sup>35</sup> "Household Water Filter Evaluation, Suitability—*Consumer Reports*." CITE, 2015.

<sup>36</sup> This could happen for a number of different reasons including the user not properly cleaning or maintaining their water filter; the user contaminating the filter by handling it after handling feces or food; or generally not keeping the home or kitchen hygienic. This is more likely to happen with cloth and *jali* mesh filters because the filter is exposed to more frequent handling.

<sup>37</sup> "Household Water Filter Evaluation, Suitability—India." CITE, 2015.

<sup>38</sup> "Household Water Filter Evaluation, Sustainability." CITE, 2015.

Social learning theory suggests “perceptions of self-efficacy may be crucial in the adoption of healthy practices, and water treatment and storage are no exceptions.”<sup>39</sup> Given CITE’s findings, this suggests that enhancing the self-efficacy of cloth and *jali* mesh users as they make a transition to more effective and expensive filters may increase adoption notably, although understanding how to do so remains a challenge.

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## Gravity Non-Electric Water Filters

### How are they used?

In the Ahmedabad marketplace, CITE found mostly non-electric, counter-top filters. Gravity non-electric water filters on the Ahmedabad market are typically in a lower to middle price range from INR 1,020 (US\$17) to INR 3,000 (US\$50).

CITE’s research team evaluated nine different models of gravity-non electric filters in the lab including the Eureka Forbes AquaSure Amrit, the Tata Swach Smart (1500 liters), the Hindustan Unilever Pureit Classic 14L, the Prestige LifeStraw, the Kent Gold UF Membrane Filter, the Tata Cristella Plus, the Tata Swach Smart with Silver NANO (3000 liters), the Espresso Stainless Steel Water Container, and the Everpure Unbreakable.



The Tata Swach Cristella Plus



The Hindustan Unilever Pureit Classic 14L



The Prestige Lifestraw

Figure 2. Examples of gravity non-electric water filters on the Ahmedabad market.

## Key findings

### Performance

The overall performance of gravity non-electric models far surpasses that of cloth and *jali* mesh filters. Yet, the performance of gravity non-electric water filters varied widely by model when measuring *E.coli* removal, turbidity removal, flow rate, and filter lifetime.

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<sup>39</sup> Hernandez, 2010, p. 24

In general, gravity non-electric models do not remove total dissolved solids or hardness from the water because it is not a part of their product design. This feature would be most appealing to users filtering groundwater in Ahmedabad specifically and Gujarat state generally, which tends to have much higher levels of total dissolved solids and hardness than surface water.

In most cases, CITE found the higher a water filter's flow rate, the lower its turbidity and *E.coli* removal. Four models of gravity non-electric filters can remove higher than 99.9% *E.coli*, including the Hindustan Unilever Pureit, the Prestige Life Straw, the Kent Gold UF Membrane, and the Espresso Stainless Steel Water Container.<sup>40</sup>

CITE's lab tests indicate the following findings:

- Seven models—all but the Tata Swach Cristella Plus and the Everpure Unbreakable—were able to remove higher than 95% turbidity throughout the lifetime of the filter.
- Of the filters CITE tested, the Unilever Pureit filter consistently provided water more than 99.99% free of *E. coli* and was the most effective at removing turbidity. However, in field tests, the Pureit did not completely remove coliform.<sup>41</sup>
- The Espresso filter was very slow in producing clean water. The manufacturer indicates that this will be the case for the first 15 days of use, but CITE found that even after 15 days, the Espresso's flow did not increase. Further, the clean water flow rate of the Espresso remained below one liter per hour, failing to produce a sufficient flow of water.

Additionally, CITE's field team observed that the AquaSure filter caused an increase in total coliform, rather than removing it. CITE found that 24% of water samples that were clean before being filtered by the AquaSure model became contaminated from these filters.<sup>42</sup>

## Affordability

Based on standards for water affordability set by the United Nations and research conducted by CITE,<sup>43</sup> the Kent, Prestige, and Tata gravity non-electric water filters are affordable for Ahmedabad's poor when comparing total cost of ownership with income levels.<sup>44</sup>

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<sup>40</sup> "Household Water Filter Evaluation, Suitability—*Consumer Reports*." CITE, 2015.

<sup>41</sup> "Household Water Filter Evaluation, Suitability—India." CITE, 2015.

<sup>42</sup> "Household Water Filter Evaluation, Suitability—India." CITE, 2015.

<sup>43</sup> According to standards set by the UNDP, affordable water should cost no more than 3% of an annual household income. CITE's research indicates households in Ahmedabad generally replace a water filter every five years and that at least five liters per person per day is needed for a household of five. Using a total cost of ownership calculation, CITE was able to show that a few gravity non-electric models are "affordable" for Ahmedabad's poor by UN standards.

<sup>44</sup> "Household Water Filter Evaluation, Scalability." CITE, 2015.

Although this is encouraging, it is important to note that total cost of ownership amortizes the initial purchase over the lifetime of the product. Affordability also depends on the magnitude of this purchase price, in combination with financing options, which determine the upfront money required to buy the product. The purchase prices for even the most affordable water filters in terms of total cost of ownership would still amount to several months of income for Ahmedabad's poorest families.<sup>45</sup>

Other than the Eureka Forbes products, monthly payment options or interest-free financing is offered by less than 20% of retailers, and the purchase price for gravity non-electric products is below the minimum amount for third-party creditors. This could be a serious barrier to product adoption for users with limited or no savings.

Eureka Forbes offers an interest-free scheme for all of its products, including the AquaSure Ambit filter CITE evaluated. The AquaSure Ambit filter is also the only gravity non-electric model that offers equal monthly installment options, with only the initial installment and no deposit due at the time of purchase. Eureka Forbes offers the best combination of affordability and after-market support, but is not available in rural areas.<sup>46</sup>

### **Availability & awareness**

Low-priced products do not necessarily reach rural populations. For example, the relatively more affordable gravity non-electric filters were not readily available in rural areas outside of Ahmedabad, where they may be needed most, while the more expensive reverse osmosis models are somewhat prevalent in this area. CITE's research shows gravity non-electric filters may not be reaching remote areas because market penetration in these areas takes time and capital that gravity non-electric filter companies are either unwilling or unable to invest.<sup>47</sup>

Further, as discussed earlier in this report, the poor generally lacked awareness of lower-cost gravity non-electric filters as an alternative to cloth and *jali* mesh filters. Investment in improving awareness and physical stock of products such as Tata and Pureit filters among poor and rural households will be key if adoption is to occur.

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## **Reverse Osmosis Water Filters**

### **How are they used?**

The high performance of a reverse osmosis water filter comes at a higher price that includes both purchasing and operating costs because these systems require electricity. On the Ahmedabad market, their cost typically ranges from INR 5,880 (US\$98) to INR 13,980 (US\$233).

In a reverse osmosis filter, water usually travels through at least one pre-filter, then through a membrane, the filter's main component. These filters also typically contain at least one post-filter, usually made with activated carbon, that gives clean water a better taste.

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<sup>45</sup> "Household Water Filter Evaluation, Scalability." CITE, 2015.

<sup>46</sup> "Household Water Filter Evaluation, Scalability." CITE, 2015.

<sup>47</sup> "Household Water Filter Evaluation, Scalability." CITE, 2015.



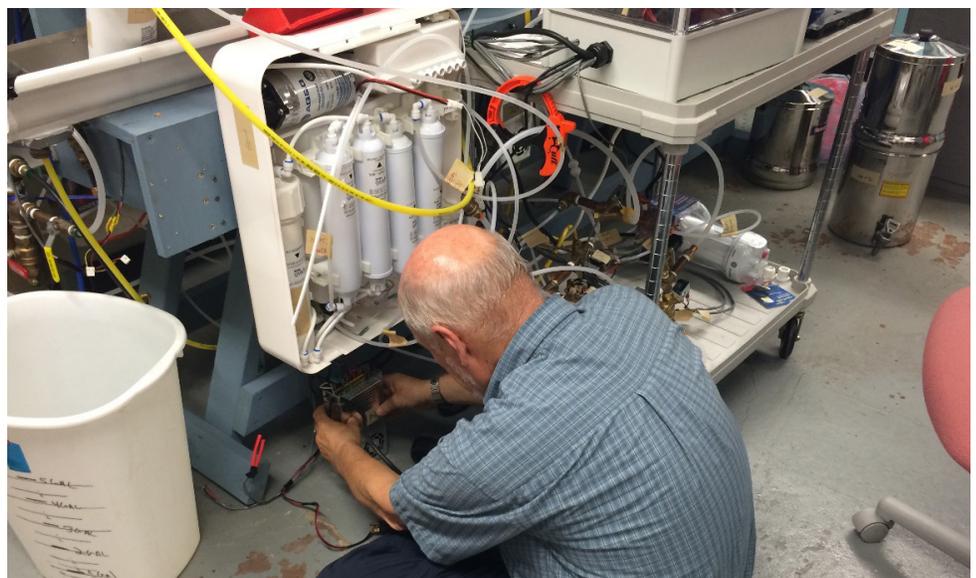
Locally assembled Dolphin water filter



An inside look at the Dolphin model pictured on the left



A Tata Swach Platina Silver water filter



Testing the Tata Swach Platina Silver, also pictured at the left

Figure 3. Examples of reverse osmosis water filters on the Ahmedabad market.

For the purposes of this study, CITE evaluated reverse osmosis filters from several manufacturers and tested three in the lab from Tata, Eureka Forbes, and a locally assembled Dolphin system. CITE's field work in Ahmedabad determined that local retailers and distributors, who generally branded their locally assembled products as Dolphin, were significant players in the market for reverse osmosis filters.

## Key findings

### Performance

CITE's lab tests show reverse osmosis filters are the only category that can dramatically reduce total dissolved solids. Additionally, all of the reverse osmosis filters CITE tested greatly reduced turbidity and removed more than 99.99% *E.coli*.<sup>48</sup>

<sup>48</sup> "Household Water Filter Evaluation, Suitability—Consumer Reports." CITE, 2015.

The lab tests also showed that based on lifetime tests of two models of reverse osmosis, the locally assembled Dolphin filters are as effective as the branded system, the Tata Swach Platina.<sup>49</sup> Despite such comparable performance, the Dolphin models are generally less than half the cost of the branded models.

### **Dolphin filters and potential for growth**

CITE's research in Ahmedabad showed that middle class consumers are buying Dolphin filters in significant numbers. These locally branded filters are assembled by distributors and retailers, closer to consumers instead of upstream. This allows the supply chain to be more responsive.

In this case it is also more efficient, since shipping components (e.g. filters) is less expensive than transporting the bulky packaging of the finished good. A product is particularly suitable for this strategy if its critical components are off patent and produced by several manufacturers, as is the case with many reverse osmosis filters. Also, given that the assembly process is fairly straightforward, requiring only about 20 minutes and few technical skills (wiring the pump, connecting hoses, etc.), the barrier to entry in this market is low.<sup>50</sup>

Finally, the consumable filters and membranes, which are a significant part of the overall reverse osmosis filter cost, provide an ongoing revenue stream for retailers. These findings require further examination of the Dolphin supply chain to determine the effectiveness of the postponed assembly strategy. Future study could focus on the transparency of cash flows, and whether informal transactions that avoid taxation contribute to the reduced cost.

Despite these advantages, Dolphins are still relatively expensive and out-of-reach for Ahmedabad's poorest households. Because most of these retailers are owner-operated and lack the ability to take on the risk of credit directly, they also do not offer financing options such as equal monthly installment payments.

### **Potential environmental impact**

Despite the aesthetic appeal of clean water produced by reverse osmosis filters, these filters produce a large volume of wastewater. The filters CITE tested in the lab had recovery rates ranging from 25-32%.<sup>51</sup> The average recovery rate was 26%, meaning for every 100 liters of fill water, the average filter only produced about 26 liters of clean water and 74 liters of wastewater, also known as "brine."

While reverse osmosis systems may be appropriate in areas where groundwater is high in total dissolved solids, hardness, or salinity, such water treatment may not be efficient or environmentally sustainable for Ahmedabad, or other water-stressed regions of India.

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<sup>49</sup> "Household Water Filter Evaluation, Suitability—*Consumer Reports*." CITE, 2015.

<sup>50</sup> "Household Water Filter Evaluation, Scalability." CITE, 2015.

<sup>51</sup> "Household Water Filter Evaluation, Suitability—*Consumer Reports*." CITE, 2015.

## Additional Development Insights

Beyond CITE’s evaluation of the water filter products themselves, our team gained valuable insights about the use of these products, particularly among low-income consumers.

### **Current water filter use seems to be dependent on past behavior and peer effects.<sup>52</sup>**

CITE found 72% of those surveyed who currently do not use a filter also did not use one growing up, while 60% of those who currently use commercial filters, such as a gravity non-electric or reverse osmosis systems also used them growing up.<sup>53</sup>

In buying a water filter, survey respondents indicated they seek the opinions and experiences of others, particularly those closest to them. As demonstrated in Figure 4, 59% of filter purchase decisions were influenced by someone in the consumer’s close network, most often a family member.

By comparison, print, television, and radio advertisements influenced only 13% of purchase decisions.<sup>54</sup> This finding, consistent with general diffusion literature, points to the importance of informal word-of-mouth and suggests that sustainable filter use would benefit more from improved peer-to-peer knowledge transfer rather than conventional, mass-media marketing approaches.<sup>55</sup>

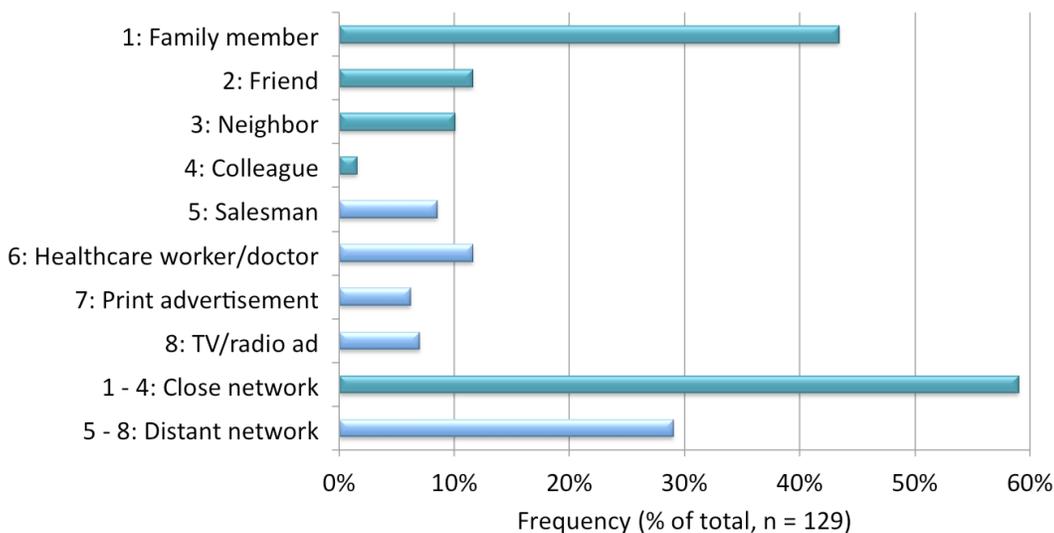


Figure 4. “Who or what influenced your decision to obtain a water filter?”

### **Knowledge about water filters designed for the poorest households is low among that market.**

Technology adoption proves difficult when one’s peers do not have knowledge about a particular product. When asked which water filter brands and models they could name, not one of the people who used cloth or *jali* mesh—overwhelmingly the poorest households we surveyed—could name a product that was designed for their market segment. The brand name models which respondents were able to recall were not within their willingness or ability to pay. Similarly, the poor do not adopt technology when their peers believe that a particular product is not necessary. This was true of 22% of non-filter users surveyed.<sup>56</sup>

<sup>52</sup> Figueroa & Kincaid, 2010.

<sup>53</sup> “Household Water Filter Evaluation, Sustainability.” CITE, 2015.

<sup>54</sup> “Household Water Filter Evaluation, Sustainability.” CITE, 2015.

<sup>55</sup> Lynch, West, Munoz, Kayongoya, Taylor, & Mmbaga, 1994; Valente, Poppe, & Merritt, 1996; Valente & Myers, 2010.

<sup>56</sup> “Household Water Filter Evaluation, Sustainability.” CITE, 2015.

### Among those who do not use a water filter, cost is a key barrier.

Half of cloth and *jali* mesh users, and 67% of non-filter users, identified cost in response to the question, “Why do you not use a commercial filter?” as shown in Figure 5.<sup>57</sup> While manufacturing cost could be reduced through technology and materials innovation without sacrificing performance, the current cost barrier at the household level also indicates the need for financial mechanisms, such as micro-loans or village savings groups. These incentives could have a large role to play in facilitating the diffusion of technologies to lower-income consumers, though their precise impact on adoption and use will need to be investigated further.

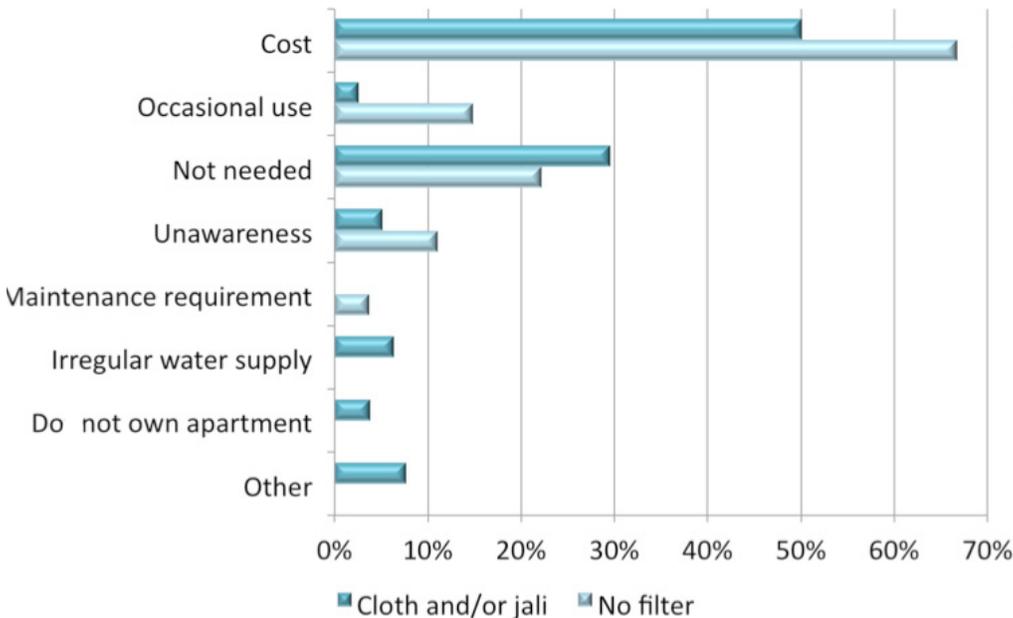


Figure 5. Identifying barriers to scale: “Why do you not use a commercial water filter?”

## Conclusions & Recommendations

### 1. Information sharing is needed to help Ahmedabad’s poor better understand their water quality and water filter effectiveness.

Even though most residents of Ahmedabad have an improved water supply, the water quality is not always consistent and can sometimes pose health threats. Although the use of household water filters is widespread in Ahmedabad, CITE found that only a few households had accurate knowledge of their water quality. This is in part because they lack the tools needed to assess water quality, but also because the quality of the water is inconsistent over time.<sup>58,59</sup>

Awareness around which water filters are effective and which are not also appears to be low given the widespread use of cloth and *jali* mesh filters, which CITE found to be largely ineffective. And although there are a few gravity non-electric alternatives to cloth and *jali* mesh filters designed specifically for poor households, knowledge about them is low among the poor in Ahmedabad.

<sup>57</sup> “Household Water Filter Evaluation, Sustainability.” CITE, 2015.

<sup>58</sup> “Household Water Filter Evaluation, Suitability—India.” CITE, 2015.

<sup>59</sup> “Household Water Filter Evaluation, Sustainability.” CITE, 2015.

There is much work to be done in raising awareness about water quality and how to test it, as well as which water filters work and which do not. CITE's research showed that perceptions of water quality in Ahmedabad are generally inflated, causing many using filters to think they don't need to use a water filter at all. The inflated perception of water quality also causes current filter users to use their filters inconsistently, using a filter one day and not using it the next.<sup>60</sup>

CITE hopes to raise awareness regarding the effectiveness of different water filters by releasing and sharing this report, but also recommends that local government actors and NGOs may play a part in raising awareness around water quality and treatment in and around Ahmedabad, especially among its poorest household.

## **2. Further exploration of water filters designed for the poor is necessary.**

Despite the fact that Ahmedabad's poor primarily use cloth and *jali* mesh filters, there are viable and even affordable alternatives, some already on the market and some that we see as opportunities for market growth and innovation.

### **Alternatives currently on the market**

There are other types of inexpensive conventional particle filters, such as ceramic filters, biosand filters, and siphon filters that may be a viable and more effective alternative product for Ahmedabad's poorest households. While these products are not commonly found on the Ahmedabad market, they can be found in other nearby regions throughout India. Exploring these alternatives would require further research to assess effectiveness of these filters. There are also existing, low-cost gravity non-electric filters that could better fit the needs of current cloth and *jali* mesh filter users, but CITE found that these filters' supply chains are inadequate, not reaching rural towns outside of Ahmedabad where they are needed most.<sup>61</sup>

### **Opportunities for market growth & innovation**

A 2003 study in Bangladesh showed that cloth filters folded at least four times could effectively remove more than 99% of *V. cholerae* (the bacteria that cause cholera) if those bacteria were attached to plankton.<sup>62</sup> The cloth tested was an inexpensive sari folded four to eight times to produce a cloth filter with a mesh size of around 20 microns. This removed most of the *V. cholerae* attached to plankton, which is larger than 20 microns.

CITE observed that cloth purchased in the Ahmedabad marketplace is largely ineffective in reducing turbidity and *E.coli*, because *E.coli* has a much smaller size of about 0.5 microns in width and 2 microns in length, while the cloths tested had a larger mesh size range of less than 30 to 300 microns.

<sup>60</sup> "Household Water Filter Evaluation, Sustainability." CITE, 2015.

<sup>61</sup> "Household Water Filter Evaluation, Scalability." CITE, 2015.

<sup>62</sup> Colwell et al, 2003.

Given the study conducted in Bangladesh, it is possible that cloth filters could be specially redesigned in India with more folds or a tighter weave in order to filter out harmful parameters like *E.coli*, while still taking advantage of the widespread acceptance of these types of filters in and around Ahmedabad.

CITE's research also shows that there is a gap in the market between low-cost, ineffective cloth and *jali* mesh filters and the higher-priced, effective filters in the gravity non-electric and reverse osmosis categories. Half of the cloth and *jali* mesh filter users and nearly 70% of non-filter users identified cost as one of the primary reasons why they do not use a commercial filter.<sup>63</sup> Taking this into account, research on a low-cost, effective alternative to what's currently on the market could reveal opportunities for product innovation in Ahmedabad's water filter market and beyond.

### **3. Gravity non-electric filters should be made more accessible to the poor.**

While gravity non-electric filters are effective, affordability and accessibility both remain barriers to product adoption among Ahmedabad's poorest citizens. In some of the rural areas CITE surveyed, gravity non-electric filters were very difficult to find, despite the fact that more expensive reverse osmosis models were available.

Even with a few affordable gravity non-electric filter options on the market, many models are still out of reach for Ahmedabad's poor due to limited financing options. There were two prevalent interest-free monthly installment financing schemes in the Ahmedabad market: one offered by a financing company, Bajaj, for several original equipment manufacturers and one offered by Eureka Forbes, exclusively for their products. With the exception of Eureka Forbes models, gravity non-electric filters had very limited financing options since retailers rarely offered direct financing and the price was below the threshold for Bajaj.<sup>64</sup>

Based on our data, manufacturers and retailers are risk-averse in offering direct financing. However, they could extend contracts with third parties like Bajaj to include products with lower purchase prices, exchanging some profit margin in return for higher sales volume resulting from their partner's interest-free consumer financing. The application of financial risk sharing to grow the business model of original equipment manufacturers and greatly improve user access to technology merits further exploration.

### **4. The Dolphin filter supply chain should be studied further.**

Reverse osmosis Dolphin filters proved an interesting case, especially regarding the way their supply chain works. As mentioned earlier, Dolphins are assembled by distributors and retailers, making the products closer to demand instead of upstream, which allows the supply chain to be more responsive and efficient.

<sup>63</sup> "Household Water Filter Evaluation, Sustainability." CITE, 2015.

<sup>64</sup> "Household Water Filter Evaluation, Scalability." CITE, 2015.

Dolphins and other water filters offer a good entrepreneurial opportunity for retailers since the assembly process is straightforward. The CITE team observed that assembling Dolphins took around 20 minutes and involved few technical skills. In addition, the consumable filters and membranes, which are a significant part of the overall filter cost, provide an ongoing revenue stream for retailers.<sup>65</sup>

These findings require further examination of the Dolphin supply chain to determine the effectiveness of the postponed assembly strategy. One question for future study is if the lessons learned from the Dolphin supply chain could apply to other kinds of high performance water filters, bringing costs down for poor consumers.

Another focus for future study is the transparency of cash flows, and whether the low cost of Dolphin models are due to tax evasion or other informal, illegal methods that should be curtailed. In addition, though our preliminary evaluation of the technical performance of these products is high, an assessment over a more extended time may reveal bigger differences in performance when compared to large scale, centrally manufactured products.

## **5. The environmental effects of reverse osmosis filters must be considered.**

CITE's research showed that reverse osmosis systems sold in and around Ahmedabad produce high levels of wastewater—for every 100 liters of fill water, 74 liters are wasted.<sup>66</sup>

This is of particular concern in water-scarce regions like Ahmedabad, and of general concern on a water-limited planet. A recent report by McKinsey & Company showed India will need to double its water generation capacity by 2030 to meet the needs of its growing population.<sup>67</sup>

While reverse osmosis systems may be appropriate in improving the aesthetics and acceptability of drinking water in areas where groundwater is high in total dissolved solids, hardness or salinity, these filters are not sustainable for Ahmedabad and other dry regions of India. Again, water quality is a complex issue, but public awareness around existing water supplies and what is needed to make them safe is very important so consumers can confidently pick a water filter that meets their needs while keeping in mind limited water resources in India and beyond.

<sup>65</sup> "Household Water Filter Evaluation, Scalability." CITE, 2015.

<sup>66</sup> "Household Water Filter Evaluation, Suitability—*Consumer Reports*." CITE, 2015.

<sup>67</sup> "Charting Our Water Future: Economic Frameworks to Inform Decision-Making." McKinsey & Company, 2009.

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