RTI Reinvent the Toilet

September 2014 User Studies: Gujarat State, India

Summary Field Report

RTI INTERNATIONAL

Table of Contents

List of Tables

Executive Summary

RTI International is developing an on-site waste treatment and toilet system designed for communal or shared applications as part of the Bill and Melinda Gates Foundation's (BMGF's) Reinvent the Toilet Challenge (RTTC). The RTTC calls for research teams to design and test novel sanitation technologies that treat human waste to remove pathogens, generate renewable resources (e.g., water, biochar), operate off of networked energy or sewer systems, and cost users less than US $.05/per person/per day. RTI's reinvented toilet (RT) system is designed to be a self-contained unit that collects human waste through a squat plate designed for low-water quantity flush, and then separates and treats the waste within the same unit. Urine is treated using electrochemical disinfection, and feces is dried and burned by combustion, in a down-draft gasifier. The treated liquid is designed to be reused within the system for flushing and cleansing—handwashing and anal cleansing—and power is generated through the combustion of solid waste.[1] RTI's first prototype was demonstrated at the Reinvent the Toilet Fair in New Delhi, India, in March 2014.

In 2011, BMGF launched the **RTTC** to promote and fund the research and design of novel sanitation technologies that disinfect human waste, generate renewable resources (e.g., water, biochar), operate without external power or sewer infrastructure, and cost users less than US $.05 daily. RTI and 17 other organizations have received RTTC grants.

RTI demonstrated its first prototype at the Reinvent the Toilet Fair in New Delhi, India, in March 2014. In May 2014, the prototype was shipped to and reassembled in Vadodara in Gujarat, India. Beginning in June 2014, a series of focus groups and surveys were conducted with 227 target users in two cities in Gujarat—Ahmedabad and Vadodara—to inform further development of the RTI prototype. Focus group discussions (FGDs) and a short questionnaire (administered to FGD participants) were designed to collect information from potential users of the RTI prototype system on factors likely to affect the adoption and use of the final RTI system.

This report presents a second round of user-focused data collection completed in September 2014 in Ahmedabad and Vadodara. Building on the June FGDs and ongoing technical R&D activities, the FGDs in this September 2014 round were designed to collect information from potential users of the RTI prototype system on a variety of topics:

- water reuse in the RTI system
- menstrual hygiene management (MHM); women only
- men's practices and preferences; men only
- reactions to particular features of the RTI prototype user interface

RTI's **field testing activities—e.g., assessing users' preferences and testing system performance**—are currently focused on India, with Ahmedabad as the primary city and additional research in Vadodara. RTI is also developing strong partnerships with local government, research and policy institutes, industry, and nongovernmental organizations (NGO) focused on improving urban sanitation.

[1] See more information on the RTI system at www.abettertoilet.org.

Table ES-1: User Study Participant Statistics (September 2014)	
Data	Observation
Total Participants	360
Male	176
Female	184
Hindu	257
Muslim	101
Christian	2

The user studies are designed to increase understanding of adoption issues related to the RTI system and its potential application in shared and public settings. Further, the topics targeted in September 2014 FGDs target areas that were identified in earlier data collection efforts.

Participants in data collection activities were residents of low-income communities in Ahmedabad and Vadodara, recruited using a convenience sampling methodology. Tables 1 and 2 offer some descriptive statistics of FGD participants, including socio-demographic and sanitation access information.

Table ES-2: User Study Participant Primary Sanitation Facilities (by Location)

		No. of FGDs	Toilet Facility			No. of FGDs	Toilet Facility
Ahmedabad	Community 1	6	80% private	Vadodara	Community 9	2	100% OD
					Community 10	2	100% public/OD
	Community 2	2	100% public				
	Community 3	2	100% public		Community 11	2	100% OD
	Community 4	2	100% public				
Vadodara	Community 5	2	50% public/open defecation (OD)		Community 12	1	100% OD
					Community 13	1	100% OD
	Community 6	2	100% private		Community 14	2	50% OD, 50% private
					Community 15	2	50% OD, 50% private
	Community 7	2	100% private		Community 16	2	100% OD
	Community 8	4	100% OD				

Participants were exposed to the RTI toilet system, participated in a question-and-answer session and took part in theme-based FGD. Sessions conducted in Ahmedabad relied on a video of the RTI system, while participants in Vadodara viewed both the video and the actual prototype, which was available for demonstration purposes only; no user performance testing was conducted. In 2015, future field testing of RTI's Alpha Prototype will incorporate performance testing as the technology matures.

RTI collaborated with several partners in India, including the Self Employed Women's Union (SEWA), and the Network for Engineering, Economics, Research, and Management (NEERMAN), a Mumbai-based research and consulting organization, to support data collection activities. SEWA recruited participants and NEERMAN facilitated and moderated the focus group activities; both nonprofit partners aided in increasing RTI's understanding of local context and supporting RTI's engagement with participants in Hindi and Gujarati. L&T Technology Consulting, a partner working with RTI to lower the cost of the system and make it more manufacture-able, hosted the user studies held in Vadodara.

Key **user input and feedback** on the RTI's prototypes treatment technology and user interface are summarized in Table ES-3. Tables ES-4 and ES-5 provide **recommendations** on how these findings should be used to guide subsequent steps in design and development of the RTI system—including both **potential changes RTI will consider making to the prototype** (in Table ES-4) and **future plans for user-focused data collection** (in Table ES-5).

Table ES-3: Summary of User Input/Feedback on Prototype Features

Topic	Observation
Highly-favored features	• Water conservation elements of water reuse • System self-powers waste processing • MHM features that promote privacy during menstruation
Gender and demographic-specific considerations	• MHM vending and disposal and external urinal provide gender-oriented features • Rail placement adjustments for system use by elderly and children.
Cabin and exterior features	• Current cabin size perceived positively as spacious • External hand rail should be easily held; participants suggested adding an interior hand rail to support squat position
Flush Mechanism	• Hand-powered flush widely favored (over foot-powered) for squat-positioned toilet; placement should be accessible on right-hand side
Menstrual Hygiene Management	• MHM system components perceived as improving privacy during menstruation • Menstrual product vending machine positively received; MHM disposal by incineration had moderate acceptance, sub-groups raised concerns about burning MHM products
Urinal	• Many men and women favor placement of urinal outside of toilet cabin with partial closure for privacy
Water reuse	• Liquid disinfection and water reuse process generally believed, however mixed acceptance remains particular to the water's use • Reusing water for flushing was widely accepted due to no direct contact with water; moderate acceptance of reused water for anal cleansing (highest among men); and, moderate reluctance to reuse water for hand-washing (particularly among women)
Handwashing	• Support for inclusion of handwashing facility inside cabin; suggestion that additional external facility could serve urinal users

Table ES-4: Recommendations for Potential System Adaptation	
Data collection findings	**Recommendation for potential system adaptation**
Preference for menstrual product vending	Add vending machine for feminine hygiene products to interior of toilet cabin
Preference for MHM disposal	Add MHM disposal chute to interior of toilet cabin, out of reach of children/animals; means of disposal requires continued investigation
Preference for hand-operated flush	Adapt flush mechanism to be hand-operated (as opposed to foot-powered), easily reached from squat position, located on right-hand side
Railing adjustments	Add railings to external element, adjust railings to be less wide than current prototype
Support for urinal	Add urinal to outside of unit with partial closure for privacy
Water reuse acceptable for flush	Incorporate reused water from liquid processing module into flush system

The user studies conducted provide valuable information on the preferences of users in RTI's target population; however, the data should not be considered representative, given the sampling and data collection methodologies used. Instead, data such as these should be used to support near-term technology and user interface design decisions that must be made and to guide future user-focused data collection efforts.

Table ES-5: Recommendations for Future Data Collection	
Data collection findings	**Recommendation for future data collection**
Widespread water supply constraints	Explore potential role for RTI system in water supply provision for water-limited communities (Note: following acceptability constraints outlined in water reuse findings)
Attributes of water cleanliness	Consider methods for and value of optimizing reused system water to reflect desirable attributes (e.g., smell, color, transparency)
Complex and mixed attitudes towards menstrual hygiene management (MHM) disposal	Continue to understand disposal practices and preferences; explore potential demographic-specific correlations of preferences
Limited support for water reuse for anal cleansing and hand washing	Refine understanding of water quality preferences as they relate to use for anal cleansing and handwashing; explore potential demographic-specific correlations of preferences

1. Introduction

RTI is developing an on-site waste treatment and toilet system designed for communal or shared applications as part of the Bill and Melinda Gates Foundation's (BMGF's) Reinvent the Toilet Challenge (RTTC). The RTTC is promoting the research and design of novel sanitation technologies that disinfect human waste, generate renewable resources, operate without either a networked sewer system or electricity grid, and cost users less than US $.05 per day.

The RTI reinvented toilet (RT) system is designed to capture human waste in a self-contained unit and separate the waste for treatment underneath a squat plate, which requires low water quantities to flush.[2] The urine is treated using electrochemical disinfection, and the solid feces is dried and burned through combustion in a down-draft gasifier. The system is designed as a closed loop, in that it uses thermoelectric devices to generate power from the combustion of solid waste—sufficient enough to power the entire system—and treats liquid waste that can be reused.

RTI demonstrated its first prototype (referred to as the "pre-alpha" prototype) alongside 16 other units at the Reinvent the Toilet Fair in New Delhi, India, in March 2014.[3] In May 2014, the RTI prototype was shipped to and reassembled in Vadodara in Gujarat, India.[4] Beginning in June 2014, a series of focus groups and a survey were administered to potential users of the RTI system in two cities in Gujarat; the goal was to inform further development of the RTI prototype and other off-grid technologies more broadly.

This report provides a summary of the goals of the September 2014 user studies, the data collection methodologies used, and the findings. Conclusions and recommendations are provided both for short-term adjustments to be made to the RTI toilet system and for future data collection needs.

2. Data Collection Objectives

The September 2014 user studies were designed to inform ongoing prototype development and to provide input into future user studies by beginning to identify the breath of issues likely to impact future adoption of the RTI system. The focus groups solicited information about potential users' sanitation practices and preferences and feedback on the RTI system. Feedback was given in response to the user interface of RTI's pre-alpha prototype, and on its potential for use in shared and public settings.

Primary research objectives for data collection in September 2014 were to conduct qualitative assessments of:

- current behaviors, beliefs, and preferences regarding sanitation, with a focus on
  - water reuse in the RTI system

[2] See more information on the low water quantity flush and squat plate at http://abettertoilet.org/roca-sanitario-develops-ultra-low-flush-squat-plate/.

[3] See more information on the RTI unit at the Reinvent the Toilet Fair in India at http://abettertoilet.org/delhi/.

[4] RTI has chosen to focus field testing activities in India, with Ahmedabad as the primary city and additional research being conducted with partners in Vadodara, where the first RTI prototype has been located. RTI has also developed strong partnerships and contacts with local government, research and policy institutes, industry, and nongovernmental organization (NGO) partners working to improve urban sanitation.

  - women's menstrual hygiene management (MHM)
  - men's practices and preferences
- reactions to potential features of the RTI system

3. Methodology

3.1. Data Collection

The user studies took place in Gujarat, India, with activities in two cities: Ahmedabad, at the Self Employed Women's Union (SEWA) offices, and Vadodara, at a facility of L&T Engineering. A total of 12 focus group sessions were completed in Ahmedabad, and 24 sessions were completed in Vadodara between September 17 and 23, 2014, for a total of 360 focus group participants.

Participants were recruited by SEWA, a community-based nongovernmental organization (NGO) active in Ahmedabad and Vadodara with operations throughout India. The sample of participants was drawn from low-resource communities in the two cities. Priority was placed on drawing participants from communities with limited improved sanitation options. Participants were recruited in community clusters by Hindu and Muslim religion, and grouped by gender and age-defined groups as follows:

- Women aged 18–30
- Women aged 31–54
- Mixed gender group of men and women aged 55 and above
- Male and female parents with children aged 18 and under
- Men aged 18–30
- Men aged 31–54

In Ahmedabad, participants came from the following residential areas: Darayapur, Jamalpur Pagathiya, and Vasant Rajabnagar—Behrampur. In Vadodara, the participants came from the following residential areas: Gamaniya Talawadi, Gandhinagar, Naya Yard, Chhani Jahat Naka, Nizampura, Bajawa, Ambika Nagar, and Chhani.

Six FGD sessions were conducted three times each day for two hours each. Approximately 20 adults, usually 10 male and 10 female, participated at each time in two separate discussions. Several focus groups were conducted with couples, including men and women in the same FGD. Over the 6 days, a total of 360 participants joined the FGDs across the two cities.

Each group of 20 participants came together in a group meeting setting. The agenda included viewing a short animation video of how the RTI toilet prototype functions and a question-and-answer discussion of RTI's waste treatment and toilet technology. The meetings in Ahmedabad relied on video and images for discussion, while participants in Vadodara were able to view the video and to view and flush the actual prototype. Following the video and prototype viewing, the FGDs were completed in approximately 1 hour per session.

FGDs focused on a variety of themes, including water reuse, menstrual hygiene, male practices and preferences, and features of the RTI prototype's user interface (Table 1). All sessions were moderated by

NEERMAN staff; SEWA staff assisted by helping to facilitate communication as needed. Male groups had a male facilitator, and female groups had a female facilitator.

Table 1: FGD Topics Discussed, by Age and Location

	Water Reuse	Menstrual Hygiene	Men's Practices and Preferences	RTI User Interface
Women 18–30 years				
Ahmedabad	1	1		
Vadodara	1	1		2
Women 31–54 years				
Ahmedabad	1	1		
Vadodara	1	2		2
Men 18–30 years				
Ahmedabad	1		1	
Vadodara	1		1	2
Men 31–54 years				
Ahmedabad	1		1	
Vadodara	1		2	2
Men and Women 55–70 years				
Ahmedabad	2			
Vadodara				
Parents of u18 children				
Ahmedabad	2			
Vadodara	2			2

3.2. Data Processing and Analysis

After data collection was complete, transcripts and unedited notes from the FGDs were compiled and analyzed. Transcripts were developed by NEERMAN using audio recordings and notes. Audio was captured in all FGDs. Unedited notes were provided with transcripts for analysis, apart from selected local words that were translated for understanding.

RTI conducted thematic analysis of the focus group transcripts using QSR International's NVivo software. Coding and analysis of transcripts formed broad thematic findings to inform research objectives. NEERMAN and RTI conducted qualitative analysis to assess the frequency of topics discussed and determine direction and intensity of participant feedback.

The findings from the qualitative focus groups are presented in this report. The results provide valuable information that will both help to inform near-term technology design and development decisions that must be made by the RTI R&D team and help to identify key issues for further investigation. However,

based on the convenience sampling method used, these results should not be assumed to be representative of a larger population.

4. Analysis Results

This section summarizes findings based on primary research objectives, which seek to identify current behaviors, beliefs, and preferences regarding sanitation—focusing in particular on water reuse in the RTI system, women's menstrual hygiene management, and men's practices and preferences—and reactions to potential features of the RTI system. The following results sections are organized along these objectives, including: (1) a description of the sample, (2) a discussion of current sanitation facilities and behaviors, (3) an overview of themes associated with ideal sanitation, and (4) details of preferences related to the RTI technology.

4.1. Community Characteristics

Focus group participants were drawn from 16 distinct communities within Ahmedabad (4) and Vadodara (12). Each community selected spanned a range of community characteristics, summarized in Table 2. Characteristics of communities are included to give background to the findings herein, in the context of the convenience sample used in the FGDs. It is important to note that, given the convenience sample, the communities that participated and findings presented are not representative of Ahmedabad or India. Qualitative comparisons between community characteristics in this sample and those of representative surveys in Gujarat slums[5] suggest that there may be some similarities along indicators of access to improved sanitation and drinking water.

Communities represented a range of religious background and included some distinctly Hindu or Muslim groups, while others represented communities of mixed religious backgrounds. On average, communities in Ahmedabad involved participants with longer-term residency in their communities, all of which had participants living in these areas for at least 40 years. Vadodara had a wider range, with communities averaging approximately 25–30 years of tenure, but ranging between 10–15 years and over 40 years.

Modes of transportation used by participants from communities in Ahmedabad and Vadodara varies. In both cities, many participants commonly use single-person scooters/motorbikes or *drays*, motorcycles which carry up to three passengers. In Ahmedabad, all sampled communities also relied on government buses for daily transportation.

Participants' housing also varied, though the majority of participants lived in *kaccha* houses, weaker structures often constructed using available organic or industrial materials. Several of the *kaccha* houses of participants used metal roof sheeting and brick walls. Other participants lived in *pucca* houses (more permanent concrete housing structures) or *chawls* (single-room dwellings in multistory buildings).

[5] FGD participant communities bear moderate similarities to Gujarati slum populations surveyed in the National Sample Survey Organization (NSSO) – 69th round (2013) along indicators of improved sanitation access (99.2% slum/99.9% non-slum) and improved drinking water access (78.6% slum/96.6% non-slum). http://mospi.nic.in/mospi_new/upload/kye_indi_of_water_Sanitation69rou_24dec13.pdf (p. 41)

Housing types are often found to be correlated with household wealth in India[6] suggesting that households dwelling in *kaccha* structures may be less wealthy than those living in *pucca* homes.

4.2. Water, Sanitation, and Electrical Amenities

Table 2 summarizes indicators related to socio-economic and demographic background of the communities from which participants were drawn, as well as the range of access to water, sanitation, and electricity. Communities in this sample rely on a mix of public and in-house taps/faucets for water. About 40% of the communities have access to an in-house tap and another 40% have access to public taps. In two communities of Vadodara, no tap water is available (in-house or public tap), thus residents collect water from nearby surface water sources, such as canals and ponds.

In the FGD sample, communities in Vadodara were more likely to rely on open defecation (OD) (25%) than in Ahmedabad. Those that did openly defecate often used sites such as nearby ponds or railway tracks. In communities relying on OD, several individuals suggested that their use of outside areas was constrained to early morning or evening use. Forty percent of participants from Ahmedabad reported owning a private toilet, with the remainder largely using public toilets. All of the participants from Ahmedabad who owned private toilets also reported having private water taps.

All except for six communities had 24-hour access to electricity in their homes. Only three communities lacked complete electricity access, both of which were in Vadodara. In communities where electricity was not available, communities also relied on OD and lacked access to a water tap, and collected water from ponds and canals. Four communities in Vadodara reported access to electricity except for 2–3 hours per day, when it was unavailable.

Table 2: Focus Group Participants: General Characteristics of the Sampled Communities

		No. of FGDs	Major Religion	House Construction*	Water point of access / Hours Available	Toilet Facility	Electricity Availability
Ahmedabad	Community 1	6	Hindu	80% *kaccha*, 20% *pucca*	In-house tap / 1 hour, a.m. only	80% private	24-hour access
	Community 2	2	Muslim	80% *kaccha*, 20% *pucca*	Public tap	100% public	24-hour access
	Community 3	2	Hindu	80% *kaccha*, 20% *pucca*	In-house tap	100% public	24-hour access
	Community 4	2	Hindu	80% *kaccha*, 20% *pucca*	Public tap	100% public	24-hour access

[6] Barenstein, J. D., & Sushma, I. *Building Back Better: Delivering People-Centered Housing Reconstruction at Scale*. Chapter 7 "India: From a culture of housing to a philosophy of reconstruction" p. 166. Retrieved from http://www.worldhabitat.supsi.ch/documents/bbb_chpt7_duyne_iyengar.pdf

Table 2: Focus Group Participants: General Characteristics of the Sampled Communities (continued)

		No. of FGDs	Major Religion	House Construction*	Water Access	Toilet Facility	Electricity Access
					Hours Available		
	Community 5	2	Hindu	Primarily *chawl*	In-house tap 1 hour daily	50% public/open defecation (OD)	All electrified; not available 2–3 hours
Vadodara	Community 6	2	Mix: Hindu-Muslim	50% *kaccha*, 50% *pucca*	In-house tap	100% private	All electrified; not available 2–3 hours
	Community 7	2	Mix: Hindu-Muslim	50% *kaccha*, 50% *pucca*	In-house tap 1 hour daily	100% private	All electrified; not available 2–3 hours
	Community 8	4	Muslim	100% *kaccha*	Public tap on road 1 hour daily	100% OD	24-hour access
	Community 9	2	Hindu	100% *kaccha*	No tap, collect from nearby community or standing water source (pond) 2 hours daily	100% OD	No electricity
	Community 10	2	Mix: Hindu-Muslim	100% *kaccha*	Public tap on road 2 hours daily	100% public/OD	24-hour access
	Community 11	2	Hindu	50% *kaccha* + brick, 50% *pucca*	Public tap on road 1 hour daily	100% OD	24-hour access (illegal)
	Community 12	1	Hindu	100% *kaccha*	No tap, collect from nearby community or standing water source (canal)	100% OD	No electricity
	Community 13	1	Hindu	100% *kaccha*	Collect from standing water source (canal) intended for agricultural use	100% OD	All electrified; not available 2–3 hours
	Community 14	2	Mix: Hindu-Muslim	50% *kaccha* + brick, 50% *pucca*	In-home tap 1 hour daily	50% OD, 50% private	24-hour access
	Community 15	2	Mix: Hindu-Muslim	100% *kaccha*	Borewell (shared by 35 households)	50% OD, 50% private	24-hour access

Table 2: Focus Group Participants: General Characteristics of the Sampled Communities (continued)							
		No. of FGDs	Major Religion	House Construction*	Water Access Hours Available	Toilet Facility	Electricity Access
Vadodara	Community 16	2	Hindu	100% *kaccha*	In-home tap 1 hour daily	100% OD	24-hour access

Source: SEWA and NEERMAN notes.

**Pucca* structures are permanent, solid structures, often made of concrete, cement, or timber. In contrast, *Kaccha* structures are often more fragile, made of organic materials (mud) or constructed with available tin sheeting. A *chawl* is a multistory building comprising multiple, single-room tenements

5. Current Sanitation: Beliefs, Behaviors, and Preferences

Many FGDs included broad sanitation-related topics identified in earlier June user studies as potentially relevant for understanding new sanitation system adoption. In particular, focus groups included discussion of water (availability, quality, and use), as well as MHM practices, men's practices and preferences, and cleaning and bathing.

5.1. Water Availability

Water availability in the communities drawn from in RTI's discussions varied. While some households accessed water through private in-house taps and others used public handpumps, taps, or community borewells, nearly all communities had some kind of time constraint on water access. Many communities were limited to approximately 2 hours per day, often in the morning (6–8 a.m.), where community taps and in-house taps would function. One community in Ahmedabad faced a non-fixed schedule of water service, making water availability difficult to predict.

Several discussions included that during the water service hours, water quality and quantity were often insufficient. Water available during these times was unclean, smelled bad, or was provided with poor water pressure. A participant from Ahmedabad said "[the water supplied] is not sufficient for entire family…," a sentiment also echoed by others. In contrast, one participant in Vadodara felt that the single hour of water supply sufficiently met his household needs.

In communities that relied on public taps, some participants suggested that they faced long lines to access water from taps or handpumps. One participant from Ahmedabad shared a single tap with limited water supply with 35 other households, frequently facing a queue to get water. Another from Vadodara noted that not only does she "have to stand in line [all day] and bring the water to home," she also must travel one kilometer to reach the tap.

Several groups were asked about periods when water is unavailable, which revealed a range of individual household coping strategies. Several participants in multiple discussions suggested that, when there is no clean water available, their household and those in their community might use a neighboring

community's water source. One participant also suggested that a household might use the water stored from the previous day's collection. Another said that they may be forced to go without water. One group in Vadodara noted that the municipal corporation will often send a water tanker if no water is available to their community for several days.

A community in Vadodara that was previously faced with ongoing water irregularities collectively solved the water availability issue by investing jointly in borewells dug for community use. Each household put in money to pay for the drilling and construction of the well, which cost over Rs. 30,000. In this community, a single bore well serves over 35 families.

5.2. Water Quality and Use

In discussions where groups were asked about how they learned of specific water use practices, such as water treatment, responses generally were related to government-sponsored programs or public health system sources. One participant in Ahmedabad noted that television ads he had seen detailed the importance of boiling water; another participant noted that government employees had given him this instruction.

Several discussions in Vadodara mentioned municipality workers and accredited social health activists (ASHAs) and who add "medicines" to the water supply or guide households to use clean water for cooking and drinking. Several participants shared that they did not receive these messages. "We leave early in the morning for work, so when would we learn about this?" Others suggest that they did not know of organizations that would tell them about this.

Nearly all discussions that were asked about how one knows when water is appropriately clean to drink generated similar answers; water's cleanliness is judged by its color, transparency, and smell.

Nearly all discussions that were asked about how one knows when water is appropriately clean to drink generated similar answers; water's cleanliness is judged by its color, transparency, and smell. One participant said "if water is black or yellowish… then it is not pure," suggesting that clean water is white. Another mentioned that "if the water is murky, it is not transparent, it would be unclean." Further, when one encounters "bad smelling" water, or can "can feel the gutter smell," many participants felt it was not suitable to drink. One participant also mentioned that when material in the water is visible, such as sand or bacteria, one should not use the water.

Because water is not in constant supply, water is stored in or near each household, predominantly in a plastic or cement tank. Some participants covered their water storage containers with a lid, others did not. One discussion detailed the importance of refreshing stored water regularly, explaining that, in their community, collected water is usually kept for a single day and new water is retrieved the next day.

When asked about water treatment, a large majority of participants said that they treat their drinking water in some way.

When asked about water treatment, a large majority of participants said that they treat their drinking water in some way. A variety of methods for water treatment are

used, including filtering through a cloth or nylon net, boiling, or dissolving purification tablets "medicines." While treatment occurs year-round, several discussions acknowledged that all water, regardless of source, is of much poorer quality during the monsoon season; thus, households take greater treatment precautions than they do during other times of the year.

For drinking and cooking, boiling and filtering are most commonly used to clean water. A participant in Vadodara linked boiling with health "[through] boiling germs can be removed. [There are] diseases if no boil." Discussions indicated that households filter water in order to get rid of the visible dirt materials in water. When asked if a child or a sick household member receives boiled water, responses were divided.

Several participants said that they do not treat their water and because the municipality puts chemicals in the water tanks to clean the water, their water is cleaned in some way. When asked about religious associations with water purification, no participant indicated that water is treated any differently during religious festivals or holy periods for Hindus or Muslims (e.g., Ramadan, Eid, Navarati).

For menstruating women, several discussions indicated different water treatment and uses. One participant suggested that "ladies on period have to drink simple (non-treated) water." Additionally, because women must take water and meals separately during their menstrual cycle, they must also wash and maintain their utensils separately during this time.

5.3. Cleaning and Bathing

The majority of participants asked about personal cleaning and bathing suggested that it occurs most often at home, in a bathroom facility ("MORI")/chokdi or courtyard, if these facilities are available. Men will bathe in the courtyard; however, women require privacy, and often bathe inside (in a MORI) or, as one participant detailed, behind some clothes in a courtyard. In these settings, household members will bring in water specifically for bathing. Where no private space inside a home (e.g., Mori or courtyard) is available, several participants suggested that they will go to a nearby canal for bathing.

Several additional suggestions regarding attributes included an interest to use bathing facilities, if they were available at the toilet facility. The women stated they could not bathe inside their houses during menstruation, and would prefer bathing inside a compound instead of in open spaces.

5.4. Menstrual Hygiene Practices

Discussions surrounding practices and perceptions of menstruation gave insight into challenges and constraints regularly faced by women participants. Many discussions covered limitations of some women's activities during menstruation, including not participating in household cooking, not touching any household members, and, in some cases, not engaging in religious activities (e.g., performing pooja, offering Namaz). During menstruation, some women who rely on OD discussed seeking public toilets for increased privacy, washing facilities, and disposal options, during this time.

Discussion of MHM products highlighted the association of menstrual periods as time of isolation, and used menstrual products with impurity; some participants believed these products carry germs and a risk of infection. Overall, activities and materials associated with MHM are considered private and are often secreted from other household members. Women reported having to hide the washing of

reusable cloths from household members (especially men) and were concerned about exposure of the disposed materials to other people and animals for both health and religious reasons. Some participants cited community superstitions or religious beliefs that heightened the importance of women's cleanliness and of product disposal, suggesting that encounters with used MHM products would be a "sin," cause them not be able to bear children or their children to become sick, or animals may become blind if pads are encountered. Several male participants also suggested that it's important for women to have a special place for menstrual products to be disposed.

5.5. Men's Practices and Preferences

Discussions of male-specific practices related to sanitation often centered around urinals at public facilities used by men only. Many men suggested that these were often dirty and not well-maintained; one participant explained that public urinals often become clogged with trash or residue from *paan* spitting. Participants had mixed experiences regarding paying for use of urinals at public toilets, however, several participants offered that they prefer to urinate in the field instead of use a public urinal because it does not smell bad and it is not as dirty as the public urinals.

Men expressed considerate concerns towards women's sanitation issues, including safety and shame associated with menstruation and open defecation. Several male participants said that they must send a male household member to accompany women going to the toilet. Additionally, many participants acknowledged that women face social shame and challenges during menstruation. Several men offered that toilet features that could reduce women's shame surrounding sanitation, such as interior disposal, are important.

6. RTI System: Preferences

6.1. MHM

Women, overall, had positive reactions to how the RTI system proposed to incorporate MHM into its system. Specifically, two key components of MHM, disposal and vending, were discussed with FGD participants. **Positive feedback appeared to be attached to these system components' increased privacy during menstruation periods.**

Women reacted positively to the RTI system's small vending machine for women's menstrual products located inside the toilet cabin. Some women saw this as a means to preserve the privacy that they sought during menstruation, a period of social vulnerability; as one participant suggested, "Sometimes we feel shy to buy from the shop, so [vending machine] is very nice." Given the positive response, this vending option may additionally create improved access to clean menstrual sanitation materials.

RTI's system additionally includes a separate mechanism for disposal of MHM products, the presence of which was also strongly endorsed for its improved privacy. The means of disposal was largely supported, with some reluctance from sub-groups. The proposed disposal mechanism in the RIT system is comprised of a chute that feeds the used MHM materials into the solid waste combustion unit, effectively adding to the system's thermoelectric energy through incineration.

A majority of participants supported the incineration of MHM products via RTI's solid waste combustion system. Proponents suggested that immediate disposal of used MHM products held value in that it eliminated the possibility that they might be encountered (by humans or animals) after disposal. A small subgroup of women aged 18–30 did not support burning MHM products offering complex reasons (e.g., superstition, religion, health), which require further data collection.

6.2. Cabin Size

Participants reacted to the current cabin size of the RTI toilet positively, with widespread approval in the nine discussions in which it was discussed. In two focus groups, participants remarked that the toilet had more space than the one they currently used, both at home and in a public setting. Participants appreciated the cabin's spaciousness adding that this contributed to its comfort; others suggested that its size would make it easier for overweight or old people to use.

6.3. Flush Mechanism

Participants who were able to see the RTI unit in Vadodara were asked about their preferences regarding flush operation and discussed foot operated flush and hand-powered options. **The majority of participants (97.3%) preferred the hand-powered flush**, with unanimous support from male and mixed-gender groups. The hand operated flush mechanism was favored by one participant "because it is easy to flush by sitting and we don't have to stand up and flush."

Additional feedback regarding the hand pedal included location preferences, where **participants preferred the hand pedal to be placed on the right-hand side**. Placement on the right side of the toilet was emphasized because people do not use their right hand to clean themselves after using the toilet and may thus keep their right hand clean for flushing hygienically. Further location concerns centered around height placement so that children could easily operate the flush, as well as making sure that it was easily reached from a seated position (i.e., one does not have to get up to operate the flush).

One FGD participant suggested that the foot flush might work better for a western-style commode (non-squat seating). Another participant suggested that the foot flush might be very difficult to operate for elderly, handicapped persons, and if one is weak after having diarrhea.

6.4. Railings

The external hand-railing on the RTI unit was universally received positively; many offered that it was particularly attractive for populations that may find stairs challenging, such as children and the elderly. The participants who saw the system in Vadodara suggested that the railing height was appropriate, however, participants in two FGDs suggested that the rail was too wide, making it difficult to clutch.

Several participants also suggested that an internal handrail would give support to elderly when getting up and down from a squat position. One participant added that moving it closer to the squat plate would allow shorter people to use it. For children who use the toilet, another suggestion was to have a second, lower handrail.

6.5. Men's Urinal

Around 60 participants from four male and two mixed-gender groups were asked about their preferences for urinals with the toilet unit, and all of these participants favored the urinal's inclusion as part of the RTI system. **All women and the majority of men favored urinal placement outside of the toilet unit, so that using the urinal would not require one to enter the toilet cabin.** Those male participants who preferred an indoor urinal cited cleanliness and filth from outside as their main concerns.

Participants suggested that the urinal's placement outside of the unit would allow men to use the urinal separately, while women could use the inside unit "without issue of being shy." This convenience allows men to use it quickly, "on our way to work," leaving women space to use the toilet. One female participant echoed this sentiment, suggesting that having the urinal outside, causing men to decrease use of the inside toilet, might allow women to use the toilet "more comfortably."

All participants supported a partial closure of the outside urinal. One male participant suggested that a urinal enclosure would give men privacy "so that we don't feel ashamed of using it." Many of the groups favored a partial opening in the enclosure, explaining that this was a necessary way to release bad odors from the urinal. One discussion group associated these bad odors with causing diseases. When probed about hand-washing in relation to urinals, one group widely agreed that some outdoor hand-washing facility was necessary for outdoor urinals.

6.6. Water Reuse

Groups that were asked about water reuse received an explanation of the RTI toilet's electrochemical disinfection process in simple, easy-to-understand terms. Overall, people understood and believed the process. Participants were, in general, enthusiastic about the concept of water conservation. A male participant from Vadodara contextualized the water reuse system in terms of its potential money savings, noting that the municipality was discussing charging for water in the way that they currently charge for electricity.

Several participants suggested that knowledge of the water treatment system (i.e., disinfecting urine) may have changed their attitude towards using it. One participant suggested that because they did not know the exact treatment process that other water undergoes, they did not feel a responsibility to know about the treatment of water in the RTI system. **Another participant stated that "If we don't know about from where that water is coming, then we can use it… But once we know the truth, we hesitate to use it."**

Overall, 30 focus groups were asked about their willingness to use reused water for flushing, anal cleansing, and hand-washing and acceptability of different uses for the reused water varied. While many groups responded positively, the discussions revealed complex attitudes and reasoning behind water use in the communities sampled:

- **Water Reuse for Flushing**: Participants were most positive about water reuse for flushing in the toilet system. Approximately 98% of participants suggested this was an appropriate use for

reused water. Because flushing did not involve direct contact with the water, participants perceived this as a more appropriate use for the water.

- **Water Reuse for Anal Cleansing**: Nearly all men were willing to use reused water for anal cleansing, but was less accepted among women and older mixed-gender focus groups. Many participants felt that because the water was once urine, the repurposed water was therefore impure and not appropriate for cleaning one's self.
- **Water Reuse for Handwashing**: Overall, the approximately three quarters of participants suggested they were open to using reused water for handwashing, however many expressed concern, particularly women. Fewer than half of women aged 31–54 were willing to wash their hands with the reused water. Many said they could not eat directly after washing their hands with the "dirty water" and stated that they must wash again at home with pure water. "I will wash my hands in case of emergency, but I will wash my hands [again] at home." When probed, several participants expressed doubt that the water would be fully purified.
- **Water Reuse for Other Purposes***:* Many participants who felt that they could not use the reused water at the toilet suggested that it would be acceptable to use the water for other purposes; however these attitudes also varied dramatically. One participant suggested that he could use the reused water to wash his vehicle; though when a moderator suggested this in a later discussion, a different participant suggested that you shouldn't use impure water on anything that brings you money (e.g. one's car). Participants were also divided on being able to use the water to feed plants and animals, with one person stating that it should not touch "any living thing." More participants (though not all) were willing to use the water for washing the floor and utensils.

Handwashing practices:
Participants frequently discussed a common practice of washing hands at home after toilet use, regardless of the handwashing options at a public toilet. While one participant noted that it is not realistic that everyone will wash at home and that people are in the habit of returning home to wash hands and feet because they use bathrooms in many places. Several noted that before starting any household work, they always wash their hands.

Many participants cited their religions (Hindus and Muslims) as being important guides as to if and for what purposes water could be reused. Several Muslim individuals used the terms "pak" and "napak" which identify things that are good and bad; the majority of these individuals said that the water was "napak" (bad) and they would not be allowed to pray if they touched it. Another Muslim participant suggested that water that has urine in it is treated as impure, giving the example that when her child soils his or her clothes, they cannot wash other clothes with the soiled clothes. A Hindu participant also noted that anything that you "do pooja on" cannot be washed with impure water. Further research is needed to determine broader attitudes towards water and common reuse practices.

6.7. Handwashing Station

Participants in Vadodara who were shown a toilet unit with a handwashing station inside found it appropriately located. However, in conversations regarding men's urinals, some mentioned the need for a hand-washing facility outside for men. Some participants opposed an outdoor basin as it could become spoiled or stolen. One male participant suggested placing a water bucket for handwashing

outside. A female participant suggested that keeping a wash basin inside the unit is nice because "we can finish everything inside."

7. Recommendations and Conclusions

The results of the September 2014 user studies provide valuable insights into individuals' current sanitation behaviors, beliefs, and preferences, and their attitudes toward the RTI system. These findings, summarized in Table 3, will directly affect decisions made regarding adjustment to be made to the user interface for the Alpha prototype being finalized in December 2014 (see Table 4) and will inform system development in the long-term through identifying important features that may affect user adoption. Table 5 and 6 summarize key areas that may have adoption implications and thus should be further explored in order to better understand user preferences.

Table 3: Summary of User Input/Feedback on RTI Prototype Features (September 2014)

Topic	Observation
Highly-favored features	• Water conservation elements of water reuse • System self-powers waste processing • MHM features that promote privacy during menstruation
Gender and demographic-specific considerations	• MHM vending and disposal and external urinal provide gender-oriented features • Rail placement adjustments for system use by elderly and children.
Cabin and exterior features	• Current cabin size perceived positively as spacious • External hand rail should be easily held; participants suggested adding an interior hand rail to support squat position
Flush Mechanism	• Hand-powered flush widely favored (over foot-powered) for squat-positioned toilet; placement should be accessible on right-hand side
Menstrual Hygiene Management	• MHM system components perceived as improving privacy during menstruation • Menstrual product vending machine positively received; MHM disposal by incineration had moderate acceptance, sub-groups raised concerns about burning MHM products
Urinal	• Many men and women favor placement of urinal outside of toilet cabin with partial closure for privacy
Water reuse	• Liquid disinfection and water reuse process generally believed, however mixed acceptance remains particular to the water's use • Reusing water for flushing was widely accepted due to no direct contact with water; moderate acceptance of reused water for anal cleansing (highest among men); and, moderate reluctance to reuse water for hand-washing (particularly among women)
Handwashing	• Support for inclusion of handwashing facility inside cabin; suggestion that additional external facility could serve urinal users

Table 4: Recommendations for Potential System Adaptation

Data Collection Findings	Recommendation for Potential System Adaptation
Preference for menstrual product vending	Add vending machine for feminine hygiene products to interior of toilet cabin
Preference for MHM disposal	Add MHM disposal chute to interior of toilet cabin, out of reach of children/animals; means of disposal requires continued investigation
Preference for hand-operated flush	Adapt flush mechanism to be hand-operated (as opposed to foot-powered), easily reached from squat position, located on right-hand side
Railing adjustments	Add railings to external element, adjust railings to be less wide than current prototype
Support for urinal	Add urinal to outside of unit with partial closure for privacy
Water reuse acceptable for flush	Incorporate reused water from liquid processing module into flush system

Table 5: Recommendations for Future Data Collection

Data Collection Findings	Recommendation for Future Data Collection
Widespread water supply constraints	Explore potential role for RTI system in water supply provision for water-limited communities (Note: following acceptability constraints outlined in water reuse findings)
Attributes of water cleanliness	Consider methods for and value of optimizing reused system water to reflect desirable attributes (e.g., smell, color, transparency)
Complex and mixed attitudes towards menstrual hygiene management (MHM) disposal	Continue to understand disposal practices and preferences; explore potential demographic-specific correlations of preferences
Limited support for water reuse for anal cleansing and hand washing	Refine understanding of water quality preferences as they relate to use for anal cleansing and handwashing; explore potential demographic-specific correlations of preferences

Table 6: Recommendations for Potential Business Model Development

Data Collection Findings	Recommendation For Potential Business Model Development
Limited/irregular water supply	Explore the value of reused water as product of system (willingness to pay [WTP])
Support for bathing component	Gain further understanding of value (WTP) of bathing component

7.1. Forthcoming Data Collection Planned (Q1 2015)

To support the development of a reinvented toilet that is desirable, cost-effective, and sustainable for those in need, RTI plans to continue to conduct field-based user studies that are designed to be iterative and provide continuous feedback into RTI's technology development and performance testing teams. Field study cycles are designed to occur quarterly throughout 2015. In early 2015, RTI will field a randomly sampled household survey to assess many of the issues identified in focus group discussions and questionnaires fielded in June and September user studies. Based on the September FGDs, recommendations to be considered in a household survey include the following:

- Attitudes towards and knowledge of sanitation behavior
- Perceptions and experience with different types of toilets (e.g. public, community, school, private)
- Demand for and preferences regarding household and community sanitation improvements
- Current costs of existing sanitation facilities
- Accessibility and safety of available sanitation to specific demographics (e.g. handicapped, women and girls, children, elderly)
- Practices and sanitation behavior during menstruation
- Preferences specifically related to RTI system attributes (e.g. applications of water reused in system, means of MHM disposal, cost to use system, availability of handwashing options) and potential business model/location-based attributes (e.g. distance, availability, maintenance)
- Correlation of preferences with household socio-demographics

Additional efforts will be made to identify external sanitation data and resources that will help to complement the ongoing research efforts planned by RTI. Government and public health system institutions that contribute to ongoing research may additionally provide important inputs to future developments in data collection.

APPENDIX A

A.1 Development of Data Collection Materials

In August, RTI and Network for Engineering, Economics, Research, and Management (NEERMAN) staff collaborated on the design and preparation of the focus group discussion (FGD) guide, planned FGD collection procedures and training documents. The FGD was shared with the Self Employed Women's Association (SEWA) prior to conducting the user sessions. The final translation of both instruments from English to Gujarati was completed by NEERMAN. RTI's IRB reviewed and approved FGD guides and participant consent forms prior to work being undertaken in Ahmedabad.

A.2 Participant Recruitment and Incentives

SEWA recruited a convenience sample of participants from populations residing in low resource areas in Ahmedabad and Vadodara. Participants were drawn from slum communities where SEWA has relationships, and targeted both Hindu and Muslim neighborhoods in both cities. To gather interest in participation, SEWA staff in the chosen slum communities distributed a flyer and disseminated information through small gatherings within the community. Community residents interested in participating were identified, clustered by age and gender, and scheduled into designated times. Participation was voluntary. Each participant received a lunch pail as a gift after his or her participation.

A.3 Training

RTI, NEERMAN, and SEWA completed a training day on September 16 in Ahmedabad. NEERMAN led the training of data collection teams, with training focusing on orientation and testing of the FGD guide, FGD administration best practices, note-taking best practices, contingency measures, and informed consent. Field supervisors were oriented for managing daily documentation procedures, collecting informed consent forms and maintaining confidentiality, and coordination and communication with partners. The training session included discussions, question-and-answer sessions, mock interviews, and practice in FGD administration.

A.4 Research Ethics

Throughout the design and data collection, NEERMAN, SEWA, and RTI adhered to strict ethical guidelines to respect the rights of research participants and to protect participant confidentiality. In early September, RTI's Institutional Review Board (IRB) reviewed and approved the FGD guides and procedures, prior to data collection activities.

During interviewer training, individuals were trained to properly administer an informed consent to a potential participant. Key components of the informed consent included a description of the study procedures, the right to refuse to participate, and a description of how participant confidentiality is maintained.

Before beginning the FGD sessions, facilitators read the informed consent script to each potential participant and answered any questions about the process. Participants and interviewers then signed the consent forms. Facilitators and note takers did not record participants' names or other information

that could potentially identify a participant. Facilitators kept completed consent forms, FGD notes, and FGD tape recordings in a secure location during fieldwork.

A.5 Staffing

The fieldwork started in Ahmedabad on September 16, 2014, and ended in Vadodara on September 23, 2014. All field study teams were experienced managers and facilitators for qualitative and quantitative data collection, and were familiar with the RTI technology from the June 2014 user sessions. NEERMAN fielded one male and one female facilitator for FGDs, each of whom were accompanied by one male and female note-taker. Both teams were overseen by one supervisor. A translator was generally available to translate Gujarati to English for international researchers on the team. SEWA staff were present to manage the flow of participants, assist in managing FGDs if needed, and provide participants with snacks at the end of the sessions. L&T personnel were available onsite to support operation of the RTI system and support meetings and logistics during sessions in Vadodara.

A.5.1 Quality Assurance

The study used several methods to ensure the quality of data collection, including field observations, review of FGD notes, and secure storage of notes, tape, and transcripts. At the end of each day, forms, notes, and transcripts were reviewed and stored safely. RTI, NEERMAN, and SEWA staff routinely reviewed data collection logistics and procedure.