Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2017.20880

91 (2017) 300–304
October

Evaluation of acceptance of a composting toilet prototype for people in slum area in Indonesia

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Received 12 January 2017; Accepted 30 April 2017

ABSTRACT

To install a system of the sanitation value chain, a composting toilet is an important alternative technology for providing value as it produces fertilizers from waste. A survey on the current practices regarding toilets, the assessment of a new protocol for operating the prototype toilet, and the evaluation of the interface design was performed with 20 people at the Indonesian Institute of Sciences (LIPI), Indonesia. Concurrently, an assessment of the interface design was performed at a mosque in Sapporo, Japan. Half of the people answered that the bad smell is a point to be checked, and 70% of respondents worried about excreta sticking to the toilet bowl. The problem of smell can be solved by installing a ventilation system. The new operation protocol was acceptable, and the impression of the toilet on the body was good and acceptable. 70% was unsatisfied with its size, and the yellow color of the cover brought to mind garbage or something polluted. 40% felt discomfort in terms of the impression of sitting on the toilet seat, feeling like they might fall into the hole. Many said that the space was too small for washing their body with their hands. Modification of the toilet was discussed.

Keywords: Muslim; Feces–urine–water separation; Solid–liquid separator; Acceptance; Interface design

1. Introduction

The sixth target of the Sustainable Development Goals is to take action to provide access to adequate and equitable sanitation and hygiene for all people by 2030 [1]. To achieve this target, suitable sanitation systems that can be adopted by all people of the world, respecting their culture, religion, and economics, are needed. In the urban slum area in Indonesia, 87% of the people have a water closet toilet. However, it is unsuitable because it directly discharges excreta into the water channel passing thorough their living area [2]. This situation is of concern as it brings an insanitary condition, which may cause serious endemic problem [3,4]. The people are unsatisfied with the situation, although the major obstacle to tackling the problem for the government is the lack of budget and human resources of the local government to improve sanitation in the area [5,6]. Therefore, the investment of people to improve sanitation conditions is low, resulting in a stagnant situation. To overcome this problem, we founded that incentives such as increasing income provide strong motivation for installing new technologies to the people [7]. Thus, the concept of a sanitation value chain,

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Presented at the 13th IWA Specialized Conference on Small Water and Wastewater Systems & 5th IWA Specialized Conference on Resources-Oriented Sanitation, 14–16 September, 2016, Athens, Greece.

as shown in Fig. 1, has been proposed to improve the sanitation in the slum area in Indonesia, on the basis of a value flow analysis of the area [8]. Considering the material flow through the sanitation system, most of the excreta should be transported away; otherwise they will accumulate and hinder the whole system. Thus, under the sanitation value chain concept, excreta are considered to be personal property that can be applied to produce valuable fertilizers to promote the transport of the materials from households to farmlands. Feces and urine are separately collected in the toilet; then feces are transformed into compost by a biological process [9–12] and urine-based fertilizers are produced by suitable technologies [13–18]. The compost and concentrated urine are transported to agricultural areas and reused as fertilizers [19,20]. Through this system, the nutrients in the excreta are transported from the people in populated areas to the farmland, and money or other benefits flow back from the farmers to the people. Pahore et al. [14] calculated that fivefold concentration of urine is required for feasible reuse of urine, including the cost of transport to farmlands. Here, the toilet system is very important because it is the starting point of the material, a terminal of the value, and has key technologies for the interface between the system and people, the separation of feces and urine, and for producing fertilizers. Some research on technology acceptance models for new technologies shows that usefulness and ease of use affect the intent to use such technologies [21,22]. The interface design strongly corresponds to usefulness and ease of use, so that it is one of the points of the whole system evaluated by the people. Consequently, user friendly design is required in the development process of the toilet. Additionally, the people in the slum area are also familiar with well-developed toilets bowl because they work in the city, resulting in requirement of better design than current commercially available toilet bowl. Therefore, the objective of this research is to identify the points needing improvement for our prototype toilet from the viewpoint of interface design.

2. Experimental methods

2.1. Prototype composting toilet

The illustration and photograph of the prototype developed in our laboratory [23,24] are, respectively, shown in Figs. 2 and 3. It is a sitting style toilet adapted for Muslims and has an enlarged toilet bowl compared with the conventional toilet to provide enough space to wash the body with water by their hands. The size of the toilet was 50 cm wide, 60 cm deep, and 50 cm height. The distance from the sitting surface to the floor can be adjusted with a step. A solid–liquid separator is under the toilet bowl. The solid feces remain on it while liquid goes into the discharging tube. After defecation, the feces are moved to the composting reactor under the separator by operating a lever, and then they are mixed with a composting matrix for rapid aerobic composting. The volume of the reactor is 40 L and half of it is filled with the matrix. The separated liquid passes the flow channel changer

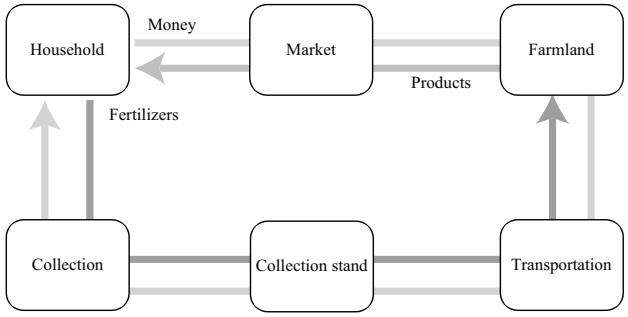

Fig. 1. Value chain sanitation system.

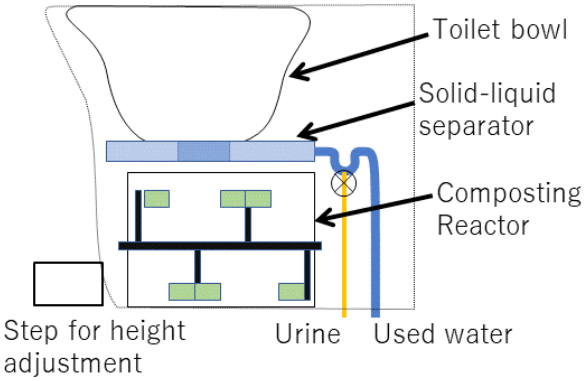

Fig. 2. Illustration of the prototype composting toilet.

Fig. 3. Photograph of the prototype.

and is separated into urine and washing water. A ventilation system provides fresh air to the reactor and removes exhaust gas. The materials of the body, reactor, and separator of the toilet were, respectively, fiber-reinforced plastic, iron, and polyvinylidene fluoride. Katukiza et al. [25] reported that the lined ventilated improved pit latrine obtained high scores for sociocultural acceptance and usability as it was an improved version of a common latrine. Therefore, the prototype provides a similar protocol for using the toilet to that of the conventional toilet, as shown in Fig. 4.

2.2. Interview survey

An interview survey on the current practices regarding toilets, the assessment of a new protocol for operating the prototype toilet, and the evaluation of the interface design was performed at the Indonesian Institute of Sciences (LIPI), Indonesia, and a mosque in Sapporo, Japan, to make a model of the composting toilet that is used by the Indonesian people. The respondents in both locations were familiar with the well-developed conventional toilet and behavior of Muslims in the toilet. The number of respondents was eight at LIPI and 12 in Sapporo. These numbers may seem small, but they were sufficient for our purpose [26]. The sheets of questions were shown to the respondents, and then the questions were asked to the respondents step-by- step. All the responses were collected onto a spreadsheet for further analysis.

An experiment to evaluate the distribution of the sitting position was conducted with 25 students in Hokkaido University to elucidate the relationship between the position and impressions on sitting. The students sat on the toilet, and then pictures were taken from the side, as shown in Fig. 5. The position of the back from the stem of the toilet was evaluated by the image analysis method.

3. Results and discussions

Most of respondents were in the age range of 20–39. 25% in LIPI and 33.3% in Sapporo were female. The age groups are summarized in Table 1. Since they normally use a brush and acidic or alcohol detergents for cleaning the toilet bowl, the material of the toilet should be resistant to scratching by the brush and chemicals. Also, only the areas of the toilet that they can see are cleaned. This suggests that they do not clean behind the bowl where they cannot see, so that the shape of the toilet bowl should be simple for easy cleaning. The answers regarding the points giving the impression of a dirty toilet are shown in Tables 2(a) and (b). Half of the people answered that the bad smell is a point to be checked, while 70% was cleaned with excreta remaining in the toilet bowl. The smell can be solved by incorporating the ventilation system. On the other hand, the development of an antifouling property to prevent feces sticking to the surface of the solid–liquid separation system is expected. The frequency of cleaning toilet is presented in Table 3. All the females answered that they clean the toilet after each use, although 30% of respondents answered "not every

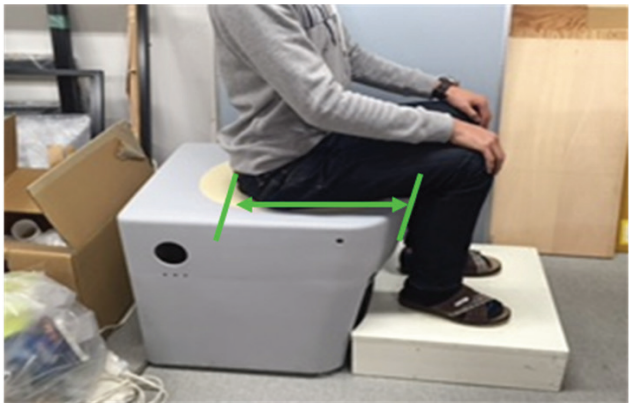

Fig. 5. Evaluation of the sitting position.

Table 1
Age groups of replicants

Age	LIPI (%)	Sapporo (%)
20–29	41.7	50.0
30–39	50.0	25.0
40–49	8.3	12.5
>50	0.0	12.5

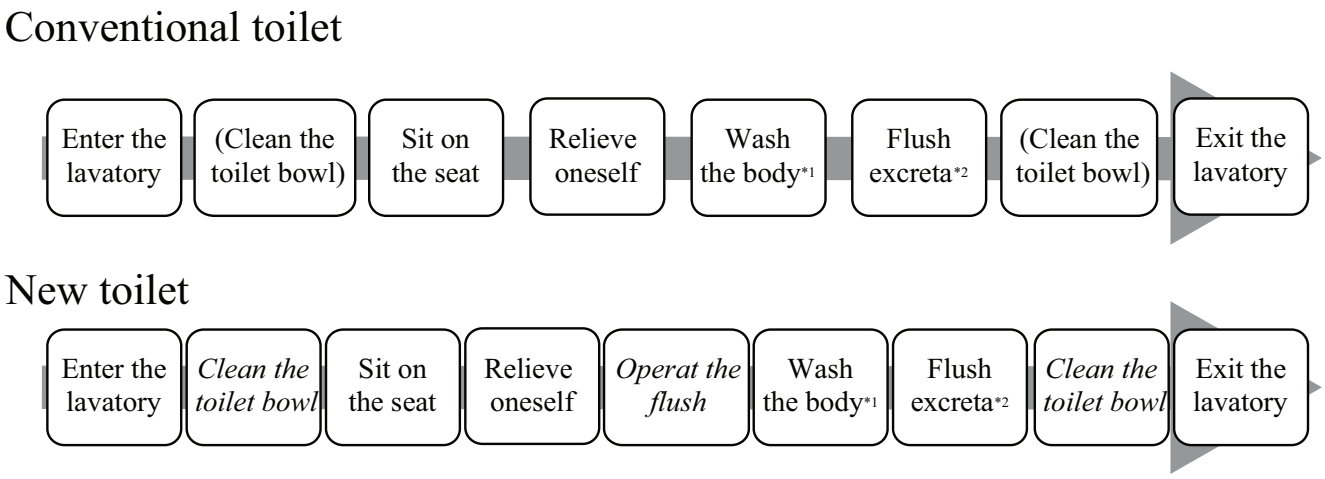

Fig. 4. Change in operation flow from conventional to new toilet.

Table 2(a)
Check points for lavatory

Points	Ratio of feeling dirty (%)
Bad odor	50.0
Slime on the floor or wall	45.0
Mould on the floor or wall	35.0
Black colored spots	40.0
Wet floor	30.0
Remaining feces or urine	45.0

Table 2(b)
Check points for toilet bowl

Points	Ratio of feeling dirty (%)
Bad odor	40.0
Mould on the toilet bowl	45.0
Remaining feces or urine	70.0
Discoloration	30.0
Others	10.0

Table 3
Possible frequency of cleaning toilet

Frequency	Ratio (%)
Every time	50.0
Some, but every time	20.0
Sometime	20.0
Never	5.0
No answer	5.0

time". Therefore, we should consider that people do not clean the toilet bowl after each use in its design. Thus, a new design with antifouling measures or the possibility of one action for cleaning is required. The new operation protocol was acceptable. The impression about the body of the toilet was good and acceptable, although 70% of the people were unsatisfied with its size. Some misunderstood the sitting style climbed onto it. The yellow color of the cover reminds them of garbage or something polluted. Thus, a different color should be chosen. 40% expressed discomfort for the impression regarding their feeling when sitting on the toilet seat, as if they might fall into the hole, also that the space was too small for washing their body with their hands. For width of the seat is the same as that of conventional toilet seats, but the impression of falling is caused by the needs to balance physical force on the legs [27]. This is owing to the sitting position on the seat and the height of the sitting surface from the floor. The pushed back sitting position and the low surface causes a moment of backward movement with the back of the thighs acting as the fulcrum, resulting in the feeling of falling. An additional test suggested that a high level of the sitting surface from the floor can solve this problem by forcing a forward posture. Another experiment on the sitting position showed a large variation in the position, as illustrated in Fig. 6.

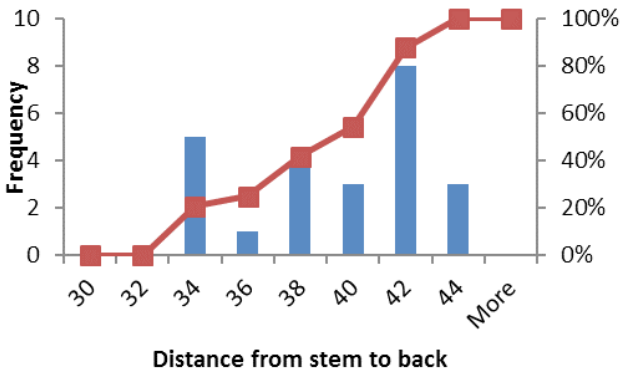

Fig. 6. Distribution of sitting position.

The respondents felt the space to be small when they sat forward on the seat. To the contrary, they had the impression of falling when sitting further back. This problem can be solved because people can adopt by gathering experience in the use of the toilet.

4. Conclusion

A survey on the current practices regarding toilets, the assessment of a new protocol for operating the prototype toilet, and the evaluation of the interface design was performed with 20 people in the Indonesian Institute of Sciences (LIPI), Indonesia, and a mosque in Sapporo, Japan, to assess our prototype toilet from the viewpoint of interface design. As a result, we found that respondents used a brush and acidic detergents for cleaning the toilet bowl, and cleaned only what they could see of the toilet. Half of the people answered that the bad smell is a point to be checked, and 70% was bothered by excreta remaining in the toilet bowl. The smell can be solved by incorporating a ventilation system. The new operation protocol was acceptable, and the impression regarding the body of the toilet was good and acceptable, but 70% was unsatisfied with its size, the yellow color of the cover reminded them of garbage or something polluted, and 40% expressed discomfort for the impression regarding their feeling when sitting on the toilet seat, as if they might fall into the hole, and also that the space was too small for washing their body with their hands. Therefore, the new protocol for operating the new prototype toilet was accepted by the respondents with some qualification. Some suitable interface designs could alleviate the problems, for example, a simple shape for easy cleaning, the development of an antifouling property to prevent feces from sticking on the surface of the solid–liquid separation system, a different cover color, and better comfort of the seat.

Acknowledgment

In memory of our colleague, Ms. Jovita Tri Astuti in LIPI, who made a great contribution to the survey.

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