WP1: SENSE

New sanitation – literature review

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1. Introduction

New forms of sanitation have been discussed over decades in and beyond Western Europe. The very high sunk costs of existing systems and infrastructure, a phenomenon referred to as "lock-in or path dependency, as well as public acceptance challenges, have, however, tempered the development of these systems (Blanken, Verweij, & Mulder, 2019; Poortvliet, Sanders, Weijma, & De Vries, 2018; Swart & Palsma, 2013) Yet, with increasing pressure on fresh water sources due to droughts and pollution, the need for alternative ways to handle sanitary waste streams is growing (Blanken et al., 2019). So-called new sanitation provides a system innovation in which elements of source separation, local treatment, the reuse and reduce of water use are combined (Poortvliet et al., 2018). New sanitation aims for the maximum recovery of energy and resources from domestic waste water, whilst minimizing emission and the use of potable water (Poortvliet et al., 2018). Examples of new sanitation appliances are vacuum toilets, NoMix toilets, food grinders and grey water reuse appliances. Besides tempering eutrophication risks, new sanitation appliances also make nutrient recovery from waste streams more efficient (Lienert & Larsen, 2010; McConville, Kvarnström, Jönsson, Kärrman, & Johansson, 2017). Source separation allows for separate treatment of waste water streams, allowing, for instance, the application of urine as fertilizer (Lienert & Larsen, 2010). Accordingly, the use of new sanitation is also found to potentially contribute to food security (McConville et al., 2017).

Whilst the value of these new sanitation options in increasingly recognized, the implementation challenges in households often tend to be overshadowed in in the literature, whereas at the same time, the successful or unsuccessful implementation of new sanitation measures happens in people's homes, and more specifically in their kitchen, bathroom or toilet. Indeed, the introduction of new technologies in these private domains can be severely hampered by both end-user opposition as well as the incorrect use by end-users. In this regard, the parallels with water reuse are evident. Providing several examples, Brouwer, Maas, Smith, and Frijns (2015) illustrate how public distrust in e.g. the quality of reused water can lead to the general dismissal of large water reuse infrastructure projects. Moreover, also Swart and Palsma (2013) argue that the uncertainty among property developers (and other stakeholders) about end-users' acceptance of new sanitation is one of the current bottlenecks for the development of new sanitation. In addition, besides the crucial support of the public required for the general implementation of the appliances, also the individual behavior of end-users is crucial for reaching the opted results. Incorrect use of the small and big flush option in NoMix toilets, for instance, can diminish the water saved by this appliance (Lienert & Larsen, 2010). Moreover, the use of chemicals for cleaning the vacuum toilet can hamper the effective recovery of nutrients (Telkamp, 2006).

Although it is evident that the support and willingness of (potential) end-users is crucial for the successful implementation of these appliances (Anand & Apul, 2014; Brouwer et al., 2015; Lienert, 2013; Poortvliet et al., 2018), empirical data on the acceptance of the technologies, both by end-users and potential users, is scarce. As expanded on below, our own literature search revealed that especially regarding the use of new sanitation measures such as food grinders and recycle showers, empirical knowledge is very limited. Considering the use of alternative toilets this number is slightly higher. Grey water reuse technologies seem to be another strand of literature, with considerably more studies performed on the topic. However, most studies concern a broad range of reuse applications, beyond sanitary reuse only. As we will focus on sanitary purposes, the use of grey water toilets and grey water use for laundry will be included. Other appliances of greywater are beyond the scope of this work.

The following sections present a first review of the empirical data on the acceptance of new sanitation appliances by (potential) end-users. To this end, as the user experiences can differ per type of sanitation, each technology will be discussed successively. After this, potential factors influencing the acceptance of these appliances will be identified. Although stakeholders of the water distribution and wastewater management sector in general often assume the social acceptance and openness of the public towards new sanitation systems -as long as they function reliably and without a loss of comfort (Kerber, Schramm, & Winker, 2016)- also several other drivers of acceptance have been identified. Each of these drivers will be discussed in more detail.

The empirical data is collected using a snowball search within the researchers own network, as well as a review by peers. Moreover data collection was supplemented by a structured search on Google Scholar regarding each of the new sanitation appliances discussed. The terms "new sanitation", "food grinders", "recycle douche", "recycle shower", "heat recovery shower", "recycled water laundry", "source separation sanitation" and "vacuum toilet" have been combined with "public perception", "public acceptance", "public resistance" and "end-user" in searches in the Google Scholar database. For each of these combinations the first five pages have been analyzed and all relevant articles have been selected. These papers formed the base for another snowball search into relevant cited articles. All selected articles have been published after the new millennium. Our focus has been on European, Canadian, American and Australian studies, to allow for comparable contexts. In the review of studies on new sanitation, our focus has been on types of new sanitation that are potentially applied on a larger urban scale. As such, appliances like compost toilets are left out of consideration. Finally, the focus considering end-user experiences with these appliances has been on citizens specifically (not on e.g. employees or others actors involved in the implementation).

2. Experiences and acceptance of new sanitation appliances

New sanitation techniques consist of a variety of appliances, raising different responses from (potential) users. In the following section the main appliances used in urban new sanitation projects will be discussed, including toilets (vacuum, NoMix, reused water), food grinders, showers (heat recovery, recycle) and laundry using reused water. For each of these appliances both the perceptions of the general public, i.e. the people without actual experience, as well as the end-user experiences will be discussed respectively if empirical data was available.

Toilets

When discussing the transition to new types of sanitation, the use of alternative toilets seems indispensable. While regular toilets often use drinking water to flush, appliances like vacuum toilets can allow for a high reduction in water use (Naus & van Vliet, 2012). Besides vacuum toilets, also the use of NoMix toilets will be discussed, as well as the reuse of recycled water to flush the toilet.

- *Vacuum toilets*: a toilet in which the flush water, urine and feces are not distributed driven by gravity, but driven by negative pressure. As such, only a small amount of the water normally required to flush the toilet is needed (only ca. 10% of a regular toilet).

Studying the general public's response to new sanitation appliances (through a survey distributed amongst 338 Dutch citizens) Poortvliet et al. (2018) found a positive attitude towards vacuum toilets. 64% of the questioned (potential) house-owners stated to stand positive towards the introduction of these new sanitation measures in their houses (Poortvliet et al., 2018).

Likewise, looking at the limited amount of empirical data on the end-user experiences regarding vacuum toilets, also a generally positive attitude is found (e.g. Naus & van Vliet, 2012; Telkamp, 2006; Hegger, 2007). Interviews with 18 end-users of a demonstration project in Sneek, the Netherlands, showed that the users in general stood positive against the use of the vacuum toilet in their home (Naus & van Vliet, 2012). Corresponding results were found by Telkamp (2006) in his study on the experiences of 20 inhabitants of a student housing project in Norway. In a second case studied by Telkamp (2006), however, less positive reactions were collected. Interviews with 18 homeowners (also in Norway) showed that the majority was dissatisfied or neutral about the use of the vacuum toilets. Their dissatisfaction was mainly due to the malfunctioning of the system. In both the studies of Naus and van Vliet (2012) and Telkamp (2006) around one third of the end-users had experienced malfunctioning of the vacuum toilet. Besides the malfunctioning, also some other negative remarks were made: the toilets were very loud when "flushing". This noise is considered to be one of the main disturbance by the end users (Hegger, 2007; Naus & van Vliet, 2012; Telkamp, 2006). In the study by Telkamp (2006) also the smell of the toilets came out as a main disturbance. The latter was related by the authors to the prohibition of the use of chemicals for cleaning the toilet (Telkamp, 2006). Protection of resources, on the other hand, is seen as one of the main advantages by end-users. Yet, the necessity to flush the toilet with additional (buckets) of water makes them question the real water savings (Hegger, 2007). However, the discussed studies are relatively old, and might be considered dated. As these technologies have developed over the last years, they have become more silent and malfunctioning has possibly decreased.

- *NoMix toilets*: Toilets in which urines source separation is applied through the use of a separate outlet. Urine is discharged to a separate storage tank with or without the use of additional flush water.

Using so-called 'informed focus groups' (citizens were provided with state of the art knowledge) Pahl-Wostl, Schönborn, Willi, Muncke, and Larsen (2003) found that 80% of the approximately 80 Swiss respondents stood positive towards the use of NoMix toilets. This study focused on members of the general public, having no particular experience with the technology. Moreover, over 60% of the respondents in this study stated to be willing to introduce this technology into their household (Pahl-Wostl et al., 2003).

Looking closer into the end-users experiences with NoMix toilets, a likewise positive attitude can be distinguished. In an extensive study, Lienert and Larsen (2010) have reviewed surveys on the acceptance of NoMix toilets in 38 projects in 7 Northern and Central European countries with in total 2720 respondents. A portion of these respondents use the NoMix toilets in their private homes (N=482). Also regarding this appliance, the experiences with the new sanitation technique are positive. Approximately 70% of the private home users of the NoMix toilet judged it to be similar or better than conventional toilets (Lienert & Larsen, 2010). Design (79%) and hygiene (85%) raised very positive responses in all countries under study. Also the smell was judged positively (77%). Cleaning and the maintenance problems raised less positive responses (respectively 52% and 59% positive). Blockage and urine drains were the main maintenance problems reported (Lienert & Larsen, 2010). Also, many of the respondents noted that they had to change their behavior to adapt to the requirements of the toilet, e.g. men usually sit on NoMix toilets (60%). The most challenging aspect of the NoMix toilet reported, is the disposal of toilet paper in a separate bin, or the feces compartment (without extra flushing, otherwise no water is saved). Only ca. 50% would dispose lightly soiled paper in a separate bin (Lienert & Larsen, 2010). A likewise number was found in a study on the use of urine separating toilets on university campuses by Ishii and Boyer (2016), as they found only ca. 60% willing to dispose lightly soiled toilet paper in a separate bin. Moreover, non-adequate flushing behavior is another behavior reported frequently throughout the surveys, with the main behavior being the use of the "big flush" (meant for feces); extra flushing to get rid of toilet paper (Lienert & Larsen, 2010).

- *Water reuse toilets:* Water reuse toilets recycle grey water and rainwater to flush the toilet. Grey water is lightly polluted water that can be collected from all household appliances excluding the toilet. Rainwater is often collected on rooftops or from other impervious surfaces. The use of recycled water often requires a storage tank for grey-/rainwater. Using recycled water in the toilet can result in a ca. 13-21% reduction of households water consumption.

As with vacuum and NoMix, toilets, also water reuse toilets gained positive feedback from the general public (Hefter, Birzle-Harder, & Deffner, 2015; Jeffrey & Jefferson, 2003; Keuter & Deeberg, 2009). Jeffrey and Jefferson (2003) found that 89% of their respondents (representative sample for the England and Whales population, n=300) stood positive toward the use of grey water as long as safety is guaranteed. Moreover, 88% of the respondent was found to be willing to use the residue water of their own shower or bath to flush the toilet. The use of waste water from other sources (other private homes or public sources) was less accepted, here only half of the respondents were willing to use the water (Jeffrey & Jefferson, 2003).
Likewise positive responses were collected by interviewing the visitors of the London Olympic Park where filtered black water was reused in, amongst others, toilets. Respondents were provided with some diagrams and information on the reuse scheme and surveyed on their willingness to introduce these technologies into their home. 90% of the 309 respondents stated to support using recycled black water in homes (for irrigation of lanes and toilet flushing). In this particular study, no differentiation was made between different black water sources (Smith, Rutter, & Jeffrey, 2015).

Also the use of rainwater to flush the toilet has yielded positive responses from non-users. In a survey amongst 240 Scotisch households Egyir, Brown, and Arthur (2016) have found that around 90% of respondents considered the use of harvested rainwater for the toilet acceptable. The likelihood that respondents would implement a rainwater toilet in their home, however, was much lower with between 58-74% of respondents deeming this likely for the different areas studied (Egyir et al., 2016).

The end-user experience with grey water reuse toilets was studied by Deffner and Birzle-Harder (2017) in Germany, by surveying 55 end-users on their experiences with grey water toilets. In general, the respondents provided a positive feedback on the system, with the majority of residents valuing the benefits for resource protection and financial benefits only appearing secondary. Likewise, also Domènech and Saurí (2010) reported users to have a positive attitude toward the use of grey water toilets (survey in Spain, n=120). 90% feels it is a positive feature of their home (with the other 10% feeling indifferent). However, ca. 35% of the users feel (very) dissatisfied by the toilet. Moreover, 20% of the respondents who initially stood positive against the technology, noted that they changed their mind after using the toilet. Main issues mentioned relate to the perceived health risks, the operational regime required and costs. Yet, although health risks are an explanatory factor, only very limited people thought there actually were health risks related to the use of grey water toilets (less than 10%). Regarding the costs of the system, ca. 30% reported them as high, which is a factor negatively influencing the attitude towards the system. Finally, in all of the four cases studied by Domènech and Saurí (2010) respondents reported negatively on the odor.

Food grinders

- *Food grinder:* A technology that crunches food with water into one single stream which can be abducted through the sewage system. The food grinder is installed commonly in the kitchen sink. The use of food grinders reduce the amount of green waste to be disposed through regular waste streams. Also the distribution through the sewage system can lead to composting benefits.

In their study on the acceptance of new sanitation technologies, Poortvliet et al. (2018) have included the use of food grinders. As was stated before a general positive attitude was found regarding the use of food grinders and vacuum toilets, with 64% of the respondents having a positive attitude towards the introduction of these in their homes.

Regarding the empirical data on the use of food grinders in a household setting, it can be concluded that only very little data is available on this topic. The study of Naus and van Vliet (2012) into the experiences of 18 tenants of a housing project in Sneek (the Netherlands) gives some first insights into the way people experience these grinders. First of all, over 90% of the users would prefer the food grinder over a green waste container and all users feel it is a good replacement. Moreover, as was found with the vacuum toilets, people also feel proud to be part of an experiment in which this technology is applied. Yet, the grinder also received some negative feedback, as the noise disturbed a little less than half of the users. Moreover, the food grinder is found to be prone to malfunctioning by as much as one third of the users. Nonetheless the occasional malfunctioning did not result in an overall negative evaluation of the grinder and users would still recommend the technique to others (Naus & van Vliet, 2012).

Showers

- *Recycling shower*: These systems are based on the reuse of the residue shower water by filtering it within the shower itself and reusing it immediately. This can result in considerable reduces in water use for shower purposes.

The search for empirical data on the (potential) use of recycling shower has not given any results in *Google Scholar*. The limited empirical data on the topic might be caused by the relative recent introduction of the technology. Commercial providers such as the Swedish *Orbital Systems*, the Australian *Cintep* and the Dutch *Harmwells* have introduced their showers from 2013 onwards. These systems are based on the reuse of the residue shower water by filtering it within the shower itself. As the latter technology can be considered a grey water reuse technology, the empirical data found on the acceptance of grey water reuse can be deemed helpful in understanding the potential motivations and barriers for the introduction of this water saving technology.

- *Heat recovery showers:* heat from the residue shower water is reused to heat up the fresh shower water. This is commonly done by aligning the piping of the residue and the fresh water in a way that allows the heat to transfer to the fresh water. In this technology no grey water reuse is included.

While there are various studies focusing on the technical appliance of heat recovery in showers (e.g. Culha, Gunerhan, Biyik, Ekren, and Hepbasli (2015) focusing on showers specifically or El Hage, Ramadan, Jaber, Khaled, and Olabi (2019) focusing on heat recovery from domestic appliances), the empirical data on the end-user experiences or the potential users expectations is very limited. A possible reason for this lack of data might be the technological base of the measure, requiring no behavioral change of the end-users (after installation). An exception is the study of van der Grijp et al. (2019), which briefly mentioned the end-user experiences with these showers. In their study on demonstration projects of Nearly Zero Energy Buildings in Sweden, the Netherlands and France, they have surveyed and interviewed residents of three different cases. Although the focus of their study was on reviewing the performance of the system as a whole, some remarks on the experiences with the heat recovery showers were included. An aspect mentioned in the Dutch case which was bothering the end-users (reoccurring focus groups with n=12) is the fact that the heat recovery system only starts functioning after showering for over 10 minutes (van der Grijp et al., 2019).

Laundry

- *Recycled water use in washing machine:* recycled water can be reused to do laundry. A regular washing machine uses ca. 50 liters each running.

While European empirical data on this topic seems to be largely lacking, our literature search revealed that the use of recycled (grey) water for laundry has been studied quite extensively in the Australian context (Chen, Ngo, & Guo, 2013; Chen, Ngo, Guo, et al., 2013; Hurlimann, 2011; Mainali et al., 2013). These studies, overall, suggest that the use of recycled grey water for laundry purposes has yielded positive responses with potential users. Chen, Ngo, and Guo (2013), for instance found that over 60% of their respondents (n=223) support this particular application, whereas only 10% opposed. People stated to be mainly concerned on the hygiene, smell and health risks (Chen, Ngo, & Guo, 2013). Also in a small UK based study (n=46), 100% of respondents were willing to use rainwater collected from their own roof for a number of household appliances, including the laundry (not specified per appliance). Respondents did, however, perceive the use of rainwater for laundry being related to relatively high risks, as they rank the risks a 4.5/10 (higher than e.g. car washing 1.9/10, but lower than personal washing 6.2/10) (Ward, Butler, & Memon, 2008).

3. Explanatory factors of (potential) acceptance

In most of the studies mentioned in the previous section, authors have also attempted to unravel the drivers of public reactions. Various approaches have been used to identify these drivers, as well as the correlation between them. Some studies, working with larger samples (Domènech & Saurí, 2010; Jeffrey & Jefferson, 2003; Lienert & Larsen, 2010; Poortvliet et al., 2018; Smith et al., 2015), were able to identify statistical correlations, whilst others based their results on more qualitative analyses (Naus & van Vliet, 2012; Pahl-Wostl et al., 2003; Telkamp, 2006).

The classical socio-demographic characteristics (like age, education and income) are analyzed in several studies. Although often not linked to motivational drivers, some authors did find correlations between acceptance and individual characteristics. A lower age and higher education were for instance found to have a significant correlation to the acceptance of NoMix toilets at work (Lienert & Larsen, 2010) and grey water toilets at home (Domènech & Saurí, 2010). Moreover, for NoMix toilets, women were found considerably more willing to purchase these then men (47% of women compared to 17% of men). The authors have provided no explanation for the latter (Pahl-Wostl et al., 2003). Many other studies, however, did not yield significant responses between social-demographic characteristics and motivation (Jeffrey & Jefferson, 2003; Smith et al., 2015), or are not reported on (Poortvliet et al., 2018).

Besides these classical correlations, another individual characteristic that was found to influence the acceptance of new sanitation appliances is the division of home ownership. Several studies have found a higher acceptance of new sanitation measures amongst tenants compared to home owners (Domènech & Saurí, 2010; Pahl-Wostl et al., 2003; Telkamp, 2006). The difference between these two groups is attributed to a higher acceptance of technology when its considered to be something temporally (Domènech & Saurí, 2010) and the unwillingness of home-owners to invest in these appliances (tenants commonly do not have to invest themselves) (Pahl-Wostl et al., 2003). Also, its suggested that potential users are less willing to accept these appliances if they are required to take personal responsibility for maintenance (Lienert & Larsen, 2010).

Also related to the individual characteristics is the type of area people reside in. One might expect a higher acceptance of new sanitation measures in ecological housing projects, such as eco-villages, compared to regular neighborhoods. The relationship between attitude and representativeness of the sample, however, is only hardly tested (Lienert & Larsen, 2010). Moreover, if tested, it has yielded mixed results. Whilst over half of the respondents in a Austrian study included in the review by Lienert and Larsen (2010) found the ecological wastewater (NoMix) concept an important motive to move in, the respondents in two Swedisch eco-villages did not (only 14%) rank ecological concerns as a main motivation to move there (Lienert & Larsen, 2010). As such the type of area people live in apparently does not always relate to their ecological concerns.

In addition, also the different conditions in which respondents have experienced new sanitation technologies might has influenced their answers. Blume and Winker (2011) for example found that users of source separation toilets (NoMix) were more likely to change their behavior on the toilet (sit down) if urine disinfection spray was made available.

Individual drivers

Although the mentioned individual characteristics provide some insights into the willingness of respondents to accept new sanitation appliances in their homes, they do not explain what factors drive the public acceptance. There are various methods to analyze these drivers, including conventional models such as the value-belief-norm theory (Poortvliet et al., 2018), the theory of planned behavior (TPB) (Ishii & Boyer, 2016) and the so called deficit model (Stenekes, Colebatch, Waite, & Ashbolt, 2006). All of these aim to explain acceptance or behavior, by suspecting a relationship between for instance attitudes, subjective norms, people's perceived behavioral control, and/or their intention to act (Ishii & Boyer, 2016). The drivers identified in these different models are a valuable way of structuring a study into acceptance. Although the casual relationships they are based on are sometimes difficult to prove, they provide insight into the subjective realities of (potential) end-users. Hence, understanding these contributes to the potential design of tailored communication with and involvement of (potential) end-users.

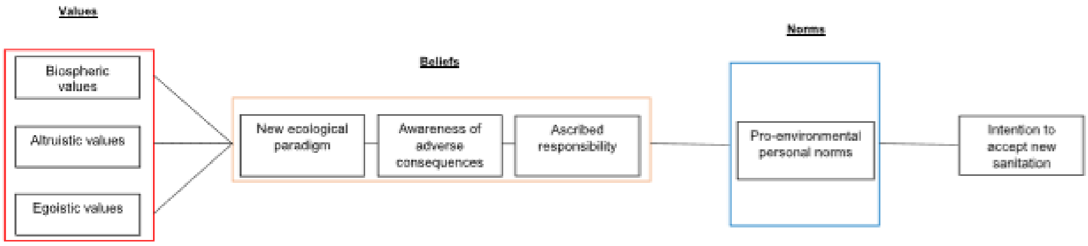
Therefore the following paragraphs will discuss a combination of drivers derived from various empirical studies on new sanitation. Discussed drivers are the values, beliefs and norms people behold (Poortvliet et al., 2018); perceived risks and benefits (Poortvliet et al., 2018; Stenekes et al., 2006); the trust people have in organizations that oversee the service offered (Smith, Brouwer, Jeffrey, & Frijns, 2018; Stenekes et al., 2006); the perceived behavioral change needed to use these appliances (Domènech & Saurí, 2010; Lienert & Larsen, 2010); and the experiences people have and expect to have regarding these new sanitation appliances (Brands, 2014; Smith et al., 2018). In the following sections each of these will be discussed.

Environmental values, beliefs and norms

In their survey on the potential acceptance of new sanitation (vacuum toilet and food grinder) by Dutch citizens, Poortvliet et al. (2018) have found an (indirect) correlation between the environmental values people behold and their attitudes towards this type of technology. By making use of a value-beliefs-norm model, the biospheric, altruistic and egoistic values people behold were compared to their beliefs concerning the new ecological paradigm (related to the relation between humans and nature), their awareness of adverse consequences (off issues related to e.g. to provision of clean water) and the responsibility they personally felt to act (to e.g. reduce their water use). These beliefs in their turn were related to the pro-environmental personal norms people hold themselves to, as well as their intention to accept the introduction of new sanitation (see Figure 1).

Except for their altruistic values (e.g. their valuing of social justice), all variables were predictive of the variable next in the described chain (values-beliefs-norms). Thus, people with strong biospheric values, are also likely to have an ecological worldview (beliefs), to hold strong environmental norms, and have a higher intention to accept new sanitation. Likewise, people with strong egoistic values score low related to the new environmental paradigm (beliefs) and do not hold strong environmental norms. As such they are less likely to accept new sanitation (Poortvliet et al., 2018). By mapping out this chain of values, belief and norms, the influence of having certain biospheric and altruistic values on the intention to accept new sanitation was shown (Poortvliet et al., 2018).

Figure 1 created by Poortvliet et al. (2018, p. 92). Value-belief-norm system to predict intention to accept new sanitation.



These findings correspond with the findings of the empirical studies into the end-user experiences. Although not reviewed related to each appliance, having an environmentally friendly attitude has been correlated positively with the acceptance of NoMix toilets (Lienert & Larsen, 2010). Also considering the use of grey water reuse toilets Domènech and Saurí (2010) have linked the attitude of respondent considering environmental conservation to their acceptance. A positive attitude towards environmental conservation favours a likewise attitude to grey water reuse technologies (Domènech & Saurí, 2010). A likewise correlation is found in the study by Jeffrey (2002) into the general public's attitude in England and Whales. Moreover, although studied in a more qualitative fashion, also many participants in the focus groups organized in the study of Pahl-Wostl et al. (2003) (focusgroups with potential users) stated environmental friendliness and water saving were main arguments in favor of using a NoMix toilet (Pahl-Wostl et al., 2003).

Another interesting approach which is worthy of pointing out here is the typology created by Deffner and Birzle-Harder (2017). Based on interviews with end-users these scholars have identified five individual user groups, each of them sharing similar perceptions and interests toward sustainability and innovative innovation systems. Based on values and motivations people behold, they differentiated between the environmental conscious users, the convenience-oriented users, the cleanliness-sensitive users, the skeptical users and the disinterested and indifferent users. Each of these groups will also react different to presented risks and benefits (Deffner & Birzle-Harder, 2017).

Perceived risks and benefits

Other aspects influencing the likelihood to accept new sanitation, are the perceived benefits and risks. The study of Poortvliet et al. (2018) showed that both the perceived risks and benefits successfully predict the acceptability of new sanitation technology. Interestingly enough, they found that the perceptions people have of the benefits to be contributing more to the intention to accept vacuum toilets and food grinders, than the perceptions people have of the risks. The perceived potential benefits are mainly related to the economic and environmental benefits, while the perceived risks relates mainly to the perceived needed behavioral change for implementation of new appliances (Poortvliet et al., 2018).

The perceived benefits of new sanitation thus seem to be a main driver for the public acceptance and are mainly environmental and financial in nature. Likewise, also Ward et al. (2008) found that the respondents in their small UK based study (n=43) mainly listed environmental and financial factors to be influencing their consideration of installing rainwater reuse systems for, amongst others, laundry purposes. Yet, communicating these only appeals to individuals with a strong biospheric value orientation (Poortvliet et al., 2018). The sole knowledge of benefits is thus not necessarily a significant driver of public response, as it will only appeal to those for whom it related to their personal values, beliefs and norms (Poortvliet et al., 2018). Moreover, the study of Naus and van Vliet (2012) also suggests that, when looking at the end-user experiences of these benefits, understanding them remains challenging. In their small sample study (n=20) evaluating the satisfaction of users (tenants) of a Dutch housing project including new sanitation measures, Naus and van Vliet (2012) found that understanding the financial benefits (or risks) of implementing these technologies is often unclear to (potential) end-users. Moreover, also the environmental benefits, related to the in- or decrease of water and electricity use of the households, were unclear to most respondents. Yet, almost everyone believed these environmental benefits would occur (Naus & van Vliet, 2012).

In general the financial benefits or risks seem to be influencing the acceptance of residents. As was stated before, the higher willingness of tenants to use new sanitation measures is linked to the willingness to bear financial responsibility for these systems and their maintenance (Lienert & Larsen, 2010). Moreover, in the case of NoMix toilets, the acceptance decreased with the inclusion of willingness to pay as a measure of acceptance (Ishii & Boyer, 2016; Lienert & Larsen, 2010; Pahl-Wostl et al., 2003).

In addition, the perceived risks seem to be more substantial in relation to water reuse appliances, such as a grey water toilet. Although still not deemed significant by most end-users (less than 10% thinks there are health risks related to the use of grey water toilets in the study of Domènech & Sauri), water reuse is more explicitly linked to potential health risks. In the study of Jeffrey and Jefferson (2003) for instance, the idea of grey water reuse within people's own household does not raise concerns with respondents, as long as it does not involve increased health risks.

Perceived behavioral change needed for implementation

As was stated before, Poortvliet et al. (2018), concluded that the need to change behavior is the main perceived risk that was found to influence peoples intention to accept new sanitation. The more people expect that a behavioral change is required for the implementation of new sanitation (and thus the higher the risks of behavioral change is), the less likely they are to accept new sanitation measures. In line with these findings van Vliet and Spaargaren (2010) have argued that behavioral routines, which are rooted in cultural traditions, can serve as important constraints in the implementation of new sanitation. This statement is backed by the findings regarding the end-user experiences with the NoMix and grey water reuse toilet. The need to dispose toilet paper in a particular place and the requirement to use the small flush are required behavioral changes reported for the NoMix toilet. Both of them were also found to link negatively to acceptance of the toilet (Lienert & Larsen, 2010). Moreover, considering the grey water toilet, common behavior like dumping waste in the sewage was found to clog the system and was noted as causing malfunctioning of the system. The malfunctioning negatively affected the attitude of users towards the system (Domènech & Saurí, 2010). For vacuum toilets and other new sanitation appliances this might also be the case, although not looked into specifically.

Another aspect related to the behavior required when using new sanitation appliances is the unfamiliarity potential end-users have with these systems. The study performed by Naus and van Vliet (2012) showed that people found it challenging to envision the use of the new sanitation measures beforehand. Providing a demonstration of the use of these technologies in combination with general provision of information seemed to be the most effective means of preparing future users (Naus & van Vliet, 2012).

Trust in the overseeing organization

Another factor influencing peoples acceptance of new technologies and water reuse in particular, is trust in the overseeing organization (Smith et al., 2018). This organizational trust is considered to be linked to the way people interpret risk-related information they receive in relation to a new technology (Smith et al., 2018). Although not looked into particularly, this is done by Poortvliet et al. (2018) as they link the perceived health and hygiene risks to the trust in the implementation of these new sanitations by responsible bodies. In their study they found that the potential impact of new sanitation on hygiene and public health were not predictive of peoples intention to accept these technologies. Consequently they suggest that the public trusts that these new sanitations will be implemented according to good practices, meeting all hygiene requirements (Poortvliet et al., 2018).

The trust people have in the technology itself, on its turn is considered to be influenced by a number of factors. Regarding the use of recycled waste water, sensorial information is an important factor that is found to influence trust (Smith et al., 2018). This sensorial information relates to the way we experience water and water characteristics, and thus to the odor and sight of the water or the technique itself. These experiences in relation to new sanitation measures will be discussed in the following section.

Experiences

A last item that will be discussed in as individual driver for perception, slightly differs from the previous ones. While the other identified drivers can be related to general knowledge and attitude, this driver relates to the more experiental aspects of new sanitation. The main experiences found in literature are twofold: emotions of disgust and noise disturbances. In the behavioral science literature the emotion of disgust is linked to the revulsion people can experience in relation to a sight or smell. This revulsion becomes larger with the closer proximity of the object of disgust to the mouth. The emotion is a nurtured feeling, which is strongly influenced by ones' upbringing, age and profession. Those working with e.g. strong odors such as feces in their professional life (e.g. as a farmer or nurse) tend to find these less disgusting compared to those who do not (Brands, 2014). This, as Smith et al. (2018) also call it, yuk-factor, can affect the willingness to accept technology. In the context of waste water reuse, the emotion of disgust is even linked to so-called *magical contamination*. Even though the waste water has been cleaned and treated profoundly and meets all drinking water requirements, people remain suspicious. Once water has been waste water, it will remain waste water in their perception (Smith et al., 2018). Moreover, Smith et al. (2018) even argue that the acceptance of new technologies is driven more by the experiential system than it is driven by the analytical system. The experiential system refers to the way people experience the technology, including its operation and smell, while the analytical system refers to the arguments people could use in favor of using new sanitation measures such as environmental and water saving considerations.

In his review paper on challenges for the implementation of source separated and decentralized sanitation Brands (2014) describes the impact the emotion of disgust can have on the attitudes and perceptions towards sanitation options. As people tend to show avoidance behavior to distinct themselves from the subject of their disgust (e.g. feces), the introduction of a new technology decreasing the distance between a person and their feces (both in sight and smell) could experience significant resistance (Brands, 2014). In addition, negative sensory experiences can even lead to a decreasing trust in the quality and safety of the water itself, disregarding any expert information provided on this topic (Brouwer et al., 2015).

The end-user experiences found in some of the empirical studies on new sanitation show that emotions of disgust can result in a negative experience of the new sanitation appliance. An unpleasant smell was reported as a negative aspect for the grey water reuse toilets (Domènech & Saurí, 2010) and vacuum toilet (Telkamp, 2006). Moreover, the storage of large quantities of water for grey water reuse also sometimes results in unpleasant, nasty smells (Domènech & Saurí, 2010). In addition, another experience which has resulted in negative feedback on new sanitation measures is the noise some of the appliances make. These complaints of end-users were particularly found in relation to food grinders and vacuum toilets (Naus & van Vliet, 2012).

These negative experiences, however, have not resulted in overall negative evaluations by end-users. Only in the study of Telkamp (2006) there is one case in which more than half of the users of vacuum toilets and food grinders were negative or neutral about these appliances. As was stated before, the most important reasons were experiental, as the malfunctioning of the system, as well as the sound and smell were considered to be the main disturbances (Telkamp, 2006).

A final remark that can be made in relation to the experiences, relates to the general unfamiliarity of the public with these technologies. As was mentioned before, people find it difficult to imagine the use of new sanitation measures if they have never used these (Naus & van Vliet, 2012). In some studies this was tackled by questioning people visiting a site in which new sanitation appliances are used, such as the London Olympic Park (Smith et al., 2015). The general attitude of respondents in this study, however, did not differentiate much from the attitude in a more general survey on water reuse as was also set out in England and Whales. In both studies around 90% of respondents welcomed the idea of water reuse in homes (Jeffrey & Jefferson, 2003; Smith et al., 2015).

In sum, we are led to the conclusion that identifying these drivers contributes to the further understanding of the complex dynamics individual attitudes and acceptance are based on. However, as they are constantly evolving, they should by no means be seen as static. As was already noted in relation to the unfamiliarity people have regarding these appliances, experiences, for one, can influence people's acceptance of new sanitation schemes. Additionally , also other means such as participation schemes, the provision of tailored information and training of can influence these drivers and the acceptance itself (Brouwer et al., 2015).

4. References

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