Using the Receptivity model to uncover 'urine blindness': Perceptions on the re-use of urine

Abstract

Population growth, climatic changes and over-exploitation of natural resources are at the basis of the world's food crisis, which counts almost 1 million people without sufficient food sustenance. These changes require novel environmental practices which are based on nutrient recovery and management in agriculture. This contribution analyses and discusses users' perceptions on re-use of urine as fertiliser through the lenses of the Receptivity model. A search was performed on Scopus (as well as other web search engine) using the keywords of urine, nutrient recovery and sanitation. Results shows how questions related to Awareness, Association, Acquisition and Application of the environmental change can represent hurdles to novel models of nutrient recovery and use urine in agriculture. Examples of hurdles identified from the literature relate to poor understanding of potential for urine reuse, social stigma attached to using dry sanitation and applying urine in agriculture and poor operational knowledge of application of urine in agriculture.

Conclusion relates to the illustration of implications of such challenges on the design of environmental interventions.

Keywords: *Waste Management, Urine reuse, Fertilisers, Receptivity, User perceptions, Developing Countries.*

Introduction

Population growth, decrease in agricultural yield, increase in fertilisers' prices together with climatic changes present an alarming scenario to the world's food crisis (Godfray et al. 2010, Rosegrant & Cline 2003). The over-exploitation of natural resources, *in primis* water and land, together with depletion of phosphate rock reserves, have brought an increase in the world's food price and demand, which calls for novel environmental management models, where the recovery of nutrients from human waste (urine and faeces) becomes a viable option for the sustainable use of natural resources (Lienert et al. 2003). The use of animal waste as composter and fertiliser has long been common practice among populations in developed and developing countries (Mariwah & Drangert 2011), however, the recycling of human waste (both urine and faeces) is still stigmatised in the contemporary societies (Drangert 1998).

The value of human waste in increasing agricultural yield and preventing environmental pollution has long been recognised (Haq & Cambridge 2012). Human urine contains most nutrients such as Nitrogen (N), Phosphorus (P) and Potassium (K) on a ratio of 11:1:2, which can be used as a fertiliser and each year an average adult disposes of 0.36 Kg of Phosphorous and 5 kg of Nitrogen from his/her urine. Urine reused directly or after storage is a reported as a safe and high quality alternative to the application of N-rich mineral fertiliser in plant production (WHO 2006, Richert et al. 2010). The safe and hygienic reuse of urine is linked to the use of environmental technologies which facilitate its separation at source from faeces, which are the main pathogen harbour. The discourse upon which nutrient management is constructed is intrinsically linked to appropriate use of the so called Ecological Sanitation (EcoSan) technologies. The concept of EcoSan broadly encompasses various forms of nutrient management, from the simple plantation of a tree over a full latrine to more sophisticated systems based on the separation of urine from faeces at source, which allow waste collection (Jackson 2005). Developing countries characterised by poor sewer networks and water stress conditions have been a prime focus of technological development of ecological sanitation to increase coverage (Morgan 2004). Whilst several contributions have discussed human perceptions on reusing human faeces as fertiliser (Mariwah & Drangert 2011), very few studies have compiled evidence on the acceptance of urine and urine-based fertilisers in low-income countries (Drangert 2005). Most studies have focused on European countries (Lienert et al. 2003) and/or have reverted around the use and acceptance of the sanitation technology itself (Pahl-Wolst et al. 2003, Lienert & Larsen 2009, Blume & Winker 2011, Tumwebaze et al. 2011).

The implementation of environmental innovations requires a radical change of how people think about and valorise human waste, a vision which in turn challenges the traditional concepts of “flush and discharge” (Esrey & Andersson 2001) and “drop and store” concepts. As we move towards different models of natural resources management shifting from wet to dry sanitation technologies and from disposal of waste to nutrient and energy recovery, a need arises to understand the human dimensions of environmental and nutrient management solutions, which valorise the relationship between the individual and human waste (Jeffrey & Seaton 2004). The application of urine in agriculture is intrinsically linked to understanding the acceptance of key stakeholders involved in the process, such as farmers applying urine in their crops and consumers who buy vegetables grown using urine (Cofie et al. 2011).

This article reviews the global trends on acceptance of urine as fertilisers discussing contributions from the academic and grey literature and reporting on knowledge gaps and opportunities for interventions in developing countries, through the lenses of the

Receptivity conceptual framework. The main purpose of this contribution is to highlight opportunities for achieving a sustained use of "alternative" sanitation systems by discussing human barriers to acceptance and use of urine.

Methodology

To address this research topic, this contribution employs a theoretical framework called Receptivity (Jeffrey & Seaton 2004), which stems from the innovation and technology transfer literature, to provide a qualitative assessment of perceptions of urine and its reuse in agriculture. The Receptivity framework originates from a critique of the *Technocentric* models of technology transfer and adoption. Important limitations of such models have been identified, perhaps the most significant of which has been the lack of focus on the human aspects (Linstone et al. 1981) and the tendency to ignore the role of individuals in the process of technology transfer. Responding to these limitations, new research has sought to re-conceptualise the process of innovation adoption building upon a re-definition of the process, which emphasizes social context, human perceptions and learning culture and includes not only the material output of scientific discoveries but also the skills, knowledge, and experience of those involved in the process (Seaton & Cordey-Hayes 1993, Gilbert & Cordey-Hayes 1996). Perhaps one of the most authoritative efforts to model the processes that shape technology adoption by focusing on the boundaries within which it occurs is Rogers' diffusion of innovation model (2003), which characterise the diffusion process as composed of the innovation itself, communication channels, time and the social system in which it is embedded (Rogers 2003, 2004). Whilst an in depth discussion of the components of Rogers' model is outside the scope of this paper, for the purpose of this contribution this model highlights the focus on human and societal dimensions governing the innovation process, subsequently influencing developments of recipient-focus frameworks and approaches to investigate technology transfer. These intellectual efforts represent the theoretical background of the Receptivity model (Jeffrey & Seaton 2004). Receptivity is defined as: *the willingness (or disposition) but also the ability (or capability) in different constituencies (individual, communities, organisations and agencies) to absorb, accept and utilize innovation option.* (Jeffrey & Seaton 2004:281-2). At the basis of the Receptivity framework is the recognition that failure of environmental policies and change to be incorporated into people's life largely depends on lack of understanding of recipients' ability to incorporate such change and adapt it to current circumstances. The main premise which rests behind the idea of Receptivity is the inability to understand the responses and behaviours of people to change without also understanding the perceptions, attitudes which are relevant to them. The model is characterised by four components, outlined in Table 1.

Table 1: Receptivity components

Receptivity components	**Description**
Awareness	Perceptions of environmental problems and their ability to search and scan for new knowledge.
Association	Understanding of the potentiality of knowledge exploitation and of its association with needs and capabilities.
Acquisition	Involves a process of learning to gain the knowledge and skills necessary to incorporate knowledge.
Application	Capability to receive long-term benefits from the new knowledge. This implies the ability of internalising change in the recipients' routine.

Source: Jeffrey & Seaton 2004

Several studies have employed and adapted the Receptivity model to investigate recipients' perceptions and adoptive capacity of technologies in the developed world. The framework has been adopted to explore sustainable water management practice (Greece), to understand user perceptions to using rain and grey water technologies (Great Britain) (Jeffrey & Jefferson 2003) and Australia (Clarke & Brown 2006). In this study, the Receptivity framework is adopted to provide a qualitative assessment of the environmental change at stake, by providing technology/policy designers with an analysis of end-users' points of view, drawn from results of existing literature. The framework serves as a theoretical guideline to explore the stages of innovation acceptance and identify case studies reporting perceptions of re-use of urine and urine-based fertilisers. In line with Jeffrey and Seaton's (2004), we postulate that there is no linear relationship between the framework components, however, the accomplishment of the four Receptivity stages should be achieved to obtained full acceptance.

A search was performed on Scopus using the keywords of "urine", "nutrient recovery" and "ecological sanitation". Further documentation was gathered from non-academic and grey literature by performing a similar search on Google. Table 2 illustrates the evidence gathered and classifies it by year, country on which it focused and typology (academic or non academic publication).

Table 2: Evidence gathered classified by year, focus countries and type

Reference	Focus Country/ies	Academic Publication
Lienert et al. 2003	Switzerland	Yes
Jackson, 2005	Malawi South Africa Uganda	No
Muskolos et al. 2006	Germany	No
Dunker et al. 2007	South Africa	No
Cofie et al., 2010	Nigeria Ghana	No
Dagerskog & Bonzi, 2010	Burkina Faso Niger	No

Mariwah & Drangert , 2011	Ghana	Yes
Pradhan et al. 2011	Nepal	Yes
Kassa et al. 2011	Mexico Ethiopia	No
Gensch et al. 2001	Philippines	No
Cofie et al. 2011	Ghana	No
Biplob et al. 2011	Bangladesh	Yes
Tumwebaze et al. 2011	Uganda	Yes
Benoit 2012	South Africa	No

Results

This Section presents a meta-analysis of the results reported in the sources identified in Table 2, using the Receptivity framework to identify and systematise barriers to the use of urine as an agricultural fertiliser. Each of the studies analysed addresses particular stages of the innovation process. Analysing the studies together provides a more comprehensive and generalisable account of the barriers to implementation than analysis of the individual cases. Common themes across the different studies are mapped onto the Receptivity framework to provide a systematic analysis across different geographical regions, cultural and economic contexts, and intervention design. The results of the analysis are discussed using the four components of the Receptivity framework: Awareness, Association, Acquisition and Application.

Awareness

In the context of nutrient management, the *Awareness* phase of Receptivity refers to recipients' understanding of existing perceptions of problems or beliefs towards emerging issues, which may be related to the innovation, such as concerns for low agricultural yield, awareness of lack of fertilisers or high product prices. The process by which people become aware of certain problems linked to technological innovation is important because it affects the generation of normative beliefs towards a certain action. A study from Pradhan et al. (2011) conducted in Nepal shows that farmers' awareness of fertilisers' value in increasing yield, combined with local conditions of poverty and dependence on sustenance agriculture contributed to enhance their Receptivity of urine as fertiliser. Conversely, two studies from Nigeria and Ghana on young crop producers and marketers reported low awareness of the possibility of using urine as fertilisers (Cofie et al. 2010). Particularly, cultural and religious beliefs as well as health concerns represented a barrier to the re-use of urine. Poor awareness was addressed through community sensitisation and participatory tests and trial showing the effects of using urine in vegetable growth.

Association

Association relates to the extent to which a recipient conforms to the process of change recognising the values and impact of adapting to such change. The importance of strengthening the *Association* component of Receptivity can be identified in two studies conducted in Kourittenga, (Burkina Faso) and Aigué (Niger) and documented by Dagerskog and Bonzi (2010). In both countries the relevant stakeholders (farmers as well as government officers) were sensitised through participatory training and trials through urine collection and application in schools and private agricultural fields. Results from the pilot test suggested the importance of raising awareness to concrete trials and to focus on changing users mindsets with regard to urine. This related the use of new terminology characterising urine as “liquid fertiliser” and stressing the association between odour and urine fertilising power (Dagerskog & Bonzi 2010). Conversely, sensorial perceptions played an important role in acceptance of urine as fertiliser in a study conducted by in Ghana, South Africa and Kenya (Mariwah & Drangert 2011). The smell of urine was associated with feelings of disgust, particularly in Kenya where many worried that crops smell and taste like urine. In South Africa the feeling of disgust towards urine has lead some farmers to conceal the use of urine for agricultural activities in order to retain customers (Benoit 2012). A further element of concern within the *Association* component relates to public perceptions of health risks and eco-toxicological effects associated with using urine as fertiliser in crops. Among European farmers and consumers, concerns were reported about the presence of micro-pollutants, hormones, pathogens, pharmaceutical residues and other contaminants in urine (Lienert et al. 2003). Comparable results were obtained in another acceptance study conducted among consumers and farmers in Germany, where apprehension for the pharmaceutical residues presence in urine was shown (Muskolos et al. 2006). People tend to have different attitudes towards the use of human waste depending on the crop that it is to be used with a higher acceptance of urine when applied to non-comestible plants (Baykal 2011). In a study conducted in Nigeria and Ghana (Cofie et al. 2010) farmers were reported that they would purchase such vegetables if there was assurance on the quality of the produce without health risk. Similarly, in rural areas of Mexico and Ethiopia, concerns were raised with regard to the burning of leaves caused by urine (Kassa et al. 2010). A further concern raised in South Africa relates to the spread of HIV/AIDS through the use of urine and possibly menstrual blood in fields (Drangert 2005, Benoit 2012).

Acquisition

In the process of change involved in adopting and re-using urine as fertiliser, the *Acquisition* component is defined by the recipients' ability to gain information on use and cost, access knowledge and presence of appropriate mechanisms that allow the process of change. An example of how poor *Acquisition* can represent a barrier to re-using urine in agriculture is illustrated in Cofie et al. (2010). Although farmers and relevant stakeholders were appropriately sensitized regarding the use of urine, questions concerning application of urine and the presence of appropriate storage represented a barrier to receptivity of the innovation.

Application

The final component of the Receptivity model, *Application*, revolves around the ability and motivation of recipients to obtain a long term value from the innovation within the context of all of the activities, agendas and beliefs they pursue. Applied to the nutrient management context, the successful implementation of this Receptivity component depends on the ability to integrate the innovation as assimilated into its sanitation routine and practices. A comprehensive review of EcoSan projects implemented in low income countries (Jackson 2005) reports that most EcoSan are primarily introduced with the purpose of minimising health and environmental risks related to inadequate or no sanitation, and often with no specific plan for nutrient recovery and reuse. Acceptance studies conducted in South Africa and Uganda shows that although implemented dry sanitation systems were generally accepted as toilets, there was little re-use of their contents (Jackson 2005). Furthermore, studies investigating acceptance and sustained use of dry sanitation systems agree on that the degree of satisfaction for the system implemented often tend to decline over time due to operational and maintenance problems related to handling of faecal matter and users' perceptions of smell (Dunker et al. 2007). Linking the sustained use of dry-sanitation technology to the environmental change of re-using urine would contribute transform dry sanitation systems into environmentally sustainable solutions which are widely accepted and used. One way of transforming sanitation systems from passive receptacle of human waste into accepted technologies relies on the concept of productive sanitation, whereby to ecological sanitation can boost its value by means of nutrient recovery and reuse in agriculture. In Malawi, the support of ecological sanitation and the re-use of human waste have been encouraged by the high prices of conventional fertiliser, which if purchased would take up a significant portion of the household budget (Jackson 2005). Similarly, a study conducted in Nepal saw the use of urine diversion toilets increase when the benefits of urine base fertilisers were described to and internalised by recipients (Pradhan et al. 2011).

Discussion

This meta-analysis of the available literature used the four components of Receptivity to provide a structured account of barriers and proposed actions to address them. The Receptivity framework has enabled the exploration of problems that may undermine sustained diffusion and acceptance of environmental innovation. Its deployment does not contradict models applied to explore diffusions of innovations (i.e. Rogers 2003) and behaviour change (Ajzen 1985), rather it complements them by allowing our audience to think through different barriers to the adoption of innovation. For instance, the sensitization to challenges related to low agricultural yield, increasing fertiliser's prices, indicated by the *Awareness* component, is consistent with other theories of diffusion of innovation, whereby recipients are exposed to a decision-making process in which the knowledge of the problem is a fundamental step to adoption of innovation (Rogers 2003). Furthermore, the framework can be deployed to explore the determinants for behavioural change, by investigating the correspondence between recipients' intentions and their actual behaviour in the post-implementation phase, by focusing on the relevant hurdles.

A summary of the main hurdles to acceptance of re-use of urine in agriculture and the implication these have for policy makers and designers of interventions are illustrated on Table 3.

Table 3: Hurdles in Receptivity of urine as fertiliser and recommended interventions

Receptivity Components	Hurdles	Sphere of intervention	Recommended interventions
Awareness	Poor knowledge on the potential for reusing urine in agriculture.	Training and education	Participatory trials to sensitise all stakeholders from government to farmers and consumers.
			Training of trainers to make sure that promotional and educational messages are appropriately tackled
			Use formal educational channel to such as schools to deliver relevant messages for the innovation.
	Lack of understanding the implication of increase in fertiliser prices.	Promotion	Increase sensitisation and awareness campaign on the benefit of re-use of urine.
Association	Concerns for presence of impurities and micro pollutants and pathogens in urine.	Technical support	Understand local issues and concerns related to pollutants and pathogens in urine.
		Monitoring	Regular collection of information on the performance based also on feedback from users.
		Promotion	Promote practice of reusing home waste (urine) and use it in home gardens for personal consumption.
	Concerns for health risks, from using urine (such as diffusion of HIV/AIDS through urine)	Technical support	Design and implement appropriate legislation and standard measures based on rigorous evidence.
			Assistance with application and interpretation of developed regulatory standards.
	Sensorial perceptions of reusing urine in agriculture (Smell, taste of food)		Participatory trials for using urine in home gardens.
Acquisition	Lack of knowledge on methods to store and apply urine in agriculture.	Technical Support	Knowledge of various methods of storage must be acquired and diffused among recipients.
Application	Failure to understand importance of appropriately use and maintain ecological sanitation technologies	Monitoring	Explore public perceptions on knowledge concerning O&M of toilets and their understanding of value.
	Social stigma attached to using dry sanitation and reusing urine in agriculture.	Incentives	Involve champions in promotion of use of Ecosan and urine reuse.
			Generate awards and prizes for cooperative of farmers based on the performance of innovation.

The synthesis of the main hurdles identified in Table 3 allowed to develop a series recommendation for change which belong to different sphere of interventions. Challenges related to the Awareness components may be tackled through training and educational activities which involve not only farmers and consumers but also local government and training organisms. Studies (Richert et al. 2010, Cofie et al. 2011) exploring *Awareness* issues, have reported that demonstration and practical experiments with farmers and local community groups together with local organisations are fundamental to increase awareness and disseminate the idea of using urine in agriculture. Furthermore, training of trainers and the implementation of education activities in school settings have also proved to be important intervention to improve awareness (Benoit 2012).

The focus on the *Association* component allows policy makers and relevant stakeholders to understand the cultural context, recipients' concerns and beliefs that may affect the uptake of such an innovation. In the case of nutrient recovery from urine, health concerns represent the strongest hurdle in the *Association* component. Human urine is still perceived by many as unsanitary as smell is often associated with presence of pathogens. This attitude, recorded both in developed and developing countries, calls for wider channels for the dissemination of results from eco-toxicological and epidemiological tests and development of appropriate guidelines in application to reassure consumers and farmers. In this case technical activities (such as the development application and interpretation regulatory standards and guidelines for use of urine) are fundamental to overcome this challenge. Richert et al. (2010) report that to reduce smell, urine should be spread close to and directly onto the soil and water it down. A further preventive measure concerns the urine handling process, where the use of sealed containers, application of urine close to soil and irrigation are strongly recommended.

Once recipients' awareness and association have been assessed, a further component to take into account is the *Acquisition* of methods which facilitate the process of change. Cost is often considered one of the most common barriers to acquisition of innovation (Jeffrey & Jefferson 2003). From the perspective of this study, the acquisition of storage for urine and the related spatial implications were raised as constraints to change. Whilst it is well known that storing urine in a close container is essential to facilitate proper hygienisation of the liquid (Gensch et al. 2011), technical support may focus on developing appropriate means of urine storage and transport and deliver them to local farmers. A successful example of this practice is reported from Burkina Faso (Richert et al. 2010), where jerry cans of different colours were used for collection of urine and for transportation of sanitised urine from storage to the field.

The final component to the receptivity of urine re-use in agriculture is linked to the practical application of the technology, which in the context of this study refers to urine separation toilets, or ecological sanitation. Operational issues such as appropriate use and maintenance of EcoSan toilets represents a hurdle in ensuring the nutrient recovery and management strategies. In this specific case educational interventions should be undertaken in order to increase understanding of the potential of EcoSan for food security and sustenance of users in low-income countries. Successful examples of acceptance of urine in agriculture show that the components of awareness (increase knowledge of use of urine) together with practical trials of urine in agriculture are important steps in increasing acceptance among farmers in Nigeria and Burkina Faso (Dagerskog and Bonzi, 2010). Further interventions to improve receptivity of this component relate to routinely monitoring waste management strategies adopted by farmers as well as provide incentives for both farmers and consumers in use of urine in agriculture and consuming vegetable grown through this practice. In all these cases, the engagement of the key stakeholders- namely farmers and consumers- from the beginning of the process of diffusion is fundamental in generating an enabling environment which allows the acceptance of the innovation.

Conclusions

The challenges of sanitation provision, waste management and sustainable agriculture loom large as issues to be addressed now and into the future. Managing urine as a resource rather than a waste or source of pollution represents a paradigm shift in sanitation and agricultural research and practice. However, the implementation of urine reuse is so far very limited. This paper aimed to identify the barriers to implementation of urine reuse using the Receptivity framework to diagnosis of acceptance of environmental solutions and analysis of the reasons why a potential change has failed to achieve expected goals. Through the application of the Receptivity framework to the agenda of nutrient management and recovery, this contribution has shifted the focus of attention from the innovation itself to the recipients of the process of change, in this case local farmers, users of ecological sanitation systems and local consumers of agricultural products. Yet, this study provides only a snapshot of recorded perceptions of a subject which is still in an initial stage of development and which require a participatory process to successfully be internalised by its recipients. More applied research is recommended in this field to understand how people perceptions can help shape concrete interventions.

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