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Scaling up small scale wastewater treatment systems in low- and middle-income countries: An analysis of challenges and ways forward through the case of Egypt

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ABSTRACT

Small scale wastewater treatment systems are a cost-effective and pragmatic alternative to large centralised systems in many contexts. However, despite the huge potential, very few low- and middle-income countries managed to scale-up such systems. This paper explores the barriers in the case of Egypt and provides recommendations to utilities and governments on how to create an enabling environment to do so. The main barriers are institutional. Utilities need to put into place drivers of change: think at scale, reach economies of scale both in terms of management and implementation, adapt the effluent standards and engage the private sector and civil society.

1. Introduction

The extension of sanitation services for all, the reduction of the proportion of untreated wastewater and the achievement of the related Sustainable Development Goals (SDG) 6.2 and 6.3 are confronted with major problems in low- and middle-income countries. Although reliable information on sewers and treatment plants is scarce for Africa and Asia, there is general agreement that connection rates remain very low, and the overall treatment of the collected wastewater remains highly insufficient, even in major cities. A recent modelling study based on past investment patterns estimated that even applying the most optimistic scenarios, only 36% of the African population and 44% of the Asian population will be connected to a sewer network by 2050 (Peal et al., 2014).

Small scale wastewater treatment systems (also termed "decentralised" or "distributed") are here defined as systems serving less than 5000 population equivalent. In the past decade, they have proven to be a viable alternative to conventional systems for contexts such as peri-urban areas, compounds, communities and small rural settlements (Wilderer and Schreff, 2000; Newman, 2001; Parkinson and Tayler, 2003; Gikas and Tchobanoglous, 2009; Larsen et al., 2013, 2016; Singh et al., 2015). In low- and middle-income countries, they remain an innovative approach to wastewater management. *Innovation* can be defined generally as the development, application, diffusion, and utilisation of new knowledge (Carlsson and Stankiewicz, 1991). Some of the most significant advantages of small scale sanitation systems are their flexibility, modularity, and cost-effectiveness (Massoud et al., 2009; Libralato et al., 2012), as well as increased water reuse potential (Gikas and Tchobanoglous, 2009). They can be implemented in stages and built as close as possible to the actual wastewater volume, reducing the possibility of accruing idle capacity costs (Maurer, 2009). There are various reasons why conventional large-scale sanitation systems are not always the best solution for rapidly growing cities and rural areas: very high capital and operational costs, the lack of stable energy supplies, spare parts and know-how for reliable operation are factors that limit their expansion (Lüthi and Panesar, 2013). These limitations have led several middle-income countries like India, Malaysia and Indonesia to promote more cost-effective and resource-efficient small scale systems that have the potential to accelerate sanitation coverage (Larsen et al., 2016).

There are numerous barriers to progress in sanitation coverage and sustainable urban water management (SUWM), but research has shown that the major barriers lie within the governance, policies and realities of low- and middle-income countries (Ross et al., 2014; Tilley et al., 2014; Starkl et al., 2013; Lüthi et al., 2011; Medilanski et al., 2007). The institutional rather than technological nature of these barriers was also proven in high-income countries (Brown and Farrelly, 2009; Mitchell et al., 2010; Kiparsky et al., 2016), the *institutions* being here

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defined as the rules, norms, and conventions that govern decision-making. However, these barriers have received very little attention in low- and middle-income countries. Besides, there is an overall paucity of research proposing strategies on how to create an enabling environment (Brown and Farrelly, 2009; Moglia et al., 2011). Through the case study of Egypt's wastewater sector, this study contributes to fill this knowledge gap and proposes a set of strategies to overcome the stated institutional barriers and create an enabling environment.

Utilities are instrumental in the implementation of small scale wastewater treatment systems. However, they are often risk averse, hesitant when faced with innovations that may require reforms or delegation of power, and prefer to stick to business as usual (Brown and Farrelly, 2009). As a consequence, many initiatives exist but in most cases remain isolated, which make them vulnerable and prone to failure. On the other extreme, in the cases of Indonesia and India where the scaling up of small scale sanitation systems happened, the process lacks appropriate institutional arrangements and monitoring and leads to a significant number of failed systems (Mitchell et al., 2015; McKinsey, 2014). In the former country, excessive responsibility placed on low-income communities limited the success in terms of sustainability, whereas in the latter, it is driven by the private sector, without a significant role for the utilities. Scaling up entails more than replicating a large number of discrete projects (Eales et al., 2013). It requires innovative management and institutional schemes, innovative financing plans and, often, bringing on board the private sector (Willetts et al., 2007; Abeysuriya et al., 2007; Evans, 2013; Gebauer and Saul, 2014; Gebauer et al., 2017). It requires different and more flexible institutional arrangements depending on the location to make the most effective use of available resources, and mechanisms to strengthen multi-sectoral coordination, cooperation and accountability between sector departments. Furthermore, implementation approaches need to be aligned with budget and project implementation cycles, respective of government requirements. Governments or parastatal utilities often do not have the capacity and resources to shape and nurture a multitude of small projects (Eales et al., 2013).

Small scale wastewater treatment plants (WWTPs) represent a major challenge to the current competencies of utilities in terms of their providing urban water management services and organizing their value chain. A future large scale dissemination, thus, depends on the successful organization of innovation processes in three domains (i) technological components and system integration, (ii) value chain formation and the development of new business models, and (iii) institutional innovations to create appropriate conditions under which these systems can reliably operate (Truffer et al., 2013). Small scale systems often show a mismatch with many institutional conditions (regulations, professional codes or user expectations) (Willetts et al., 2007; Truffer et al., 2013). Many factors and explanations have been put forward to explain why conventional sewerage remains the predominant paradigm for urban sanitation delivery, such as the lack of legitimacy and accountability of alternative sanitation systems, the lack of permitting and approval process for the latter, and risk management (Mitchell and al., 2008). There is, however, little hard evidence to prove whether this technological "lock-in" (Schertenleib, 2005) is mostly due to bureaucratic or technical inertia, risk aversion, corruption (and, hence, the preference for high-cost schemes with limited transparency and local accountability), political expediency (the need to be seen to be doing something), the perception that only these systems are "modern," or simply a lack of knowledge of alternative sanitation options (Evans, 2013). What is clear is that whatever incentives currently exist tend to encourage local and central authorities and their advisors to stick to conventional top-down planning and conventional centralised sewerage schemes.

There are few studies investigating why, in a specific country, small scale sanitation is unable to scale and be institutionalised. The enabling conditions and implications for the successful operation and management of scaled up small scale sanitation systems are addressed in specific cases like Indonesia (Mitchell et al., 2015) and Malaysia (Narayana, 2017). This paper builds on the case of Egypt, which illustrates well the above-mentioned trends. Small scale sanitation is seen as very promising alternative for the numerous isolated small settlements in the country, as well as in the region (Bakir, 2001; Engin and Demir, 2006; Van Afferden et al., 2010). However, initiatives have so far failed to take off and be widely replicated.

In this contribution we will (i) provide an overview of the challenges faced by small scale sanitation in Egypt (ii) critically highlight the main institutional bottlenecks that prevent moving to scale, (iii) define the steps that the government and utilities need to take to allow the scaling up of small scale sanitation systems and thus bridge a major gap in sanitation coverage. The case of Egypt is representative of the situation in many low- and middle-income countries, with a complex and not fully functional institutional framework, capacity issues, and a big gap between urban and rural sanitation coverage. Beyond Egypt, this research provides deep insight in the challenges and institutional barriers that most low- and middle-income countries are facing with small scale sanitation, and explores ways to move forward.

2. Context of the study

Egypt has a long history of implementing large scale centralised wastewater treatment plants (WWTP). There are more than 300 such WWTPs all over the country. While the main cities are increasingly being covered with wastewater treatment, rural sanitation coverage is less than 15% (Abdel Wahaab, 2015). In Egypt, the concept of "rural sanitation" encompasses 4700 villages (defined as towns up to 50,000 inhabitants) and 30,000 scattered settlements (Abdel Wahaab, 2015). The high diversity of settlements and densities makes it a complex topic, with the need for different solutions. Addressing rural sanitation issues became urgent as many settlements experienced a steady increase in wastewater production after the connection of houses to modern water supply systems, in quantities that are too high for the traditional onsite sanitation systems.

If large scale centralised WWTPs are the best option for the Egyptian cities, considering the high population density and the possible economies of scale, there are many small settlements which cannot be connected cost-effectively. Indeed, the high groundwater table, the need for multiple pumping stations, as well as the complicated network of drains and canals along the main populated areas of the Nile Delta, can result in very high costs per capita. A large proportion of the cost of the conventional systems is allocated for sewers, pumping equipment and earth works required to install this infrastructure, making it a very expensive option in such a context (Abdel Wahaab, 2015). Small scale sanitation is a promising solution, as it allows a significant reduction of implementation and operation and maintenance (O&M) costs, and the reuse of the treated wastewater and nutrients close to its source.

The Egyptian water and wastewater sector is complicated, with more than ten ministries are involved in the sector and its management. The utility was created in 2004, under the name "Holding Company for Water and Wastewater" (HCWW) and functions as a private company. This division of responsibilities in the water sector leads to conflicts and blockages. In the rural areas, the Ministry of Water Resources and Irrigation (MWRI) plays an important role, as it is responsible of all the canal and drain networks, the latter being the receiving water body for the effluent of the WWTPs. The most important stakeholder for the effluent standards is the Ministry of Health. The main focus on large scale centralised WWTPs. The responsibility for small scale systems and faecal sludge management, very widespread in the rural areas, is not clearly allocated and HCWW is reluctant to embrace these huge sectors of activity. This study identified dozens of pilots of small-scale sanitation systems, but none of them was replicated on a large-scale nor institutionalised. Most pilots were developed by NGOs, private companies or international donors. From the government side, MWRI led several trials with the aim to improve the water quality in the drain network,