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The regulation of onsite sanitation in Maputo, Mozambique

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Poor quality onsite sanitation causes drinking water contamination and diseases in cities in sub-Saharan Africa. In this article, we consider to what extent regulation reduces onsite sanitation-related health and environmental risks. We examined regulatory standards and how they are enforced in Greater Maputo, the capital of Mozambique. Standards for the construction of pit latrines and management of faecal sludge are incomplete. Reforms in the sanitation sector complicate the enforcement of standards. Responsibilities have not been clearly divided between the organisations in charge of regulation. We are sceptical that regulation can be effectively implemented in lower-income areas without a (cross-)subsidy mechanism.

1. Introduction

The vast majority of people living in cities in sub-Saharan Africa and other low-income countries in Asia and South and Middle America uses onsite sanitation. Onsite sanitation is a term used for decentralised sanitation facilities that are not connected to the sewerage system. Pit latrines and septic tanks are common onsite sanitation facilities used in sub-Saharan Africa. These facilities are emptied with mechanised equipment such as vacuum trucks or smaller vehicles (vacutugs and MAPETs), or manually. According to a survey conducted by the non-partisan research network Afrobarometer in 2014 and 2015, the percentage of households connected to a sewerage network in urban areas in Africa is about 30% (Afrobarometer, 2016). The survey shows that in several countries in sub-Saharan Africa, coverage is much lower e.g. 9% in Tanzania, 7% in Niger, 11% in Guinea, 18% in Mozambique and 16% in Kenya.

Construction and emptying of onsite sanitation are mainly carried out by the private sector and residents themselves in cities in sub-Saharan Africa (Chowdry and Khone, 2012; Schaub-Jones, 2010). There are many providers, varying from small-scale contractors building and emptying pit latrines and septic tanks, to medium and large-scale companies operating vacuum trucks. For under-resourced government agencies, it is a considerable task to regulate these large numbers of providers. In many low-income countries, the regulatory framework lacks concrete provisions on faecal sludge management (Koné and Peter, 2008). In some countries, existing standards for the disposal of human waste are not enforced by the government organisations. Unregulated manual emptying proliferates in low-income neighbourhoods in sub-Saharan Africa (Chagu et al., 2002; Chowdrey and Koney, 2012; Diop and Mbéguéré, 2017; Okoth et al., 2017; Simwambi et al., 2017; Tsinda, 2015). Contractors or residents use simple shovels and buckets, without protective clothing such as boots, gloves, and masks. The content is burned or illegally dumped in the area. Alternatively, pit latrines are closed and new pits are opened elsewhere, leading to an accumulation of faecal sludge in dense urban areas. Pit latrines and septic tanks cause infiltration of faecal sludge in the soil, leading to contamination of groundwater that, particularly in low-income areas, is used for drinking purposes (Lapworth et al., 2017). These practices (manual emptying, faecal sludge disposal inside urban areas, faecal sludge infiltration) increase the risk of sanitation-related diseases such as cholera, diarrhoea, dysentery, hepatitis A, typhoid, and polio. Diarrhoea is the second leading cause of child mortality and accounts for 525 000 deaths annually among children under five, despite being both preventable and treatable (WHO, 2017). In Africa, diarrhoea is responsible for 7.7% of all deaths (WHO, 2018). Potentially, government regulation can reduce these health and environmental risks.

With few exceptions (see for instance Murungi and van Dijk, 2014; Chaggu et al., 2002), detailed case studies on the regulation of onsite

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sanitation in low-income areas are scarce in academic literature. Regulation of onsite sanitation and its impact are mainly documented in grey literature, such as reports and (hand)books, produced and/or financed by development organisations. The focus of academic writing with regard to the regulation of basic services has been on water utilities and small-scale water providers (Ayalew et al., 2014; Ahlers et al., 2014; Ahlers et al., 2013; Gerlach, 2008; Franceys and Gerlach, 2008; Gerlach and Franceys, 2010; Marson and van Dijk, 2016; Mbilima, 2008; Mande Buafa, 2015; Matsinhe et al., 2008; Schwartz, 2008). In this paper, we consider the extent to which the regulation of onsite sanitation reduces health and environmental risks in Greater Maputo, the capital of Mozambique, a low-income country colonized by Portugal.

The approximately 2 million residents (INE, 2007) living Greater Maputo rely to the same extent on poor quality onsite sanitation as residents in many other cities in sub-Saharan Africa. Onsite facilities have been mainly constructed and emptied by private providers, residents and Civil Based Organisations (CBOs) (WE consult, 2014; WSP, 2014; WSP and TU Delft, 2016). The experience of Greater Maputo epitomizes the problems faced by other urban areas in sub-Saharan Africa and important lessons can be drawn from its analysis. An estimated 37% of the population in the Maputo municipality use facilities connected to septic tanks and 53% of the population use pit latrines (WSP, 2014). A large share of the onsite sanitation facilities causes infiltration of faecal sludge (WSP and TU Delft, 2016). 50% of onsite sanitation users replaced their pit in the peripheral areas of the city, and 30% in the settlements close to the city centre, where the population density is high (Muximpua et al., 2017; WSP and TU Delft, 2016). Manual emptying with shovels and buckets is a common way to empty pit latrines. About 50% of Greater Maputo's population depends on drinking water provided by small-scale water providers, in the fringe of the city (USAID, 2015). These providers extract groundwater from a superficial semi-confined aquifer, 10–20 m deep and distribute water through small-scale water supply networks (Marques-Arsénio et al., 2018; Schwartz et al., 2015; Hydroconseil, 2009). Groundwater is already contaminated by onsite sanitation. Many boreholes display high nitrate concentration levels, above WHO's threshold of 50 mg L^{-1}, even up to 250 mg L^{-1} (Marques-Arsénio et al., 2018: Bhatt, 2014), attributed to poor faecal sludge management. This paper aims to: (1) assess the regulatory standards set to reduce health and environmental risks related to onsite sanitation in Greater Maputo; and (2) investigate how and to what extent regulatory standards are enforced by the government agencies.

2. The regulation of onsite sanitation in sub-Saharan Africa

Regulatory standards for onsite sanitation should include rules and guidelines for safe collection, transfer, and treatment of faecal sludge, to protect human and environmental health (Bassan, 2014; Schaub-Jones, 2010). Over the past decade, many authors have stressed that simply building onsite sanitation facilities is not enough. Sanitation facilities should be safely emptied and the content disposed or reused as, such as fertiliser, to mitigate sanitation-related diseases and environmental contamination, including the contamination of drinking water resources (Baum et al., 2013; Cotton and Bartram, 2008; Gunawardana and Galagedara, 2013). 'Emptying safely' in this context means avoiding human exposure to faecal sludge. Sanitation should be seen as a *system* or a *value chain* (Blackett and Hawkins, 2017; Chowdry and Koné, 2012; Reymond et al., 2016; Strande et al., 2014) rather than a one-off construction project. The organisational, institutional, financial, legal, and technical aspects of the entire faecal sludge service chain, from collection and transport to the disposal or reuse of treatment products should be considered (Strande et al., 2014).

Unsafe faecal sludge management is tied in with poverty in sub-Saharan African countries (Chowdry and Koney, 2012; Chunga, 2016; Hurd, 2017; Murungi and van Dijk, 2014; Nkurunziza et al., 2017; Okoth et al., 2017; Schaub-Jones, 2010; Simwambi et al., 2017; Tsinda, 2015). Introducing regulatory standards for the construction and emptying of on-site sanitation facilities and treatment of faecal sludge will not have the desired effect, when low-income households have no means to comply with these standards (Schaub-Jones, 2010). Lining a pit latrine with cement, to avoid the infiltration of faecal sludge, is more expensive than just digging a hole in the ground. Once a pit latrines is a contained system, it requires frequent emptying, which comes at a considerable cost. Murungi and van Dijk (2014) concluded from their study in informal settlements in Kampala (Uganda) that the prices of mechanised emptying were too high, which was an important reason for people to resort to unsafe manual emptying. To lower emptying fees, the authors suggest regulating pricing regimes, increasing the number of vacuum trucks to stimulate competition, and providing support to manual emptiers and low-income households to make their practices safer. Schaub-Jones (2010) sees potential in 'out-put based aid' to ensure affordability of onsite sanitation for low-income households. This entails contracting the private sector on the basis of services delivered and introducing a cross-subsidy mechanism whereby high-income households pay a higher amount for mechanised emptying than low-income households. In EThkwini Municipality, South Africa, a cross-subsidy mechanism has been successfully implemented (Gounden and Alcock, 2017). EThikwini Water Services, the public utility, provides most of the sanitation services throughout the sanitation chain. Companies are contracted to collect and transport of faecal sludge from septic tanks, ventilated improved pit latrines, and urine diversion toilets. Improved pit latrines and urine diversion toilets have been provided free of charge to low-income households unable to afford sanitation through a municipal infrastructure grant provided by the national government to municipalities. Emptying services are free of charge, every two years for urine diversion toilets  and every five years for improved pit latrines. Funding has been raised through cross-subsidisation from the water and sewerage service revenues collected in more wealthy areas.

Another approach is setting-up call centres as a market-based mechanism to bring down the costs of mechanised emptying through bidding. The principle is that the onsite sanitation user, whose sanitation facility has filled up, contacts a call centre through a phone call or SMS and provides information on the pit or septic tank that needs emptying. The call centre then invites a number of companies to submit quotations. The onsite sanitation user receives the lowest bid and is free to accept or reject this bid. Call centres financed by development organisations have been piloted in cities in sub-Saharan Africa, including Dakar in 2011 (Diop and Mbéguéré, 2017) and Kampala in 2016 (Nkurunziza et al., 2017). In Dakar, the call centre covered the districts Pikine and Guédiawaye, both of which had very high levels of manual emptying (Diop and Mbéguéré, 2017). The costs of USD 50 per emptying was brought down to USD 40. The call centre is likely to have made the service accessible for a larger segment of the population in Pikine and Guédiawaye, but may still be out of reach for the majority, who earns less than USD 2,00/day. In comparison, manual emptying was on average USD 20. In this case, the external funding to operate the call centre is provided by the Bill and Melinda Gates Foundation. Measures to ensure financial sustainability were still being explored. Under the same programme, companies offering mechanised services were registered and certified. A GPS tracker was installed in every truck to prevent illegal dumping.

3. Methodology

The study can be classified as a heuristic case study (Merriam, 1998), conducted with the aim to provide an in-depth understanding of the regulation of onsite sanitation. We selected Greater Maputo as a case study because it resembles many other post-colonial cities in sub-Saharan Africa, characterised by a diversity of conditions of sanitation infrastructure, providers and financing mechanisms with most of the

population relying on onsite sanitation. Further, the bylaws of the municipalities of Maputo and Matola have been recently approved (respectively in 2016 and 2015) and provide a good opportunity to examine recent trends in regulation of onsite sanitation.

3.1. Methods

We combined a legal document review to research the existing regulatory standards with 43 semi-structured interviews with key stakeholders from 2015 to 2017 to examine the way and context in which standards were enforced. The document review included national and local legislation and onsite sanitation policies. We examined the regulatory standards in place for construction and emptying of onsite sanitation facilities; for the treatment faecal sludge and disposal/reuse of end products; and for drinking water quality, because of the link between onsite sanitation and drinking water contamination. We also examined the tariff to find out whether a (cross-subsidy) mechanism exists to ensure affordability of onsite sanitation to low-income households.

Through stratified purposeful sampling, we selected interviewees with insight into the way standards were enforced in the water and sanitation sector. We applied a sampling strategy to cover the key stakeholders in the regulation of onsite sanitation and water quality in Greater Maputo (Table 1 and Section 4.1). These include local government agencies in Maputo and Matola, national public bodies, main donors (e.g. World Bank), NGOs, private sector organisation (contractors in Maputo and Matola), and users of onsite sanitation. Semi-structured interviews with government officials, NGO and CBO staff and consultants lasted on average between 50 and 120 min, while those with contractors, water providers, and onsite sanitation users in the field took between 10 and 25 min. Through the interviews, we could get access undocumented information and reports produced by organisations in the onsite sanitation sector (e.g. WE consult, 2014; WSP and TU Delft, 2016).

The interview questions related to the institutional context, the existing regulatory standards, the extent to which they are enforced on households and providers and the existence and application of sanctions in case of non-compliance. Interviews were transcribed and qualitatively coded in Atlas Ti, using coding categories to distinguish whether and how standards for onsite sanitation, and drinking water quality standards were enforced by organisations in charge of both onsite sanitation providers, water providers, and households.

4. Standards for onsite sanitation and water quality

4.1. Regulatory framework

After the independence in 1975, Mozambique suffered from a civil war (1977–1992) between the ruling party FRELIMO and the opposition party RENAMO. At the end of the civil war, bilateral donors and lending agencies began to invest in the country, including the water sector. The Water Law 16/91 forms the basis for the institutional set up in the water sector. From 1998 onwards (World Bank, 2009), a Delegated Management Framework was adopted by the Mozambican government. Under the framework, the responsibilities for water delivery were handed over from the National Directorate of Water (now: National Directorate of Water and Sanitation) to a public-asset holder (FIPAG) in the main cities. The operation of water supply infrastructure became the responsibilities of autonomous public organisations or companies. The Delegated Management Framework marked the birth of the Water Regulatory Council, tasked with overseeing utilities in the water sector. The Water Regulatory Council approves the tariff and protects the public interest.

Regulation of the sanitation sector lags 10–20 years behind and the Delegated Management Framework was only emanated in 2009 (decree 18 and 19/2009). The decree 18 and 19/2009 transferred the responsibility for sewerage infrastructure, including wastewater treatment plants, from the National Directorate of Water and Sanitation (DNAAS), a department within the Ministry of Civil Works, Housing and Water Resources (MOPH), to the national asset holder (AIAS) and to the municipalities. The mandate of the Water Regulatory Council, responsible for the regulation of water utilities, has been extended to the sanitation sector. Today, the National Directorate of Water and Sanitation's main task is policy development at the national level. In 2017, when the data for this research was collected, government agencies were still debating on the division of responsibilities with regarding the regulation of sanitation (see Section 5.1). A major challenge is that in Mozambique the water and sanitation sectors are highly dependent on external funding. On average 80% of the total funding is external and the amount of funding available for urban sanitation has been much lower than the one allocated to the water sector (UNICEF, 2017; WaterAid, 2013).

Standards for onsite sanitation and sewerage infrastructure are defined in decree 30/2003 'Regulation of public water distribution and wastewater systems' and in decree 15/2004 'Building regulations of domestic water distribution and wastewater drainage systems' (Fig. 1). The purpose of these decrees is to define the technical conditions for domestic and public water supply and wastewater systems in order to ensure their proper functioning and to preserve public health (decree 30/2003 and 15/2004 article 1). The standards for wastewater disposal are listed in Decree 18/2004 Regulation on environmental quality and effluent emission standards. Key policy documents with respect to onsite sanitation are the National Water Policy of 2007, amended in 2016, and the National Urban Water and Sanitation Strategy (NUWSS) of 2011. At the local level, municipalities develop sanitation bylaws, based on national decrees and policies. A sanitation masterplan was still under development for Greater Maputo. The Ministry of Health is responsible for monitoring the water quality and has laboratories across the country. The minimum standards for water quality were established with the Diploma Ministerial 180/2004 'Regulation on water quality for

Table 1
Overview of the interviews.

Individuals and organisations represented	Number of interviews	Covering Maputo	Covering Matola
CBO Pfukanine	1	x	
NGO's (WaterAid, Water, and Sanitation for the Urban Poor, USAID, and WASTE)	4	x	x
WEconsult	1	x	x
World Bank Water and Sanitation Programme	2	x	x
Municipality of Maputo and Matola	4	x	x
Water Regulatory Council	3	x	x
National asset holder (AIAS)	2	x	x
National Directorate of Water and Sanitation	2	x	x
Ministry of Health	1	x	x
Onsite sanitation users	12	x	
Contractors	3	x	x
Water providers	8	x	x

National legislation
- Water law 16/91
- Regulation of public water distribution and wastewater systems (Decree 30/2003)
- Building regulations of domestic water distribution and wastewater drainage systems (Decree15/2004)
- Regulation on environmental quality and effluent emission standards (Decree 18/2004)
National policies
- National Water Policy 2016 (Resolution 42/2016)
- National Urban Water and Sanitation Strategy 2011-2025
Local legislation and policy
- Maputo's sanitation bylaw (2016)
- Matola's sanitation bylaw (2015)
- Sanitation masterplan (under development)

Fig. 1. Summary of the legal framework for the onsite sanitation sector.

human consumption'.

4.2. Standards for the construction and emptying of on-site sanitation facilities and treatment of faecal sludge

4.2.1. National standards

Although pit latrines are used by most urban residents, at the national level there are no concrete provisions for their construction and management. In 2015, 2.7 million people used pit latrines in urban areas in Mozambique, while 1.3 million people used septic tanks and only 205 644 people were connected to a sewerage network (WHO/UNICEF JMP, 2015). This aptly illustrates the gap between standards and the actual state of sanitation in urban Mozambique. Regulatory standards formulated at national level concern the public sewerage network and septic tanks, sanitation options that are mainly available to high and middle-income households. In areas that are not served by public sewers, decree 30/2003 'Regulation of public water distribution and wastewater systems' and decree 15/2004 'Building regulations of domestic water distribution and wastewater drainage systems' stipulate the use of septic tanks. Though the legal framework at the national level lacks clear provisions on the construction of pit latrines and faecal sludge treatment and disposal, it stipulates that wastewater is to be treated and disposed of safely. This can be used as a guiding principle to regulate other sanitation technologies.

According to the national standards, septic tanks are private domestic wastewater treatment systems that purify residual water, so that they can be safely discharged whenever there is no public wastewater system (decree 15/2004 article 188). Preferably, they should be constructed in armed concrete and must be watertight. The decree also establishes that septic tanks should be placed at a minimum distance of 1.50 m from buildings and property limits and at least 3.00 m from large trees and water pipes. Further, they should be located at a considerable distance (i.e. 15–30 m, depending on the type of soil) from upstream water sources. The technology is to be adapted to the water table and permeability of the soil to avoid groundwater contamination. Decree 15/2004 annex 26 provides guidelines on the dimension of the septic tank and on the frequency of emptying, which depends on the volume and the number of users. National regulations do not mention *how* a septic tank should be emptied in terms of technology, provider, and financial mechanism and *what* is required with regard to the treatment and disposal of faecal sludge. Decree 30/2003 article 172 further stipulates that the disposal of domestic and industrial wastewater and treatment processes must guarantee the protection of the surrounding environment and public health.

Regulation on discharge focuses on wastewater (Decree 18/2004 Regulation on environmental quality and effluent emission standards, annex IV and V) and provides standards that are not always realistic, given the technological options available in Maputo (see Montagèro and Strauss, 2002 and Koné and Peter, 2008 on relevant parameters). Standards for faecal sludge treatment, therefore, need to be adapted to the available treatment options.

4.2.2. Municipal bylaws

At the local level, regulatory standards are recorded in municipal bylaws. In Greater Maputo, the responsibility of constructing and maintaining onsite sanitation facilities is with the residents ("Municipality of Maputo's sanitation and drainage bylaw," 2016, article 44.2; Sanitation Bylaw for Matola, 2015, article 32.3), while municipalities are tasked with faecal sludge management. The Municipality of Matola is responsible for the collection of faecal sludge from septic tanks (Matola's sanitation bylaw, article 6 and 32). As further detailed in the bylaw, the provision of this service can be ensured 'by means of a combination that it deems appropriate of its own and/or outsourced human and technical resources, as well as public-private partnerships or private companies or associations as well as co-operatives.' Maputo's sanitation bylaw states that the Municipality is responsible for the *licencing* of the providers that collect and transport faecal sludge to wastewater treatment facilities (article 44.1). The Municipality assumes direct responsibility for the treatment of faecal sludge (article 51.4) and the set-up of a call centre (article 51.e). Emptying services will be provided by the municipality or by companies licenced by the municipality (article 58.1). Municipal authorization and a licence is also required for the use of the wastewater treatment plant and the construction of private transfer stations or private wastewater treatment plants and other services provided by private entities in the area and sanitation and drainage (article 54).

Though both municipal bylaws are based on national legislation, standards set by the municipality of Maputo and Matola are different. The sanitation bylaw of the Municipality of Maputo prescribes standards for the construction of septic tanks and pit latrines, whereas the bylaw of the Municipality of Matola only sets standards for septic tanks. The acknowledgement of the existence of pit latrines typically used by low-income households in Maputo's bylaw could be seen as a big shift from policies dating back to colonial times, oriented towards high-income areas where the Portuguese population lived. For residents in low-income areas, compliance with some of the requirements may be difficult due to unaffordability.

The standards for pit latrine construction in Maputo's bylaw take health and environmental risks into account. The requirements include:

- Pit latrines should be lined with masonry blocks and have a concrete slab to facilitate cleaning of the pit.
- The pit should have a cover and a superstructure (simple building) with a door and roof (article 42.1).
- To avoid infiltration, the construction of pit latrines is only possible in areas where the water table is at least below 1.5 m (article 43).
- Latrines should be ventilated and allow access for emptying and cleaning. Septic tank designs must be approved by the Municipal Council and verified on the spot by inspectors.
- The regulation for septic tanks builds on national standards (decree 15/2004).
- Septic tanks should have at least two chambers.
- Improved latrines are only authorised for residents without the means to pay for the construction of septic tanks (article 42.3).

The municipal bylaw of Maputo includes standards for the emptying of on-site sanitation facilities and the collection of faecal sludge, which are important to prevent manual emptying and pit replacement:

- Onsite sanitation facilities should be emptied whenever the level of the faecal sludge is 70 cm from the lower part of the septic tank outlet and 50 cm from the pit latrine cover, and faecal sludge brought to a faecal sludge treatment plant (article 45).
- To obtain a licence for emptying services, the organisation must present information on its activities, this includes the number of employees trained in faecal management and measures taken to protect workers, users and the environment (article 58.2).

The bylaw prescribes that faecal sludge should be disposed at a faecal sludge treatment plant or, in case the latter does not exist, at a wastewater treatment plant. Yet, it does not specify standards for the treatment of faecal sludge and standards for the discharge or reuse of the end products (i.e. treated faecal sludge).

Matola does not have standards on pit latrines, which means there is a risk that providers and households in Matola continue to use inadequate pit latrines, such as unlined pits that are emptied manually by a household member or local contractor without wearing protective clothing. The provisions of Matola's sanitation bylaw on septic tanks' design are similar to Maputo's bylaw (article 29). The bylaw stipulates that septic tanks should be emptied and the faecal sludge is to be disposed at a wastewater treatment plant. We asked an employee of the Water and Sanitation department of the municipality of Matola why there is no reference to pit latrines in Matola's sanitation bylaw. He commented:

The idea is to reduce the number of pit latrines. Pit latrines cannot be the objective. There is a problem with pit latrines contaminating groundwater. People use pit latrines out of poverty, but it is not our objective. The objective is to have adequate sanitation and drinking water treatment and not to contaminate groundwater sources. Within some time, we will not have drinking water in Matola, because of salt intrusion and the infiltration of sludge from onsite sanitation.

The Municipality of Matola intended to replace pit latrines with septic tanks in the coming five to 20 years, and implementation plans do not yet exist. The sanitation bylaws of both Maputo and Matola specify fines for users and companies who do not comply with standards.

4.3. Standards for water quality

According to 180/2004 'Regulation on water quality for human consumption', the water quality is to be monitored through four types of inspections: initial inspections when the water source is tested at the time the water supplier establishes itself; routine inspection to be carried out by the providers; periodic inspection carried out by the Ministry of Health; and exceptional inspection in emergencies (Annex II Water quality control). To monitor faecal contamination of drinking water, water is to be tested for total coliforms, faecal coliforms, nitrates and vibrio cholera during the initial and periodic inspection. In 2016, decree 51/2015 came into force, stipulating the regulation of small-scale private water providers. Small-scale water providers are also subject to water quality regulation (Diploma Ministerial 180/2004). The provider should test the drinking water every three months, or more frequently if necessary. Non-compliant providers incur a fine of 75 000 MT and water supply is halted until good water quality is ensured. In the case of small-scale private water providers, the department within the municipality issuing the licence is in charge of inspecting the compliance with the terms and conditions of the licence, including drinking water quality standards, together with 'other entities' (Decree 51/2015, article 21).

4.4. Affordability

The National Urban Water and Sanitation Strategy (MOPH, 2011) and the National Water Policy (Resolution 42/2016) articulate the ambition of achieving universal water and sanitation coverage by 2025–2030. The minimum service level to be achieved in terms of sanitation is the improved pit latrine. The National Urban Water and Sanitation Strategy proposes that dedicated support in the form of technical assistance and financial support shall be provided to poor families in areas with a high incidence of diarrhoea and cholera (p14, 2011). The National Water Policy also specifies that the government will contribute towards the cost of improved pit latrines and hygiene promotion for the poorest families (4.8, p895).

Maputo's bylaw aims at balancing cost recovery and pro-poor goals (article 6). The minimum and service level to be ensured by residents in an improved pit latrine or at least one toilet, one bath unit and one lavatory for 25 persons, connected to septic tanks (article 4.2). However, Maputo's ambition to address 'economic weaknesses' through cost redistribution does not translate into a tariff that reduces the cost of constructing and emptying these facilities for low-income households (Table 2). In contrast, the tariff for the sewerage network includes a cross-subsidy mechanism: residents in unpaved and often lower-income areas pay less to connect to the public sewerage system, *though no public sewerage network exists in those areas*. People who fall into the social tariff category will be exempted from paying a monthly fee for wastewater disposal, which amounts to 15% of the water bill (article 50.2). There is no further specification concerning the social tariff category of pit latrines, making its implementation unlikely. Emptying companies pay an annual fee for their licence, depending on the amount of faecal sludge collected and disposed at the wastewater treatment plant, as well as a monthly fee. As the tariff is incremental, it might increase the risk that providers opt for illegally dispose of dumping sludge to reduce their operation costs.

Matola's sanitation bylaw is equally 'guided by principles of universality in access' (p1). The ambition to achieve universal sanitation coverage is not accompanied by financial support for low-income households. Matola's bylaw sets a variable tariff for households connected to the centralised water supply network, that is, 20% of the water bill and fixed tariff for those with 'alternative drinking water sources' of 1200 Mozambican Meticais per year, approximately 19 USD. The amount is to be paid monthly if the household does not have the means to pay on an annual basis (article 37). The company hired to empty latrines and septic tanks also pays a fee consisting of an unspecified fixed amount and an amount per m^3 disposed. There is no (cross)subsidy for low-income households to construct and empty onsite sanitation in Maputo and Matola's tariff structure.

A citywide survey carried out by the World Bank Water and Sanitation Programme and the Technical University of Delft (2016) showed that 67% of about 1200 respondents using onsite sanitation, lived under the World Bank's extreme poverty threshold of 1.25 USD per person per day. The average price for mechanical emptying of USD 58, with prices price ranging from USD 30 to 80, is too high for poor households (Muximpua et al., 2017). Some providers allow payments in two or three instalments, but the service is still too expensive for poor households. In contrast, manual emptying, which carries higher risks for humans and the environment, is much less expensive, with emptiers typically charging between 7 and 13 USD. By introducing the call centre, the Municipality of Maputo intended to decrease the costs of mechanised emptying, but this is likely to be an insufficient measure to reach the poorest households, as we have seen in the pilot project in Dakar (Diop and Mbéguéré, 2017).

5. The enforcement of standards

5.1. Standards for construction, emptying, and disposal

Pit latrine construction, replacement, and emptying are usually carried out by a contractor who belongs to the community and/or by residents themselves (WSP and TU Delft, 2016). The exact number of contractors was unknown. Eight entrepreneurs, with experience in waste collection, were trained and provided with manual and mechanical emptying equipment in 2014, with funding provided by the World Bank's Water and Sanitation Program (WSP) and the NGO Water and Sanitation for the Urban Poor (WSUP) in the district Nhlamankulo (Muximpua et al., 2017). There were about 24 companies with vacuum trucks in 2015, almost exclusively emptying septic tanks (WE consult, 2014). Before the implementation of the reforms in the sanitation sector, companies offering mechanical emptying services used to be registered by the National Directorate of Water and Sanitation. At the time of this research project, the municipality of Maputo

Table 2
Sanitation tariffs in Maputo and Matola.

Sanitation tariff Maputo	Amount
Connection fee for households to the sewerage system (per meter pipeline)	
Households living in paved areas (per household)	500 Mt/8 USD
Households living in unpaved areas (per household)	300 Mt/5 USD
Collective connection of apartment buildings in paved areas (per building)	2000 Mt/31 USD
Collective connection of apartment buildings in unpaved areas (per building)	1500 Mt/23 USD
Variable fee for households connected to the sewerage system	
15% of the water bill	n.a.
Annual fee for a licence (emptying companies with vacuum trucks)	
Operators with a capacity to transport 20.000 L per month	4000 Mt/63 USD
Operators with a capacity to transport 50.000 L per month	6000 Mt/94 USD
Operators with a capacity to transport 100.000 L per month	8000 Mt/125 USD
Operators with a capacity to transport 200.000 L per month	10.000 Mt/156 USD
Monthly fee to use the wastewater treatment plant (emptying companies with vacuum trucks)	
Operators with a capacity to transport 20.000 L per month	1500 Mt/23 USD
Operators with a capacity to transport 50.000 L per month	2500 Mt/39 USD
Operators with a capacity to transport 100.000 L per month	3500 Mt/55 USD
Operators with a capacity to transport 200.000 L per month	4500 Mt/70 USD
Sanitation tariff Matola	**Amount**
Annual tax for all households	1200 Mt/19 USD
Variable fee for households connected to the public water supply network	20% of the water bill
Fixed fee for emptying companies with vacuum trucks	To be determined
Variable fee per m^3 faecal sludge disposed at the wastewater treatment centre	To be determined

was in the process of registering companies offering mechanised emptying service. Apart from the registering of companies with vacuum trucks, the municipalities of Maputo and Matola had not taken concrete steps to enforce the standards for construction and emptying prescribed in the sanitation bylaws.

The treatment and disposal of faecal sludge and wastewater remained unregulated. The wastewater treatment plant, located in Maputo near the border with Matola, received faecal sludge collected by companies with vacuum trucks. The treatment plant had not been maintained and the wastewater was disposed of without sufficient treatment in Maputo's bay. It is estimated that 6% of faecal sludge and wastewater is treated in Greater Maputo (WSP and TU Delft, 2016). The wastewater treatment plant has been designed to process wastewater of the sewerage network, servicing about 10% of Maputo's population, living in the former colonial centre. The wastewater plant should be expanded to treat more concentrated faecal sludge collected from onsite sanitation facilities.

Our interviews with onsite sanitation users (2016) indicate that community leaders called 'Chefes de Quarteirão' (literally 'bosses of the block'), were the only active authority in low-income areas. These community leaders are appointed by the neighbourhood representatives that are selected by the district administration (Castán Broto et al., 2015; Ensor et al., 2015). Each community leader oversees about 50–150 households. The tasks carried out vary from approving newcomers in the neighbourhood, deciding where toilets and latrines should be located on the plot, and providing guidelines on waste collection to prevent illegal dumping of faecal sludge and wastewater in open drains or elsewhere in the neighbourhood.

In line with the Delegated Management Framework introduced in the Water Law 16\91, municipalities should form autonomous organisations to operate sewerage infrastructure, including wastewater and faecal sludge treatment plants or delegate the operation to the private sector. The National Urban Water and Sanitation Strategy 2011 states that it is the ambition to create independent Municipal Sanitation Departments (MOPH, 2011, section 3.2.3). These autonomous bodies were to be regulated by the Water Regulatory Council. However, the municipality of Maputo was unwilling to create an autonomous organisation to operate wastewater treatment plants and opted for operating the public sewerage infrastructure, including the wastewater treatment plant, through its Water and Sanitation Department. The Water Regulatory Council has been mandated to regulate autonomous public or private organisations. The guidelines led to confusion at the national level as to which organisation is to regulate the operation of the sewerage network and wastewater treatment plant. In the city of Beira and Quelimane, for instance, an autonomous organisation was created to operate the sewerage network.

An employee at the Water Regulatory Council felt that the role of the municipality and Water Regulatory Council with respect to the regulation of sanitation should be further clarified in national policies and legislation:

The problem is even this decree that gives the Water Regulatory Council the mandate for sanitation, it says 'The Water Regulatory Council regulates sanitation'. But what regulating sanitation means is not clear. Do we set the tariffs? Do we define the service structure? Do we give licenses? We need more clarification, not only the municipality but also us. We need to clarify responsibilities here in order to provide what is recommended. But for now, it only says *the Water Regulatory Council regulates sanitation*, full stop.

The Water Regulatory Council had not taken the lead in further developing national standards for onsite sanitation construction, emptying, and treatment. The reason for this, in addition to the limited guidelines provided by national policies, is that the organisation is already overcommitted. The organisation's responsibilities increased quickly in a short time span, while the organisation remained relatively small. Originally, the Water Regulatory Council was only regulating water utilities in the main cities, but recently its responsibilities have been extended to water supply systems in smaller towns. In addition to this, the 2015 decree 51/2015 stipulated that the licencing of more than 500 small-scale water providers, owning 800 systems, in Greater Maputo also fall in part under the responsibility of the Water Regulatory Council. At the time of this research, the regulatory body was in the process of introducing a tariff for small-scale water providers. Further to that, the Water Regulatory Council had also started regulating sanitation utilities in the cities of Beira and Quelimane.

5.2. Water quality

In principle, the Ministry of Health enforces water quality standards on all water service providers. However, according to our interviews with eight small-scale water providers and a staff member of the

Ministry of Health's National Laboratory, inspections did not take place often enough due to a lack of staff. This means water contamination could go unnoticed for a while. In Maputo and Matola, the Ministry of Health employed two inspectors for the water quality assessment. The water quality parameters monitored included nitrates and faecal coliforms, indicators for faecal contamination, in compliance with WHO standards (2004).

The inspectors of the Ministry of Health communicated the results of the water quality assessment to the water provider in a one-page report. Table 3 displays the parameters monitored by the Ministry of Health in the small-scale systems, as reported by small-scale water providers during the interviews. When the water quality is found to be inadequate, the provider should be forced by the Ministry of Health to close business until the water quality improved. Both providers and governments organisations indicated that closing the business would entail cutting off customers from the water supply. As a result, providers are asked to improve quality and to recommend customers to treat water at home, while continuity of water supply is preserved. Rules stipulate that routine inspections are to be carried out by the provider. Small-scale providers often did not carry out routine inspections. In 2015, the municipality asked small-scale water providers for documentation of routine inspections and many providers 'ran to the National Laboratory to get their water tested', according to the staff member of the National Laboratory. The small-scale water providers we interviewed generally saw the inspections of the Ministry of Health as important.

Despite these inspections, the aquifer used by small-scale water providers as the drinking water source is contaminated by onsite sanitation runoff (Marques-Arsénio et al., 2018). As a result, nitrate levels are too high for human consumption. Treating water contaminated by nitrate is costly (Cronin et al., 2007). Studies suggest that nitrate pollution in low-income countries is to be avoided through the use of contained systems, to prevent the infiltration of faecal sludge (Cronin et al., 2007; Nyenje et al., 2013). Drinking water (from alternative drinking water sources) transported by trucks is too expensive for low-income households in Greater Maputo and is only a short-term solution for areas with high levels of contamination. The remaining option for the medium and long term is to expand the public drinking water supply network. Drinking water supplied through the public network is extracted from the Umbeluzi river. This option, however, is not without complications either: the drinking water network is porous, illustrated by the 45–50% water loss and only operational for a few hours a day in many parts of the city. A recent study shows that contamination occurs also in the centralised water supply network of Maputo as well as in the water storage tanks and buckets used by residents to cope with the discontinuity of the public service (Rusca et al., forthcoming).

5.3. The long-term sustainability of sanitation regulation

The tariffs set in the sanitation bylaws are are not yet collected, leaving the municipalities of Maputo and Matola without sufficient financial resources. According to an interview with a municipal employee (2017), the municipality of Maputo intends to use some of the funds that will be collected in the future to support low-income household access to pit latrines or shared sanitation blocks. This cross-subsidisation mechanism could contribute to increasing the effectiveness of regulation in lower-income areas. Currently, there are no tax instruments nor government's grants to fund coverage expansion in lower-income areas.

Water utilities in Mozambique use a cross-subsidy mechanism to ensure affordability to low-income households (CRA, 2016). The tariff implemented is a block tariff: the price per unit of consumption increases with the level of water consumption. This tariff structure benefits low-income consumers using small water quantities. Standpipes connected to the centralised network have a lower unit price for drinking water, which is also advantageous to consumers in low-income areas. To implement a cross-subsidy mechanism in the onsite sanitation emptying sector, a licencing procedure is required for providers as well as standardisation of construction and emptying prices across Greater Maputo.

6. Discussion

Our study raises questions about the suitability of pit latrines for high-density low-income urban areas in Maputo and other cities in sub-Saharan Africa with similar conditions. Urban areas with high population densities may require different infrastructural solutions than low-density areas. In Greater Maputo, health and environmental risks related to onsite sanitation are high in low-income neighbourhoods close to the city centre. These neighbourhoods have a high level of poverty and a high-water table, which results in poor quality onsite sanitation facilities and high rates of manual emptying. Sanitation facilities are hard to access for mechanised emptying, because of the lack of access roads. During the rainy season, faecal sludge overflows onto the properties.

In dense areas, simplified sewers may be a better option than onsite sanitation. Marques-Arsenio et al. (2018) found that building simplified sewers in low-income areas close to the city centre would significantly decrease aquifer contamination. The team of engineers estimated that simplified sewers in the districts of Nhlanmankulo and KaMaxaquene, with densities of almost 200 habitants per square kilometre and high prevalence of manual emptying, will reduce nitrogen infiltration in groundwater with 29%. Paterson et al. (2007) calculated that for densities above 160 hab km^2 simplified sewers can result to be a cheaper option than onsite sanitation, in terms of annual cost per household, when implemented at considerable scale. Simplified sewers have been implemented in a number of locations, among which Brazil, Pakistan and South Africa (UN Habitat, 2006). In the context of Mozambique, in line with the Delegated Management Framework, simplified sewers could be publicly owned and operated by an autonomous public or

Table 3
Water quality parameters assessed by the National Laboratory of the Ministry of Health (LNHAA).

Parameters	Method	Permissible limits		Unit
		Min	Max	
pH	Potentiometric MI B05	6.5	8.5	–
Conductivity	Conductivity meter MI B02	50	2000	µs/cm
Total dissolved solids	Visual inspection	–	Ausente	–
Color	Visual inspection MI B04	–	Incolor	–
Turbidity	Turbidity meter MI B12	–	5	NTU
Nitrates	Molaculair absorbtion MI CO7	–	50	Mg/L NO3
Nitrites	Molaculair absorbtion MI CO6	–	3	mg/L NO2
Chlorites	Volumetric MI C17	–	250	mg/L Cl
Hardness	Volumetric MI C14	–	500	mg/L Ca CO3
Faecal coliforms	Filtering membrane MI – P/LNHAA/ML/110	–	10	CFU/100 mL

private organisation, like the public water supply network. These systems would require less capacity and resources than those needed for regulating an extensive, yet unknown, number of onsite sanitation providers.

Most governments and development organisations in sub-Saharan Africa have not invested in sewerage infrastructure over the course of the Millennium Development Goals (Sattherthwaite, 2016). The increase in sanitation coverage was mainly reached through building 'simple and cheap' pit latrines, without much involvement of the public sector. However, when taking into account that pit latrines in (dense) urban areas should be lined, frequently emptied and faecal sludge treated, the cost of a 'cheap' pit latrine raises significantly. Onsite sanitation requires public and private investments in vacuum trucks, vacutugs (small emptying vehicles), transfer stations, and faecal sludge treatment plants. Widespread unsafe practices have yet to be eradicated through the training and regulation of a challenging large number of private providers, and support to households unable to afford adequate onsite sanitation is essential for regulation to be effectively implemented.

7. Conclusion

The bylaws of the municipalities of Maputo and Matola were approved in 2016 and 2015, respectively. We found that the shortcomings in the regulation of onsite sanitation in low-income countries as described by Koné and Peter (2008) persist. Regulatory standards in Greater Maputo were incomplete and the existing standards were not enforced. Standards for pit latrines are needed at the national and local levels. There were no standards for the treatment of faecal sludge and discharge/reuse of end products. The wastewater treatment plant had not been maintained and lacked the capacity to treat faecal sludge. Investments should be allocated for one or more faecal sludge treatment plants in Greater Maputo. Once the treatment technology has been decided, standards can be put in place to monitor the treatment efficiency. Though vacuum truck companies were in the process of registration, contractors working in pit latrine construction and manual emptying stayed outside the scope of the municipality in Maputo and Matola. To reduce health and environmental risks associated with manual emptying, emptiers could be trained by municipal inspectors and equipped with equipment in the form of protective gear, hand pumps, and vacutugs. NGO's have engaged with manual emptiers in sub-Saharan Africa (Blackett and Hawkins, 2017), but often at the neighbourhood level, rather than citywide.

Public-sector involvement is key to making onsite sanitation affordable to low-income households in sub-Saharan Africa. In Mozambique, national policies articulate that low-income households will be supported through a contribution towards the provision of pit latrines; however, no specific measures have been taken in Maputo and Matola in this direction. We evaluated mechanisms to make onsite sanitation more affordable to low-income households and cross-subsidy seems to be the most promising mechanism. The effectiveness of subsidies as well as possible trade-offs and controversies arising from this approach are in need of further research. In general, we encourage research to further understandings of on-site systems and their potential to ensure adequate sanitation.

In Mozambique, reforms have been ongoing in the sanitation sector since 2009. Almost a decade on, responsibilities regarding the regulation of onsite sanitation continue to be debated. In our view, the national government, namely the National Directorate of Water and Sanitation and the Water Regulatory Council, should take the lead in developing an implementation framework to resolve the impasse.

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