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ADVANCES IN SCIENCE, ENGINEERING AND TECHNOLOGY IN COMBATING POLLUTION FOR A SUSTAINABLE FUTURE

Situational assessment for fecal sludge management in major cities of Pakistan

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Abstract
With enhanced focus on global sanitation, access to toilets at the household level is increasing in developing countries although the provision of sewer networks is not expanding at the same pace. This is resulting in the adaptation of on-site sanitation facilities to contain the fecal sludge. The fecal sludge generated by the on-site sanitation facilities requires emptying, treatment, and safe end-use or disposal. In this study, the sanitation situation and need for fecal sludge management was evaluated in major cities of Pakistan including Karachi (provincial capital), Lahore (provincial capital), and Islamabad (national capital). Primary and secondary data were collected from key informant interviews of the stakeholders, national and international reports, research, and review articles. Infographics on wastewater and fecal sludge from origin to disposal were developed using a shit flow diagram tool and enabling environment was evaluated with a modified service delivery assessment tool. The results indicate that sewerage network coverage exists for 60%, 63%, and 50% of the areas in Karachi, Lahore, and Islamabad respectively. The sewerage network in major cities is old, leaking, and insufficient, thus a limited amount of wastewater reaches the treatment plants. Total wastewater treatment in Karachi and Islamabad is 10% and 9% respectively whereas, in Lahore, there is no infrastructure for the same. The safe sanitation in Lahore (8%) and Islamabad (25%) is coming from on-site sanitation systems with fecal sludge buried safely onsite. National level sanitation programs exist in the country but are limited to reducing open defecation and containments of fecal sludge only. The inclusion of complete fecal sludge management related framework, guidelines, and policies can help achieve the goal of safe sanitation for all.

Keywords On-site sanitation (OSS) · Fecal sludge management (FSM) · Shit flow diagram (SFD) · Service delivery assessment (SDA)

Introduction

Access to safe water and sanitation is a basic human right (WHO/UNICEF 2017). Sanitation refers to having access to a proper sanitary system (either on-site or off-site) with safe excreta and wastewater disposal along with a proper stormwater drainage system (ISO 2018). United Nations put the first global level commitment toward safe water; sanitation and hygiene (WASH) in Millennium Development Goals (MDGs) 2000–2015 (von Schirnding 2002). Target 7C of MDGs has planned to reduce the number of people without access to sanitation by half (Bartram et al. 2005; Editorial 2008). The goal was partially achieved as 1.9 billion people gained access to improved sanitation between 1990 and 2015, equivalent to more than 200,000 people every day (Mara and Evans 2018). Following MDGs, the second and more comprehensive global effort to tackle the sanitation issue is the Sustainable Development Goals (SDGs) (WHO/UNICEF 2017).

Goal 6 of SDG is the provision of safe drinking water and sanitation for everyone. The rapid decrease in open defecation and provision of basic sanitation was achieved through a massive increase in on-site sanitation (OSS) technologies especially in low and middle-income countries (Water 2021). OSS includes flush/non-flush toilets connected to a

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septic tank, aqua privy, composting toilets, single or double pit latrine, etc. (Franceys et al. 1992). Lack of sanitation contributes to 10% of the global disease burden, mainly causing diarrheal diseases. To achieve equitable sanitation, quadrupled-paced improvement is required as one-third of the world's population still needs basic toilet facilities (WHO/UNICEF 2020). The current COVID-19 pandemic has further highlighted the need for access to safely managed sanitation as fecal excreta contains COVID-19 RNA that can be transmitted through water bodies if it is not properly managed (Sangsanont et al. 2022; Wang et al. 2022).

Huge economic implications exist for countries that fail to address safe sanitation. According to the World Bank, 165 million children globally under the age of five are trapped in poverty and living under substandard sanitary conditions. Children living in places near open defecation are 11% more likely to have stunted growth (WHO 2018). The importance of sanitation can be assessed that for every dollar spent on sanitation, there is a return of US $5.50 in lower health costs (Nishat 2013). The stark inequalities between different regions and classes further complicate the issue. The differences exist between the global south and global north and between the rural and urban areas. Globally, two third of the rural population lacks basic sanitation as compared to merely 12% in the urban areas (WHO/UNICEF 2021).

About 52% of households in rural areas of Pakistan do not have any sanitation system as compared to only 8% of households in urban areas (Khan, Fatima et al. 2021). Since 2000, Pakistan is among the 16 countries that have reduced open defecation by more than 20% yet 16 million people still practice open defecation (Ababa 2016). The impact of unavailability of safe sanitary facilities is directly affecting the lives of people, especially in slums and informal settlements in Pakistan. Every year 94,000 people including 53,000 children under five die from diarrhea due to poor quality of water and sanitation (WHO/UNICEF 2021; Ali et al. 2022).

According to a recent survey by the Pakistan Bureau of Statistics (PBS) on Pakistan Social and Living Standards Measurement (PSLM) 2019–20, toilets are divided into three main categories, Flush, Non-Flush, and No Toilet. Flush toilets (an improved form of a toilet) connect to either a sewerage system, septic tank, pit, or an open drain. Around 83% of households all over Pakistan have Flush toilet facilities out of which 27% are connected with sewerage, 21% have septic tanks, 17% have pit latrines, and 18% have open drains (PBS 2021). Currently, non-networked on-site sanitation systems are the predominant form of sanitation systems in the country. In Pakistan, 43 million people living in urban areas have access to sewer networks, and only 7 million in rural areas. A complete shift can be seen in the use of OSS as 52 million people in rural areas use a septic tank and only 13 million people in urban areas (WHO/UNICEF 2021). The current emphasis is on toilet construction and containment but the fate of fecal sludge generated by the OSS is unknown as no policy or guidelines regarding fecal sludge management exists in Pakistan. During PSLM 2019-20 survey, it was revealed that 62% of the OSS are never emptied and 13% of users do not even know about emptying. Only 4% have emptied within the last 5 years and 16% replace the OSS when it becomes full (PBS 2021).

OSS is considered a relatively inexpensive system for the public sector for the management of excreta and wastewater generated by the households but puts more responsibility on the households for emptying and private sludge collection and transport service provider for its transport, disposal, or end-use (Dodane et al. 2012; Beard et al. 2022). OSS require a proper management scheme termed as fecal sludge management (FSM). The FSM service chain includes the containment, collection, transportation, treatment, and disposal of fecal sludge from the on-site sanitation systems. The sludge that accumulates in the OSS needs to be regularly removed and treated before safe disposal (Strande et al. 2021). The collection, emptying, and treatment of fecal sludge from on-site sanitation is undeveloped in Pakistan and the collected fecal sludge is disposed of untreated in the environment. In Pakistan, a major focus has only been on containment, and the service chain of collection, treatment, and safe disposal is missing (Sarbagya Shrestha et al. 2019). The concentrations, quantities, and consistency of fecal sludge are highly variable (Strande et al. 2014). The quantities and qualities of fecal sludge accumulated in the OSS depend upon many demographic, environmental, and technical parameters. These include water availability for cleaning, dietary habits of the individuals, sludge storage space availability, type of infrastructure built for storage and storage time in the OSS, and type of water entering the OSS (Blackwater only and/or mixed with greywater (Strande et al. 2018). Thus, a local scenario investigation is always required to identify the stakeholder, local practices followed, the weak links of safe sanitation, and how they can be addressed.

FSM in Pakistan needs implementation after planning and coordination between the different stakeholders involved, i.e., households, desludging service providers, the city administration, Non-Governmental Organizations (NGOs), Environmental Protection Agency (EPA), Water and Sanitation Authorities (WASA), Public Health Engineering Department (PHED), etc. In Pakistan, the institutional framework is present but particular attention is given to sewerage networks and FSM does not get due attention. The infrastructure for the service chain is missing even though the majority of the population uses OSS (CDA 2008). In Pakistan the information available on wastewater and treatment is scarce. Data related to sanitation and especially OSS is completely missing. Thus, the performance of the currently available OSS cannot be gauged.

The objective of this work is to get a first-hand view of the situation of fecal sludge management in Pakistan. Primary data was collected from Key Informant Interviews (KIIs) with officials who overlook the sanitation situation in different cities of Pakistan. Data from primary and secondary sources were used to assess the sanitation situation in three major cities of Pakistan i.e. Karachi, Lahore, and Islamabad. Shit flow diagrams (SFD) were developed and modified service delivery assessment (SDA) was assessed on information gathered from primary and secondary sources. This helps in understanding the gravity of the sanitation situation in major cities of Pakistan and advocating for the redressal of the issue. The weakness in the existing legislation and infrastructure are also highlighted.

Methodology

Study area

Three major cities of Pakistan were selected for situational assessment, Karachi, Lahore, and Islamabad. Karachi and Lahore are the capitals of Sindh and Punjab provinces and the top two populated cities while Islamabad is the national capital of Pakistan. The cities were selected to have an overview of the sanitation services offered in the major cities of Pakistan. Karachi is the largest city in Pakistan with more than 16 million people (Khan and Qureshi 2018). This city alone contributes 15% to the national GDP (Arshad et al. 2020). Karachi Water and Sanitation Board (KWSB) is the department responsible for the provision of water and sanitation facilities for the city. A large number of refugees have settled in informal settlements covering approximately half of Karachi's population (Khakpour et al. 2019). Major surface water in Karachi comes from Indus and Hub Rivers. Groundwater resources are limited. There are small streams draining water from the coastal basins of Lyari, Malir, and Budnai serving 80% of the surface runoff generated from the city. The untreated wastewater heavily pollutes these streams and carries the same toward the Arabian Sea (Amin et al. 2019; Fatima et al. 2021).

Lahore is the second-largest city in Pakistan with a population of approximately 11.1 million (PBS 2017). The population is expected to reach 13 million by 2030 and urban water demands are expected to double by 2050, thus resulting in increased domestic sewage being produced over time (Hasan et al. 2021). Water and Sanitation Agency (WASA) Lahore is responsible for services provided related to water and sanitation. Lahore disposes of its wastewater directly into River Ravi through 14 main drains without any treatment (Haider and Ali 2012).

Islamabad has a population of 2 million which is almost equally divided between the rural and urban parts of the city (PBS 2017). The Deputy Commissioner is responsible for the administration and the Mayor for political governance. Capital Development Authority (CDA) is responsible for water and Municipal Corporation Islamabad (MCI) for sanitation facilities in the city. For administrative purposes, the city is divided into 5 zones (Adeel 2010). Zone I and II are declared as urban areas and households are connected with a centralized sewerage network and a treatment plant while zone III, IV, and V are peri-urban and rural areas with complete dependency on OSS. Different types of fecal sludge containment (septic tanks and pit latrines), and transport systems (manual and mechanical) are used but no treatment facility exists (Sarbagya Shrestha et al. 2019).

Primary and secondary data

Secondary data was collected from national and international publicly available reports and published research articles. Under the 18th amendment of the national constitution in 2010, provinces were delegated to make and implement policies to meet their specific requirements. National and provincial policies along with national water and sanitation plans were analyzed. Publicly available data was taken from the Pakistan Bureau of Statistics (PBS) (www.pbs.gov.pk), Pakistan Social and Living Standards Measurement Survey (PSLM) conducted by PBS, Multiple Indicator Cluster Survey (MICS) (mics.unicef.org) by the United Nations International Children's Emergency Fund (UNICEF) and Joint Monitoring Programme (JMP, 2021) (washdata.org) of the World Health Organization (WHO) and UNICEF. The gaps available, contrasting figures among different data sources and missing information were completed by primary data collected.

Primary data was collected from KIIs, focused group discussions (FGDs), and direct observations from the areas. KIIs were conducted to get insight from the personnel administrating the water and sanitation services. It helped validate the data collected from secondary sources. KIIs were conducted with senior officials at the CDA, MCI, WASA, and KWSB. Questions were asked from representatives of these organizations on the current sanitation situation in these cities (details in the “Modified service delivery assessment (SDA) and Shit flow diagram (SFD)” section). The existing sewerage coverage, shortfalls in the systems, planning, budgeting, and areas that need improvement were discussed. The officials were supportive of the necessity of an alternative centralized sewerage network including decentralized and OSS technologies. FGDs were made with households' representatives and emptying and transport services providers. Walk-through surveys were conducted in parts of the cities to help understand the on-ground situation of existing sanitation systems. Limited secondary data is available on sanitation systems, especially OSS, and priority is given to ending open defecation. Beyond containment, data is not available and was obtained majorly from KIIs.

Modified service delivery assessment (SDA) and shit flow diagram (SFD)

The service delivery assessment (SDA) is a tool used that analyses the quality of the ecosystem including planning, policies, financial health, regulatory and institutional arrangement. The infographic presents a vivid picture of the strong and weak areas of each city. A comparison can be developed with other countries around the world having similar socioeconomic conditions Scott et al. 2019). It is an analytical framework with three building blocks used to measure (1) the quality of the enabling environment, (2) the level of service development, and (3) the level of commitment to maintain the WASH services sustainability. The details on how to use the tool and comprehensive questionnaire are available on FSM toolbox webpage (https://fsmtoolbox.com). A composite SDA 'score' is calculated for each building block at each step along the value chain. The scores are representative of each area of evidence and are averaged on a scale between 0 (worst case) to 3 (best case) (Peal et al. 2014).

Shit flow diagram (SFD) is a universally accepted visual tool (part of the SDA tool) for focusing the attention of involved stakeholders and politicians on critical areas in sanitation that require utmost attention. The infographics are quite understandable and show how excreta flows through a city or town (Panesar et al. 2018). It reveals information on the movement of excreta from point of generation to its disposal (whether safe or unsafe). It clearly shows which components of the FSM need attention for the safe disposal of waste. SFDs are made with a graphic generator on the SuSanA website (https://sfd.susana.org). An overview of the adopted methodology is presented in Fig. 1. Data is entered for the available sanitation systems and services. The groundwater pollution aspect is also considered based on contamination by excreta and the population's dependency on groundwater consumption. The percentage population using each category of sanitation systems is entered to get an overall qualitative assessment of safe/unsafe sanitation. These tools are easy to use and at present widely adopted by the World Bank's Water and Sanitation Program (WSP) to compare management in cities across developing countries (Baltazar et al. 2021). The outcomes of the SDA and SFD tools provide an overview of the sanitation situation without detailing recourses to field studies (Peal et al. 2020). These tools are used in this study to assess the situation in the three cities of Pakistan, namely, Islamabad, Lahore, and Karachi using the mentioned data sources.

Results

FSM scenario in Karachi

Out of 16 million people residing in Karachi, only 9.6 million (60% population) have access to sewerage. Out of the remaining 40%, 3% use OSS technologies (mix of pits and septic tanks), 1% population practices open defecation and the rest is connected with open drains. Open drains contain supernatant from septic tanks, or wastewater directly from households and are directly discharged into receiving water bodies (Hifza et al. 2020). The SFD for Karachi (Fig. 2a) gives a pictorial representation of the waste flow from the entire city along the FSM service chain. Though a centralized sewerage network contains 60% population's wastewater yet, only 29% reaches the existing treatment plants. The reduced capacity of the system to deliver wastewater to the treatment sites is due to the dismal condition of the laid sewerage network. These treatment plants are partly

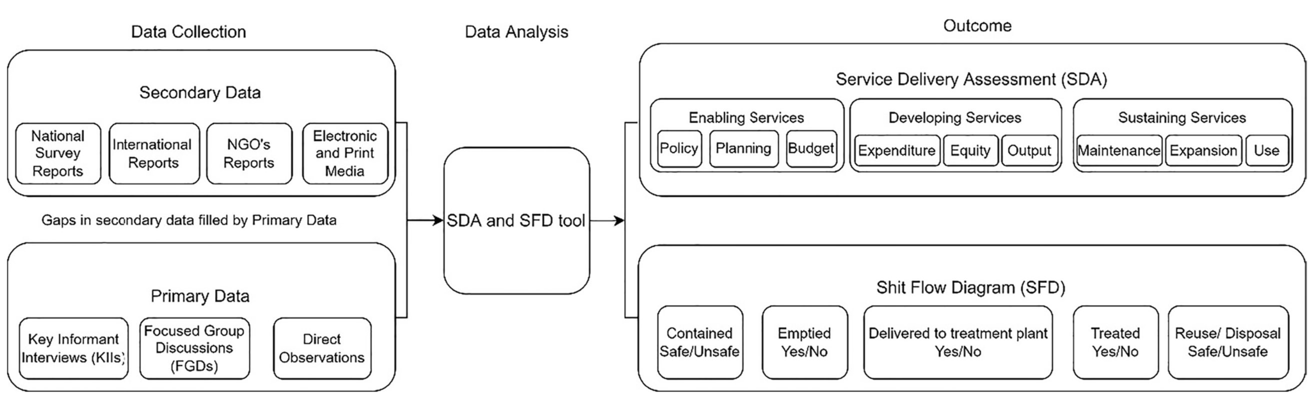
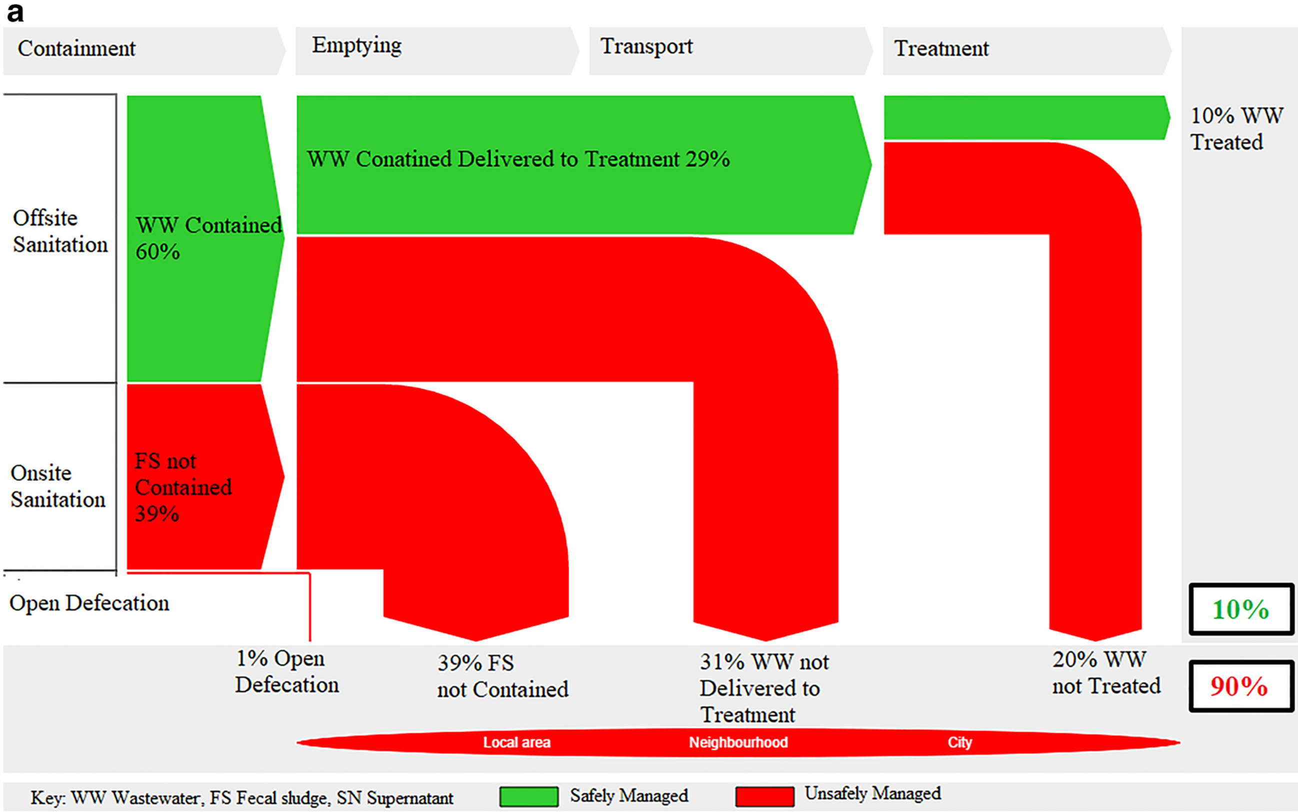


Fig. 1 Overview of methodology adpoted to perform service delivery assessment (SDA) and develop shit flow diagrams (SFDs) for major cities of Pakistan

a

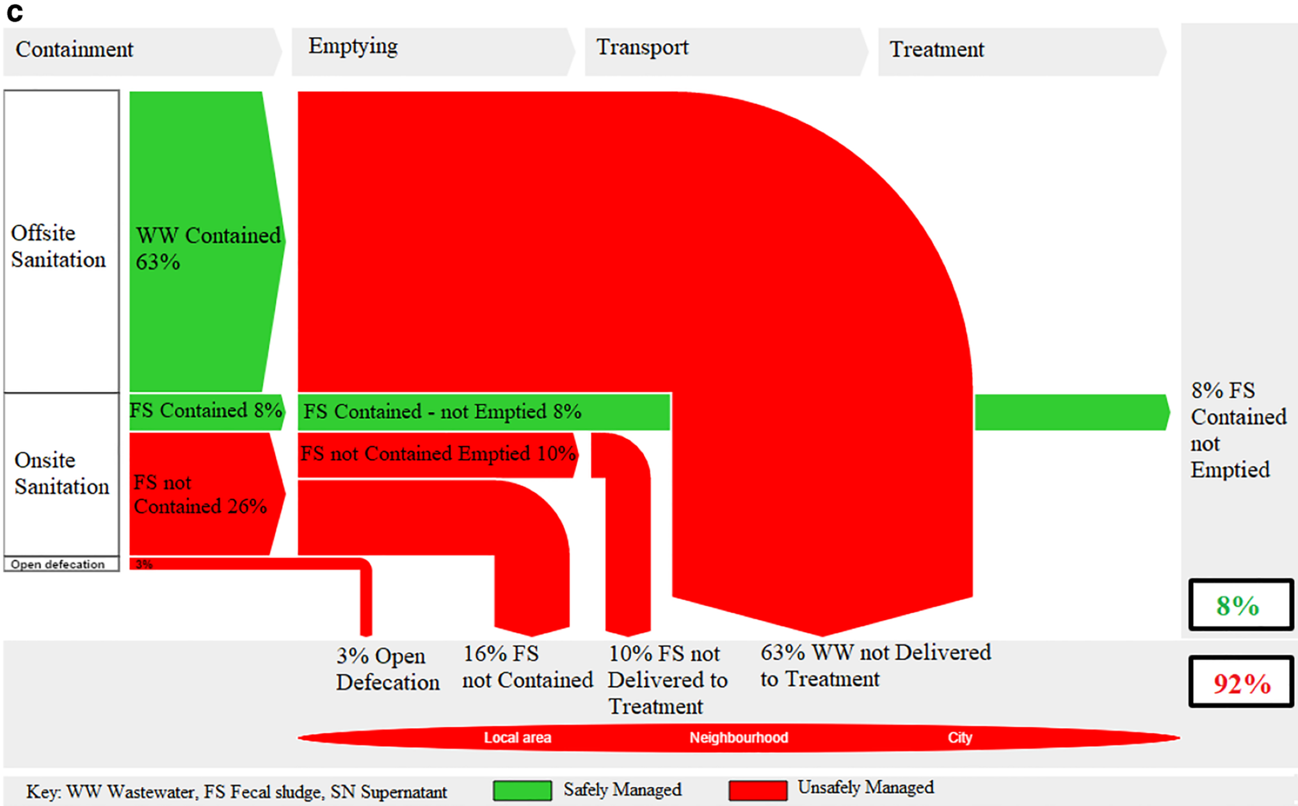


b

	Containment	Emptying	Transport	Treatment	Disposal
Policy	2.5	1	2.5	2	1.5
Planning	1	0.5	0.5	0.5	0.5
Budget	1	0	1	0	0
Expenditure	0.5	0	0.5	0	0
Equity	0.5	0	0.5	0	0
Output	1	0	0	0	0
Maintenance	0	0	0	0	0
Expansion	1	0	1	0.5	0.5
User Outcomes	0.5	0	0	0	0

Fig. 2 (**a**) SFD representing safely and unsafely managed sanitation in Karachi, (**b**) SDA scorecard for Karachi, (**c**) SFD representing safely and unsafely managed sanitation in Lahore, (**d**) SDA scorecard for Lahore, (**e**) SFD representing safely and unsafely managed sanitation in Islamabad, (**f**) SDA scorecard for Islamabad

c

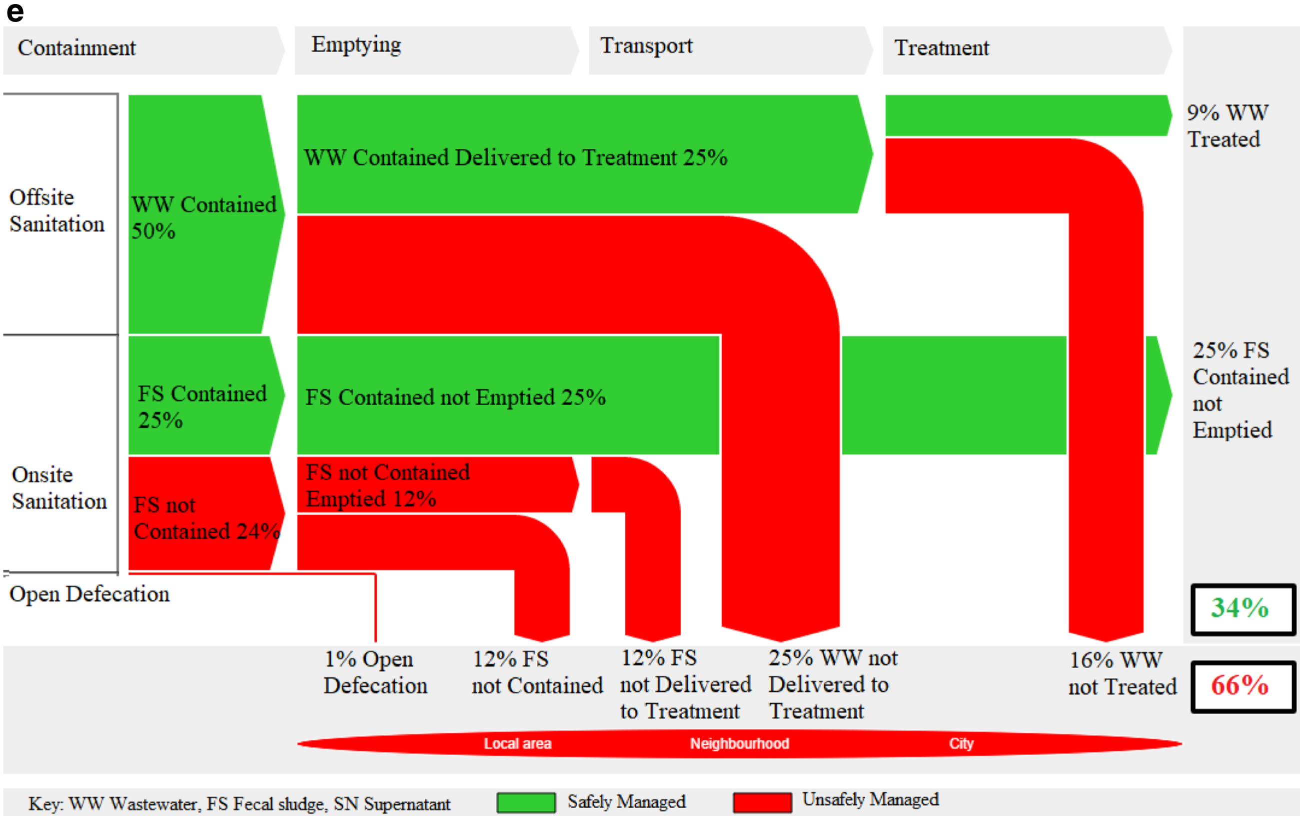


d

	Containment	Emptying	Transport	Treatment	Disposal
Policy	1	0.3	0.1	0.1	0.3
Planning	1	0	0	0.1	0.6
Budget	0.5	0	0	0	0
Expenditure	0.1	0	0	0	0
Equity	0.5	0	0.1	0	0.3
Output	0.3	0	0	0	0
Maintenance	0.2	0	0	0	0.2
Expansion	0.8	0	0	0	0
User Outcomes	0.2	0	0	0	0

Fig. 2 (continued)

e



f

	Containment	Emptying	Transport	Treatment	Disposal
Policy	2	2	2	2	1.5
Planning	1.5	1.5	1.5	1	0.5
Budget	1	1	1	0.5	0.5
Expenditure	1.5	1.5	1.5	0.5	0.5
Equity	1	1	1	1	1
Output	1	1	1	0.5	0.5
Maintenance	0	0	0	0	0
Expansion	0.5	0.5	0.5	0.5	0.5
User Outcomes	1	1	1	0.5	0

Fig. 2 (continued)

functional and ultimately only 10% of the wastewater is treated (Fig. 2a). The remaining wastewater is discharged untreated to the nearby water streams of the Lyari and Malir rivers ultimately falling into the Arabian sea (Sánchez-Triana et al. 2015). The existing treatment plants were built in the 1960s and the population has increased significantly in that time, yet treatment capacity has been nearly stagnant. The sewer lines were also laid down at the same time and deteriorated to the extent of being dysfunctional (Beard et al. 2022).

About 39% of the population has no access to sewerage so the wastewater does not even get contained. The portion of the contained wastewater not delivered to a treatment plant i.e. 31% together with fecal sludge not contained 39% contributes to 70% of the unsafe sanitation in Karachi (Fig. 2a). Fecal sludge generated by OSS (3% population) is also disposed of openly and 1% population practices open defecation. There are three primary treatment plants with 151 million gallons per day (MGD) capacity, out of those, one treatment plant is nonfunctional and the other two are operating at a limited capacity of 55 MGD (Source: KII KWSB). All the remaining excreta and wastewater eventually contaminate and majorly pollute the waterways leading to the Arabian Sea. Discharge of wastewater and fecal sludge in open environments and rivers is common in developing countries like Bangladesh, India, and Sub-Saharan Africa (Semiyaga et al. 2015; Singh et al. 2017; Singh et al. 2020; Foster et al. 2021; Chandana and Rao 2022). Global implementation of SFDs in 39 cities identified that dumping of excreta is widespread and discharge to open drains is common in some Asian cities (Peal et al. 2020).

The composite SDA scorecard for Karachi is shown in Fig. 2b. The policy framework related to wastewater is largely in place but does not mention FSM at all. Containment and transport are having the highest scores illustrating that a centralized sewerage network is considered only. The planning and finances are also allocated for the development of sewer-based infrastructure. Although, the National Sanitation Policy (NSP) 2006 mentions "safe disposal of excreta by using sanitary latrines, creating an open defecation free environment" (GoP 2006). This does not imply on centralized sewerage network but on alternate options including OSS too. Alongside the NSP, the provincial Sindh Sanitation Policy (SSP) 2016 is trying to align itself with SDG Target 6.2. The intention is to completely cover the densely populated areas with sewer networks and peri-urban areas with septic tanks. Oxidation ponds-based wastewater treatment units are considered and public-private partnership is encouraged. NGOs and development partners often coordinate directly with the municipalities and community based organizations (CBOs) and private sector operators play a role in supporting safe sanitation (GoS 2014). Orangi Pilot Project (OPP) is an example of a successful initiative of a community-led total sanitation program. Under this project, the informal settlement of Orangi town was connected by a self-provisioned decentralized sewer network (Hasan 2006).

FSM scenario in Lahore

In Lahore, 63% of the population is connected to the sewerage network, 34% is relying on OSS and 2% perform open defecation (Fig. 2c). Despite having higher access to the sewerage network as compared to other cities discussed, none of the wastewater gets treated (Source: KII WASA). The nonfunctional treatment plant in the city is the major reason for having very low scores in safely managed sanitation (Murtaza and Zia 2012; Ashfaq et al. 2019). The generated wastewater is directly disposed of in river Ravi resulting in human waste back to drinking water sources.

The informal settlements have limited access to sanitation facilities as lower income and population density. There are no safely managed public toilets resulting in open defecation (2%). Only 8% of the fecal sludge contained onsite is buried safely. Septic tanks are the major type of OSS available but they are not properly operated. The tanks are connected to unlined leaching pits and/or unlined single-chambered tanks from the bottoms. However, the sludge is not emptied on regular basis, thus making the operation of the septic tank incapacitated. Lahore lies in flat terrain and the groundwater level is below 60 ft (Muhammad et al. 2016). The groundwater is contaminated by industrial and residential sources largely (Khan et al. 2021a). Lahore is also facing the issue of water levels lowering down due to excessive pumping compared to recharge. 80% of the domestic water usage including drinking is met from groundwater sources (Mahmood et al. 2011; Khan et al. 2021b). Lahore is the country`s second-largest city but without any wastewater treatment plant. There has been an increase in consideration of policy components for containment of wastewater, however, there is also no systematic approach for overall FSM in Lahore (Fig. 2d). The major issue is the lack of implementing policy and city-wise funding for FSM in the province of Punjab. Moreover, it was observed during KIIs, that there is less knowledge and awareness regarding fecal sludge management.

FSM scenario in Islamabad

In Islamabad 50% of wastewater is contained by a centralized sewerage network, 25% is delivered to the treatment plant and only 9% is treated. About 25% of the fecal sludge is contained safely on-site, 24% is unsafely contained and 1% population defecates openly (Source: KII MCI). The SFD for Islamabad (Fig. 2e) paints a picture of the contrasting fortunes of the urban and peri-urban populations. The centralized sewerage network mostly contains the wastewater generated by urban sectors. Total wastewater of 60 million gallons is generated per day. There is only one treatment plant located in the I9 sector in Islamabad. The treatment capacity of the plant is 17 MGD but the actual wastewater treated is 6 MGD. The remaining 13 MGD is discharged untreated into the Lai stream (Source: KII CDA).

SDA scores for Islamabad are represented in Fig. 2f. As Islamabad was a properly planned city and the sewerage network condition in the urban region is relatively better, thus the score in policy planning and budgeting is better (Adeel 2010). But due to the unavailability of a fecal sludge management service chain, the score in developing and sustaining services building blocks falls in the unsafe category. The peri-urban and rural areas have septic tanks and pit latrines that are emptied manually/mechanically on a need basis. Sludge emptying is mostly performed by private companies and due to a lack of legal dumping sites and treatment plants for fecal sludge, the sludge is discharged into the environment (Zahid 2018, Khan, Fatima et al. 2021). The overall scores for emptying, treatment, and disposal are all in the lowest range (0–1) and unsafe category.

Discussion

Pakistan made significant progress in reducing open defecation and providing basic sanitation during the MDGs era 2000–2015 (Ababa 2016). This is attributed to the provision of toilet facilities at the domestic level individually (Ali et al. 2022). Sewers and OSS including pit latrines and septic tanks provide the separation of excreta from the human. A large portion of the population is connected to sewerage system i.e. 60% in Karachi, 50% in Islamabad, and 63% in Lahore yet the safely managed portion is low i.e. 10%, 34%, and 8%, respectively. The safe sanitation in Karachi is 10% and is generated by the primary wastewater treatment plants. In Islamabad, the major portion of safe sanitation (25%) is coming from the peri-urban areas where fecal sludge is disposed of onsite. Lahore is only generating the safe sanitation score (8%) from OSS disposing of fecal sludge insitu.

The main reason for low safe sanitation scores in the major cities of Pakistan is that the sewerage network is considered a permanent solution and OSS is regarded as temporary. Among other South Asian countries, Pakistan has the highest coverage provided by sewers (27%) followed by Bangladesh (18%) and India (13%) as depicted in Fig. 3a (JMP, 2022). It is worth noting that the sewerage network in the major cities was laid decades ago and requires huge investment in repair and maintenance. Annually US$12.3 billion is required for safe water and sanitation provision in Pakistan including US$7 billion for capital and US$5.3 billion for operation and maintenance (Richard Watts et al. 2020) while US$860 million was the total budget allocated for WASH in 2019–20 (UNICEF 2020). However, the entire service chain of emptying, transport, treatment, and safe end-use or disposal is missing. The fate of excreta when the OSS becomes full is a big question that needs addressing.

National and provincial level policies have been made to improve water and sanitation provision in Pakistan including the Constitution of Pakistan (1973), National Sanitation Policy (2006), National Water Policy (2018), and provincial sanitation policies for Punjab and Sindh. These policies have resulted in approaches like Pakistan Approach to Total Sanitation (PATS), Community-Led Total Sanitation (CLTS), and School-Led Total Sanitation (SLTS) programs. However, the working frameworks have not gone beyond the containment of fecal sludge. Recently Clean Green Pakistan Movement (CGPM) has emphasized treating liquid waste to improve sanitation and public health.

The sanitation situation in Pakistan is not much different in comparison to other South Asian countries including Afghanistan, Bhutan, Bangladesh, India, Nepal, and Sri Lanka. More than 50% of the population is relying on septic tanks and pit latrines in all countries. However, the approach taken to resolve the sanitation issues are playing a major role in shaping the outcomes. The strong political will and partnership with donor agencies like WHO, UNICEF, World Bank, national and local level NGOs have made Bangladesh, Bhutan, and Sri Lanka open defecation free (Giribabu et al. 2019; Lindamood et al. 2021; Haque et al. 2022). National level programs like Sanitation and Water for All (SWA) in Bhutan and Nepal, National Sanitation Program in Bangladesh, Clean Indian Mission in India have increased access to safely managed sanitation (WaterAid 2019). The safely managed sanitation in Bhutan, India, Bangladesh, and Nepal is 65%, 46%, 39%, and 29% respectively while Afghanistan, Pakistan, and Sri Lanka have no safely managed sanitation available to date (WHO/UNICEF 2021). The safely managed criteria are divided into two categories i.e. disposed of in situ, fecal sludge treated and sewerage treated. The major portion of safely managed sanitation in these countries is coming from disposed in situ (Fig. 3b) and is a common practice in rural areas (WHO/UNICEF 2021).

In Pakistan, the major reason for no safely managed sanitation is due to unavailability of government capacity to regulate and enforce sanitation standards for safe public health and the environment. To meet the targets of safe sanitation in Pakistan, it is important to look beyond containment and improvise the policies related to collection, transport, treatment, and safe disposal. Currently, there is no policy on fecal sludge management and the focus is primarily given to sewer-based networks only. Lack of coordination among government departments and stakeholders, non-existent FSM policies, lack of financial resources, poor implementation of existing policies, lack of FSM capacity among practitioners, political instability, and natural disasters have led to

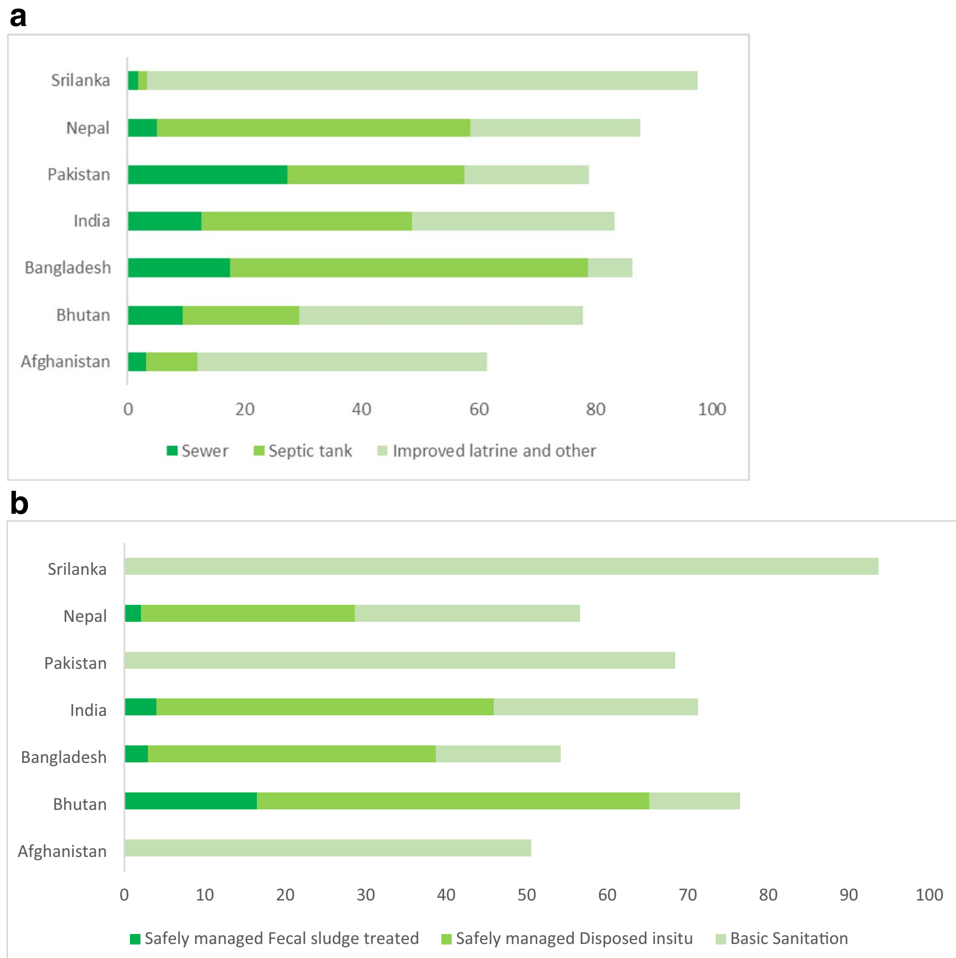


Fig. 3 (**a**) Sewer and OSS coverage in South Asian countries; highest sewer network in Pakistan and lowest in Sri Lanka, (**b**) Proportion of safely managed OSS sludge treated, disposed insitu and basic sanitation coverage in South Asian countries

limited safe sanitation in Pakistan. In India and Bangladesh, the holistic approach of offsite and onsite is taken side by side (Narayan et al. 2021a). Citywide inclusive sanitation (CWIS) targets safe sanitation provision for everyone either connected by a centralized/decentralized sewerage system or utilizing OSS (Narayan et al. 2021b). The current policies in Pakistan are completely ignoring this component. To meet SDG Target 6.2, complete recognition of the importance of OSS technologies and the service chain required for FSM is mandatory. The policies, plans, and guidelines need to be revised in light of the prevailing sanitation options.

Conclusion

Karachi, Lahore, and Islamabad are covered with sewer-based networks but still, the safely managed sanitation score is very low i.e. 10%, 8%, and 34% respectively. Wastewater treatment plants are not available in all the cities. In cities where they are available, their performance is far below the designed capacity. In Karachi, three treatment plants of 151 MGD are available but only treat 33% of the wastewater. In Islamabad, the total capacity is 17 MGD but 6 MGD receives treatment, and wastewater from Lahore does not receive any treatment at all. The major safe sanitation score from Lahore (8%) and Islamabad (25%) is coming from fecal sludge buried onsite safely. Policies related to planning, budget, allocation, infrastructure development, operation, and maintenance for sanitation are concerned with sewer-based networks majorly. However, in all the cities OSS including septic tanks is a prevalent alternative sanitation option. Yet, there is no service chain available for fecal sludge accumulated within these OSS. There are no guidelines at the national, provincial, or local level for the handling of fecal sludge. FSM can be included in already existing water and sanitation policies with a due highlighted share on the complete service chain. Less capital investment is required from the public sector for OSS and puts more responsibility on households and private service providers. The government needs to develop a greater capacity in the CWIS context to enforce and regulate the sanitation standards and leave no one behind to meet SDG Target 6.2.

Availability of data and materials The data used in the study can be obtained from the corresponding author on request.

Author contribution Nida Maqbool: Designed the study, data collection, manuscript drafting

Muhammad Arslan Shahid: Data collection and compilation, editing manuscript

Sher Jamal Khan: Supervising research, editing manuscript

Declarations

Consent to participate All authors participated in the research and the content of the manuscript.

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Competing interests The authors declare no competing interests.

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