Interdisciplinary Publication
REPA PROCEEDING SERIES

Vol 1 (1): Pages 102-109 (2020)
DOI 10.37357/1068/SODC2019.1.1.13
ISSN 2435-7308

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International Conference on
Sustainability Outreach in Developing Countries (SODC 2019)
16-19 November 2019, Kabul, Afghanistan

An overview of sewage system management in Kabul

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Conference Proceeding
Open Access
Published

Keywords
- Drainage
- Sewage system
- Kabul sewage system
- Sewage management
- Environmental sustainability

ABSTRACT

This research is about management of the sewer and drainage system in Kabul city, which is predicted to continue growing in population. According to the new Master Plan, the city population will grow from 4.5 million in 2017 to 9 million by 2050. Kabul's rapid population growth has put pressure on its economy, social services, and housing. However, the major urban systems such as roads, water supply, and sewage were poorly planned and implemented. In this article, we will analyze the current problems of sewage in Kabul as it does not have a pre-established municipal sewage system. Kabul's management, and control of wastewater is compared with the various cities around the world. In this research, a new approach is proposed for the Master Plan improvement considering review of similar cities in the world and a case study of Omid-e-Sabz, a town west of Kabul.

Received: January 17, 2020; Revised: March 15, 2020; Accepted: March 20, 2020; Published: June 12, 2020

1. Introduction

One important part of the city management is the collection of the sewage to a proper site for infiltration. Proper sewer management enhances the sanitary, health and environment of the citizens in a city. We focus on waste management in Kabul comparing it with a case study and literature review from other countries. Omid-e-Sabz, a town located in the west Kabul city is considered as case study in this research. We also use three literature reviews of other cities around the world like Ancient Rome, London, England, which modernized their sewer management systems. The other literature review focuses on the small town of Court Case in the United States of America. Finally, we studied the Sasaki [1] recommendations for waste management.

As it rapidly grows in population, Kabul is challenging to keep up with infrastructural demand. One main problem is wastewater management. Most parts of Kabul do not have this infrastructure which allows wastewater and ground potable water to mix and causes health risks to the citizens. Kabul must develop solutions to improve this sewage management system as it sounds to be a critical need of the city. This study defines the problem, performs a literature review from other countries, and investigates a case study of Omid-e-Sabz. First, the problems of urban wastewater management range from the smell and stench of living environments to the contamination of drinking water. Second, we have studied the sewage system of Omid-e-Sabz, which has successfully managed its sewer system yielding good results. Finally, we discuss and exchange information by studying external and internal samples. We look at the advantages and disadvantages of all three wastewater collection systems (latrine, septic tank and lift station) and suggest a suitable system for drainage management in Kabul.

2. Literature review

2.1. Ancient Rome sewerage system

The Roman Empire was very famous for public baths, the water supply system, and the municipal sewage system in the ancient world [2]. The Romans presumably built the first sewage system between

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800-735 BC [3]. Water management recycled bath water for the latrines through a network of covered drains. Terracotta pipes were used for plumbing, and houses were directly connected to the sewer drainage system. The Cloaca Maxima was the first drainage system that reached the Tiber River and still exists after 28 centuries. In ancient Rome were eleven aqueducts that transported water [3]. Indeed, it is the inspiration for most water management systems used today.

Figure 1. Inside of the tunnel drains water from the Roman Forum the Cloaca Maxima [4].

2.2. A small town sanitary sewer: The court case

A sanitary sewer system consists of a network of pipelines that conveys human and industrial waste to a treatment plant. The treatment plant then separates the waste material and discharges the remaining fluid to a stream or river for dispersal to a nearby larger body of water. Initially, sanitary sewer piping systems were combined with storm sewer systems that collect and convey rainwater to a stream or ,more extensive body of water for disposal without treatment. The advantage of a combined sanitary sewer system and storm sewer system is that the rainwater helps dilute and pass raw sewage through pipelines more easily. It also helps to clean wastewater and aids in preventing sewer line plugging.

The disadvantage of a combined sanitary and storm sewer system is that during a torrential rain downpour, treatment plants are sometimes filled beyond capacity and must pump raw sewage into open waterways, posing an environmental health hazard [5]. Separation of two systems has thus become common.

A small community (population under 10,000) city that lies in a northern state of the U.S [5]. On the shores of one of the Great Lakes was recently involved in a court case. A river flows through the city and empties into one of the Great Lakes, and a new, ultra-modern wastewater treatment plant was built on the river as mandated by the government. The plant has three levels of wastewater treatment; primary, secondary, and tertiary (advanced) [5]. Primary treatment separates solid material from the liquid using fine screens or other separating devices. Secondary treatment breaks down organic material with biological treatments. Advanced treatment involves a variety of methods to purify the treatment plant effluent further. One such advanced treatment is having secondary sewage effluent chlorinated before being discharged as a safety precaution as the treatment plant output is located near the city drinking water intake, popular bathing beaches, and fishing grounds.

The plant can also introduce alum and polymers for further purification of the discharge. The government also required that the plant must be constructed with enough capacity to adequately serve the entire river basin as adjacent neighborhoods were frequently experiencing backup problems. In one of the new upstream developments, the mainline malfunctioned three times in the last few years, resulting in raw sewage flowing into residents' basements. In the first two of the three incidents, the mainline overflowed because of heavy rain downpours, but the third incident occurred when there was no rainfall. After this third incident, one of the residents decided to take action.

The local sanitation company determined that the line from his house to the mainline along the street was not plugged. The sanitation company workers then opened up a manhole cover near the home and saw that the fluid level in the manhole serving the main county line had risen above normal levels, indicating a blockage somewhere in the system causing the problem.

The county immediately went to work, discovering that the mainline had plugged on the first street downstream, causing upstream backup and raw sewage to flow into this elderly resident's basement. It took three days for a restoration company to clean, disinfect, and ventilate his basement at the cost of over two thousand dollars [5].

3. London sewerage system

The London sewerage system is part of the water infrastructure serving London, England, since the late 19th century, and as London has grown, the system has been expanded. It is currently owned and operated by Thames Water and serves almost all of Greater London [6].

From the early 19th century, the Thames River was an open sewer system, London experienced many public health crises with frequent cholera epidemics. In the early 1700s, many proposals to upgrade the London sewer system were considered but not acted upon, usually due to cost concerns. Finally, the 1858 "great stink of Parliament" motivated the government to take urgent action to build a more reliable sewage system [6].

Joseph Bazalgette, a civil engineer and chief of the Metropolitan Board of Works, was given the responsibility for constructing the London modern sewage system. With his team of colleagues, London's vast underground sewerage system was designed to divert waste to the Thames estuary [7].

Downstream of the city center were six main interceptor sewers with a total length of 160 km (100 miles). Three interceptor sewers were constructed at the north of the river, and the southernmost site was placed at the lowest level in the Thames embankment. The embankment also allowed new roads, new public gardens, and the circle line of the London underground [7].

Victoria Embankment was finally and officially opened on July 13, 1870. The intercepting sewers, constructed between 1859 and 1865, were fed by 450 miles (720 km) of main sewers that, in turn, conveyed the contents of some 13,000 miles (21,000 km) of smaller local sewers. Construction of the interceptor system required 318 million bricks, 2.7 millions cubic meters of excavated earth, and 670,000 cubic meters of concrete. The innovative use of Portland cement strengthened the tunnels, which were still in good order 150 years later [8].

Gravity allows sewage to flow eastwards in places like Deptford, Chelsea and Abbey Mills. Pumping stations were built to raise the water and support flow– sewers on the north side flow to the northern outfall sewer that feeds into a major treatment center. A southern outfall sewer extends to a similar facility. Major improvements during the 20th century reduced the pollution of the Thames river at the North Sea and the Thames Estuary.

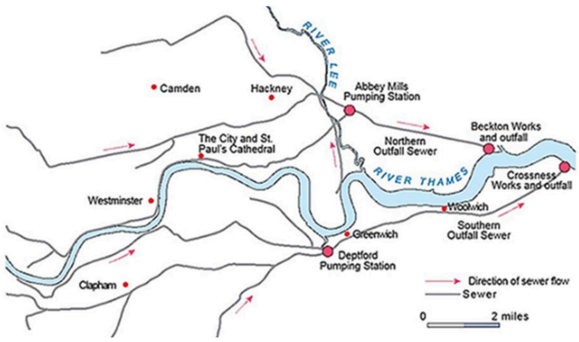

Figure 2. Map of Bazalgette's 1858 scheme [9].

Design of the London sewage system originally had a capacity of 6.5 mm (1/4") per hour of the rainfall within the catchment area. London's population growth increased pressure on the capacity of the sewage system, such that a high level of rainfall (over 6 mm per hour) over a short period of time can overwhelm the sewage system. Under periods of heavy rain, the rainwater mixes with sewage water as it is discharged into the Thames. If the discharge does not clear quickly, the sewage system backs up, and localized flooding occurs, posing a health and environmental risk. During the redevelopment of the Isle of Dogs and Royal Docks areas of east London during the late 1980s and early 1990s, the London Docklands Development Corporation invested in new drainage infrastructure to manage future sewage and surface water run-off. Using a system of large-diameter tunnels that are served by a new pumping station at the Tidal Basin, approximately 25 km (16 miles) of surface water drains in the Royal Docks were built. The Isle of Dogs drainage network is served by a stormwater pumping station at Stewart Street [10]. After much debate, improvements have been approved for construction to be completed in 2024. The New Thames Tideway scheme will include wide-diameter storage and transfer tunnels for 35 km (22 miles) underneath the Thames riverbed between Hammersmith and Beckton/Crossness at the cost of £4.9 billion [8].

4. Case Study: Omid-e-Sabz

The town of Omid-e-Sabz is located at the hillside of Ghoreq mountain west of Kabul. The town manager expects the population to reach approximately 22,000 people in 2019. Each house has a septic tank which collects all wastewater but not stormwater. The wastewater from the septic tanks flows into the public town infiltration system. Owners of houses and apartment dwelling determine the size of the septic tank, but a capacity of 60-70 cubic meters should be enough for every single house with three families for two years.

At the public treatment plant, wastewater passes three steps. First, water is collected at the tank allowing some solids to sediment. For the second step, the water is sumped into an infiltration tank with varying sizes of sand. Finally, the filtered water is used for irrigation of the town's parks and trees.

Figure 3. Pump station(after filtering pump water for landscaping).

Figure 4. Construction phase.

Figure 5. First storage of sewage after septic tank.

5. Kabul master plan

Approved in 2017, the plan's vision for the future of Kabul includes a goal to build a water/sewage system so that 80% of the drinking water will come from retreated wastewater.

"The scale of implementing a solution to treating wastewater in a city of 4 million people growing to 7 million largely without sewage currently requires a major, not a minor, initiative. A bold approach with strong leadership, in which, donors, public sector administrators' support is needed" [1]. Tankers pump waste from latrines into the Microrayon WWTP (wastewater treatment plant). When the plant is not in operation, the wastewater flows into the city drains into the Kabul River, especially during months with dry weather.

"An estimated 600-700 private waste haulers traverse the city daily to empty containment tanks, each with an estimated capacity of $10m^3$. Haulers discharge wastewater loads across Kabul in the existing stormwater drainage network and at the Microrayon Treatment Facility" [1]. A decentralized network with limited lengths of transfer runs works best for most areas of the city with medium to low population density.

Two systems of wastewater management are suggested for Kabul. For low-density areas close to agricultural land, managing latrines and wastewater for agriculture are the best fit. For areas with high population density, lift stations are the best option. Because Kabul has a complex population distribution, one station to collect wastewater is not feasible, so dividing the city into smaller areas where waste can be collected and treated would need to be considered.

Table 1: Summary of wastewater load estimates as per Kabul population [1].

			Medium-term Planning Scenario*		Lang-term Planning Scenario**	
			Estimated Population	Wastewater land Estimated	Estimated Population	Wastewater Land Esti-Mated
		m3/day	MCM/yr		m3/day	MCM/yr
Sewered	4,850,000	310,000	110	4,870,000	390,000	140
Future sewered	1,240,000	79,000	30	2,390,000	191,000	70
Cluster	760,000	37,000	10	780,000	50,000	20
Septic	690,000	28,000	10	770,000	37,000	10
Total Kabul	7,540,000	454,000	160	8,810,000	668,000	240

* Based on Potential population growth to 7.5 million people
** Based on Potential population growth to 8.8 million people

Table 2: Population-based wastewater load estimation [1].

District		Medium-Term Planning Scenario*			Long-Term Planning Scenario**		
		Estimated population	Wastewater load Estimate		Estimated population	Wastewater load Estimate	
AUWSSC	1	144000	5000-9000	1.7-3.4	154000	9000-12000	3.4-4.5
	2	242000	8000-15000	2.8-5.7	252000	15000-20000	5.7-7.4
	3	617000	20000-39000	7.2-14	624000	39000-50000	14-18
	4	446000	14000-29000	5.2-10	462000	28000-37000	10-13
	5	560000	18000-36000	6.5-13	569000	35000-46000	13-16
	6	488000	16000-31000	5.7-11	500000	31000-40000	11-14
	7	65000	2000-4000	0.8-1.5	67000	4000-5000	1.5-2.0
	8	165000	5000-11000	1.9-3.9	170000	10000-14000	3.9-5.0
	9	106000	3000-7000	1.2-2.5	110000	7000-9000	2.5-3.2
	10	385000	12000-25000	4.5-9.0	396000	24000-32000	9.0-11
	11	573000	18000-37000	6.7-13	581000	36000-46000	13-17
	12	397000	13000-25000	4.6-9.3	403000	25000-32000	9.3-11
	13	258000	8000-17000	3.0-6.0	262000	16000-21000	6.0-7.7
	14	263000	8000-17000	3.1-6.1	266000	15000-21000	6.1-7.8
	15	239000	8000-15000	2.8-5.6	783000	36000-63000	13-22
	16	373000	12000-24000	4.4-8.7	379000	23000-30000	8.7-11
MRRD	17	418000	13000-27000	4.9-9.8	412000	26000-33000	9.8-12
	18	334000	11000-21000	3.9-7.8	341000	21000-27000	7.8-10
	19	647000	21000-41000	7.6-15	654000	41000-52000	15-19
	20	107000	3000-7000	1.2-2.5	144000	7000-12000	2.5-4.2
	21	152000	5000-10000	1.8-3.6	166000	10000-13000	3.6-4.8
	22	564000	18000-36000	6.6-13.2	1119000	36000-90000	13-32
Total		7540000	241000-483000	85-175	8810000	282000 - 705000	180-260
Total AUWSSC		5320000	170000-341000	60-125	5980000	340000 - 478000	124-175
Total MRRD		2220000	71000-142000	25-55	2840000	142000 - 227000	52-85

* Based on potential population growth to 7.5 million people
** Based on potential population growth to 8.8 million people

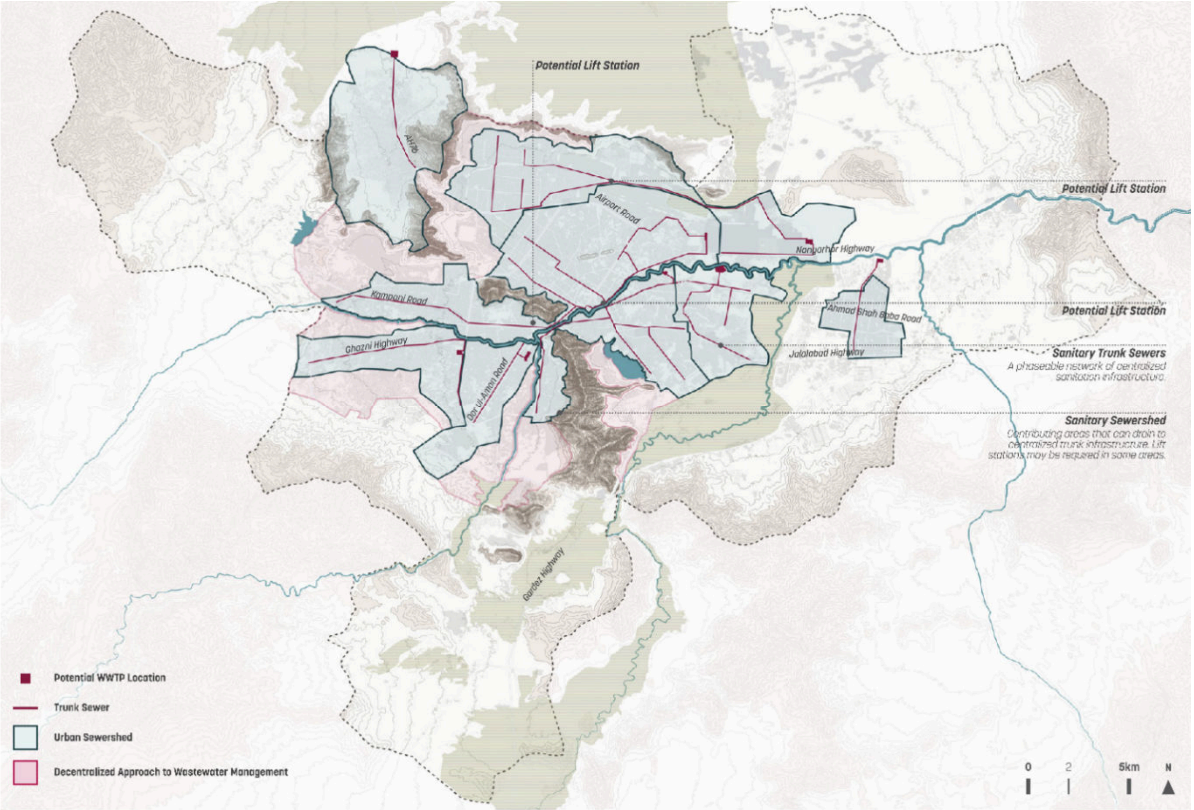

Figure 6. Lift station for the Kabul which are suggested for waste management by KUDF [1].

6. Significance of sewage management in SDGs achievement

The UN sustainable development goals (SDGs) were authorized to establish an agenda for global development by 2030, consisting of 17 major goals and 169 smaller goals. Implementation begins in January 2016 and serves as guidelines for future decisions over the next 15 years. This research regarding Kabul's waste management system has relevance to the SDG concerning impact on human life and the environment [11].

GOAL 3: Good Health and Well-being: effective waste management promotes health and well-being. If a sewer system is not managed well, the waste will increase health risks for everyone and reduce the quality of life.

GOAL 6: Clean Water and Sanitation: waste management directly impacts surface and underground water sanitation as well as sources of clean water. If the wastewater is not effectively managed, surface and underground water will be polluted and not potable for human usage negatively impact wildlife, the environment, and human health.

GOAL 9: Industry, Innovation and Infrastructure: Waste management is part of the infrastructure supporting innovation and industrial development.

GOAL 11: Sustainable Cities and Communities: All cities should have a strong infrastructure, potable water, and good industries. Sustainability allows cities to maximize use and reuse of resources, such as treating and recycling waste water for irrigating city landscapes.

GOAL 13: Climate Action: A city's pollution can interfere with the local climate. Waste management plays an important role in protecting the local environment and public health.

GOAL 14: Life Below Water: Treating and recycling waste water reduced waste discharge into lakes and rivers, thereby protecting natural wildlife and water resources.

We conclude that improved waste management in Kabul will benefit citizens with a more comfortable life with clean climate, clean potable water and a clean river.

7. Analysis

From these three case studies and literature review, we argue that a modern sewage system has a vital role in Kabul. Without it, life in the city will be difficult as citizens are threatened with a harmful and hard life due to the risk of illness. To properly serve its citizens, the government first needs to finance design and construction of a modern system. City planning and management play a critical role. It must continue to manage and expand the capacity of current projects like Microrayan and the Industrial Water Reuse Pilot.

8. Recommendation

Cities have responsibilities to manage waste, especially in anticipating future growth. Kabul's planless developments comprise about 70% of the area, making wastewater management a challenge. From our research on wastewater management in other cities, we have made these recommendations.

– A short-term plan must include placing responsibility for the management and financing of a modern sewage system to the municipal government. Sewage water must be contained and separated from groundwater and the living environment. We look at the example of Omid-e-Sabz, where wastewater passes through septic tanks and filtration system before being treated for reuse for landscaping and crop irrigation.

– A long-term plan should include a network of lift stations to help manage and treat wastewater throughout Kabul. Filtered water from these stations can then be reused for landscaping and crop irrigation.

– Implementing the short-term plan should be easy as the costs for septic tanks can be shared with property owners and private sector investors. In contrast, life station construction relies on municipal commitment to purchase land and construct the sewer system underground and connect with the users in the city.

Table 3: Comparison and recommendation.

Sasaki	SDGs goals	Recommendation
– For rural areas, the waste managing system relies on latrines and waste. – Lift station systems will provide each service for small areas of Kabul. The land for the lift station must be bought by the municipality.	– No poverty – Zero hunger – Good health and well-being – Quality education – Gender equality – Clean water and sanitation – Affordable and clean energy – Decent work and economic growth – Industry, innovation and infrastructure – Reduced inequality – Sustainable cities and communities – Responsible consumption and production – Climate action – Life below water – Life on land – Peace and justice strong institutions – Partnerships to achieve the goal	– Septic tank installations should be constructed at the expense of the house owner and private investment. The area needed is at least 800 m2 for each infiltration system. – Lift stations support neighborhoods and communities and should involve municipality investment for their construction.

9. Conclusion

Omid-e-Sabz offers an example system of wastewater management for Kabul, which faces challenges due to unplanned growth. With the help of its citizens, Kabul's government must have a long-term commitment to improving its sewer management to ensure quality potable water and maintain public health through the design and implementation of planned growth.

References

[1] Sasaki (**2017**) "Kabul urban design framework," 1st ed. Kabul, Afghanistan, *Ministry of Urban Development and Housing*. (https://www.sasaki.com/projects/kabul-urban-design-framework/) *Accessed*: *1 November **2019***

[2] Skyline Civil Group (**2016**) "The sewers of ancient Rome" *Skyline Civil Group* (http://www.skylinecivilgroup.com/sewers-ancient-rome/) *Accessed*: *9 March **2010***

[3] Nicki jo Armfield (**2019**) "Sanitation in ancient Rome" *Online Learning - Prezi* (https://prezi.com/o87e9rrkfqnr/sanitation-in-ancient-rome/) *Accessed*: *8 March **2020***

[4] [4] Dwarf Fortress Wiki (**2019**) "DF2014: Sewer" (https://dwarffortresswiki.org/index.php/DF2014:Sewer) *Accessed*: *1 November **2019***

[5] Tata RP (**2013**) "Municipal sewer systems: Case studies" New York, USA, *Continuing Education and Development, Inc.* (https://www.cedengineering.com/userfiles/Municipal%20Sewer%20Systems%20Case%20Studies.pdf) *Accessed*: *1 November **2019***

[6] Abellán J (**2017**) "Water supply and sanitation services in modern Europe: developments in 19th-20th centuries" 12th International Congress of the Spanish Association of Economic History Salamanca, Spain, *Spanish Association for Energy Economics (AEEE)* - pp. 1–17.

[7] De Feo G, Antoniou G, Fardin H, El-Gohary F, Zheng X, et al. (**2014**) "The historical development of sewers worldwide" *Sustainability* (vol. 6, no. 6, pp. 3936–3974) https://doi.org/10.3390/su6063936

[8] Baker M (**2008**) "Discovering London statues and monuments," 5th ed. Princes Risborough, *Shire*. 128 p. ISBN: **978-0-7478-0495-6**

[9] OpenLearn (**2018**) "How London got its Victorian sewers" *Medium* (https://medium.com/@OUFreeLearning/how-london-got-its-victorian-sewers-a60293f8dd60) *Accessed*: *1 November **2019***

[10] London sewerage system (**2020**) *Wikipedia* (https://en.wikipedia.org/w/index.php?title=London_sewerage_system&oldid=948716404) *Accessed*: *10 April **2020***

[11] United Nations (UN) (**2019**) "Sustainable Development Goals (SDGs)" (https://sustainabledevelopment.un.org/sdgs) *Accessed*: *1 November **2019***