Challenges and Opportunities for Septage Management in the Urban Areas of Indonesia – Case Study in Bandung City

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Highlights:

- The shit flow diagram provides a new and innovative way to engage sanitation experts and planners, political leaders and civil society in septage management at city level in a coordinated manner.
- Establishing national guidelines and standards is necessary for ensuring proper septage management across the sanitation service chain.
- A regular desludging program should be introduced in each city that requires all households to empty their septic tanks periodically (3-5 years), which will consequently help to improve public demand for septage services.

Abstract. Because of the burgeoning urban population, there is huge pressure on both natural resources and basic urban infrastructure, especially sewerage systems, with Indonesia as no exception. It is estimated that about 95% of human waste in Indonesia ends up untreated or partially treated in septic tanks before being discharged in the natural environment, contaminating the living environment as well as adversely affecting human health and economic development. This study conducted a comprehensive investigation on septage management in Bandung City, Indonesia, to gain a better understanding of the challenges and opportunities for improved performance of on-site sanitation systems as well as septage management across its sanitation service chain. The results showed that the following issues are the main reasons behind poor sanitation in Bandung city: a) poor design and construction of septic tanks with no or only partial lining, resulting in leaking (>90% of septic tanks are malfunctioning); b) irregular desludging, i.e. about 2/3 of population desludge their septic tanks only once in more than 5 years; c) lack of proper guidelines and awareness about the benefits of regular monitoring and operation of septic tanks; d) lack of good sanitation service providers; and e) lack of funds for building sufficient capacity of septage treatment plants.

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1 Introduction

Indonesia is the fourth most populous country in the world and has the largest economy in Southeast Asia. Its population is estimated at 260 million people in 2017 and will exceed 290 million by 2045 [1]. According to the World Bank (2016), Indonesia has the highest urbanization rate in Asia and it is predicted that 67.5% of the population will live in urban areas by 2025. Urbanization comes with economic benefits, but it also places great challenges on urban infrastructure services, especially related to water and sanitation.

Because of technical advancement, a remarkable increase in access to improved sanitation has been observed from 45% in 1990 to 85% in 2016, i.e. in a period of 25 years [2]. However, the ramifications of the effluent collected from these improved sanitation systems have not received appropriate attention. Despite the progress in sanitation access, 95% of human waste in Indonesia still ends up untreated in waterways or marginal land, contaminating the living environment and causing negative impacts to human health and economic development [3]. The World Bank estimates that inadequate sanitation and poor hygiene lead to more than 120 million disease episodes and 50,000 premature deaths annually [4]. It is estimated that Indonesia experiences a loss of 56 trillion rupiah or $4.2 billion each year due to the poor quality of sanitation [5].

It is also estimated that more than 90% of Indonesian households still rely on on-site sanitation systems, especially septic tanks. However, due to poor design and performance, effluent and sludge generated from septic tanks (often referred to as septage or fecal sludge), which are rich in organic compounds and nutrients, are discharged directly into the environment, posing a threat of contamination to both soil and water bodies. Septage also contains disease-causing viruses, bacteria and/or parasites [6]. On the other hand, more than 150 septage treatment plants have been constructed in medium and large cities over the last 20 years across Indonesia, but only less than 10% are currently operational [7]. Septage management in Indonesia faces major challenges at the regulatory and practical level due to lack of attention from local/central government, weak enforcement of regulations and practical standards, and poor understanding of proper septic tank design. This leads to improper treatment, lack of demand for septage treatment plants and illegal septage sludge discharge into the open environment.

Against the aforementioned background, this study conducted an in-depth investigation on septage management across all stages of the sanitation service chain (starting from containment identification in households, emptying, transporting, treatment, to end-use or disposal) in an urban area in Indonesia, with

Bandung city as the case study location. Different aspects related to septage management, including regulations, policies, institutional arrangements, as well as technical aspects, were addressed. In addition, based on the results of the literature review, key informant interviews, questionnaire surveys, and septage sampling and analysis, opportunities for improving the performance of the septage management system through its sanitation service chain have been identified. Finally, a shit flow diagram (SFD) was developed. The SFD is a new and innovative way to engage sanitation experts, political leaders and civil society in coordinated discussions about septage management at city level.

2 Study Area and Research Methodology

2.1 Study Area Profile

Bandung, the capital city of West Java Province with 2.5 million of inhabitants [8] is the third largest city in Indonesia after Jakarta and Surabaya. The total area of Bandung is approximately 167 km^2 (See Figure 1). The whole city is divided into eight sub-city regions, which are further divided into 30 districts for development purposes. Currently, the entire sewerage pipeline network serves 21.4% of the population in Bandung. The central government has the plan to develop a new services area to increase the number of household connections in the future.

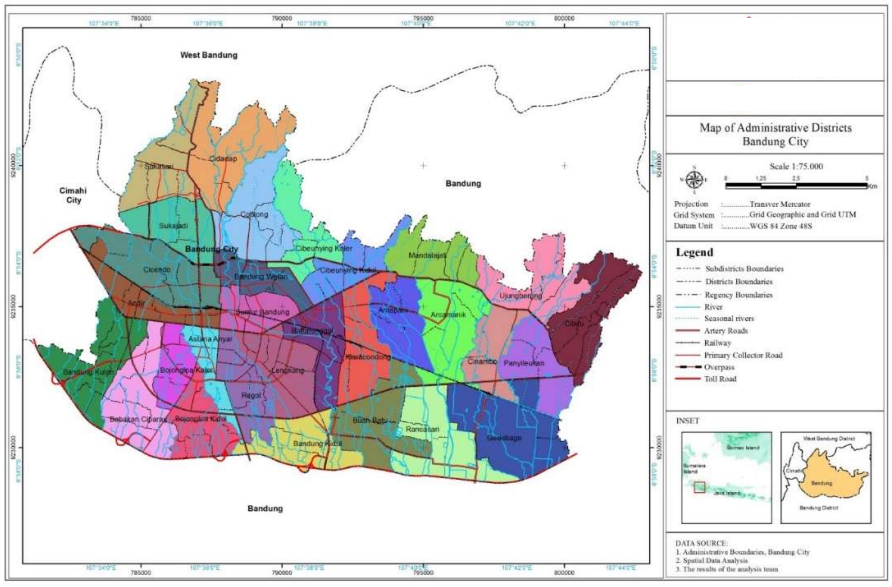


Figure 1 Map of Bandung city.

Although Bandung city already has a wastewater management plan since 1916, the city still faces problems with bad sanitation conditions because of various reasons. Data from *Sanitasi Total Berbasis Masyarakat* (STBM), managed by the Ministry of Health, Indonesia and supported by the World Bank, show a high percentage of open defecation (OD). Here, OD is defined as the direct disposal of untreated human excreta along with domestic wastewater into the environment (drainage system, rivers, lakes, etc.) despite people having toilets. It is reported that 245,000 household, or approximately 40.13% of inhabitants, still discharge their wastewater directly into the environment without any treatment process [9]. This is one of the prime factors causing both groundwater and surface water pollution. The above fact is well supported by the report, which mentions that domestic wastewater is considered the biggest pollution contributor for the Citarum river, a receiving body of Cikapundung river, which runs through Bandung city [10-13].

2.2 Data Collection and Methodologies

The methodology adopted for data collection and analysis for this study is divided in two parts: collection of secondary data and field/primary data.

1. Secondary data. The data that were collected in this stage included:
   (i) overview of regulatory, legislation and policy frameworks, institutional arrangements, and service standards affecting sanitation and septage management in Bandung city;
   (ii) supporting information about Bandung city, including population, population growth rate, location, topography, climate, key physical and geographic features, urban boundaries and a map highlighting significant areas in the context of septage management, potential supply and demand for septage services, and quality of service providers;
   (iii) existing off-site and on-site sanitation technologies and systems in use, contribution percentage of each off-site or on-site sanitation technology or system to the septage management; and
   (iv) how on-site sanitation technologies (mainly septic tanks) are emptied and the types and percentage contribution of different emptying technologies. The source of all the abovementioned data were national governmental reports, as the most credible sources.
2. Field data. Since the institutional set-up in Indonesia is very complex and therefore many actors play an important role in formulating and executing policies or guidelines. In order to get a holistic picture, we opted for a top-down approach and included all key stakeholders to gather important information regarding septage management in Bandung city. Here, the following approaches were used to collect both qualitative and quantitative information from sources ranging from policy makers to end users:

(i) a questionnaire survey distributed among 250 households from 30 districts in Bandung city. The number of 250 households was decided by taking one representatives from each quadrant of approximately 10 x 10 km;
(ii) questionnaire-based in-depth interviews with 40 key informants (research institutions, NGOs, local environmental protection agency, department of public works, city planning agencies, Ministry of Public Works and Ministry of Environment, and septage desludging provider) was completed;
(iii) two focus group discussions with main sanitation service providers;
(iv) septage sampling at different stages of the sanitation chain (inside septic tanks, collection trucks, and effluent from a septage treatment plant) and its laboratory analysis at Bandung Institute of Technology.

2.3 Sampling and Septage Analysis

First, samples of septage were planned to be collected from three designated points (septic tanks, septage trucks, and effluent from a septage treatment plant); however, since there is no septage treatment plant in Bandung, we only took samples from septic tanks and septage trucks (Figure 2). The samples were then analyzed at a certified laboratory at the Bandung Institute of Technology.

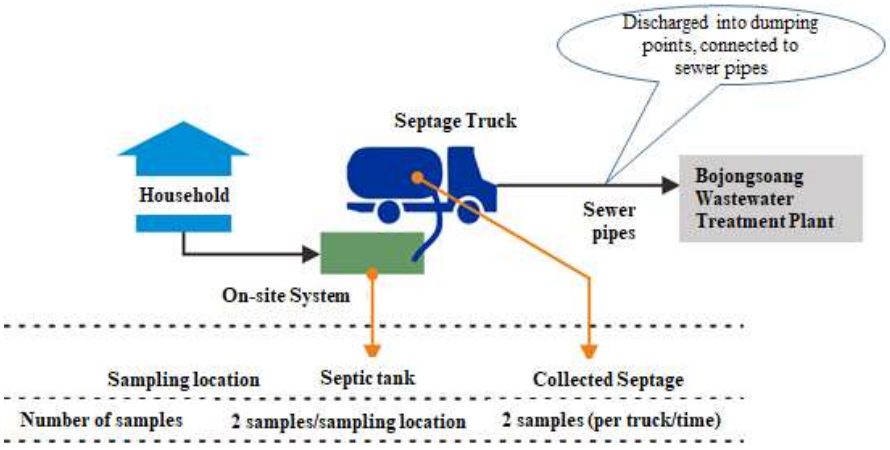


Figure 2 Septage sampling locations in Bandung city.

Septage sludge samples were taken using a modified pipe sludge sampler from the bottom of septic tanks, which were constructed without ventilation and had not been emptied for the last five years, a quite common practice in Bandung and Indonesia. Ventilation is often not built due to the lack of understanding of its function and lack of space for pipes. Also, the pipe, which was used for sampling,

had been modified to take sludge from the bottom of septic tank. We modified the pipe by installing a check valve in the lower segment of the pipe. When the pipe was inserted into the septic tank, the check valve opened and sludge entered the pipe. The check valve closed when the pipe was pulled up. From the sludge truck, the collected septage samples were taken from the tank to a discharge point. Sampling from sludge trucks was carried out after the truck had made enough movement so that solids did not settle on the bottom of the tank.

3 Results and Discussion

3.1 Regulations and Institutional Arrangements Related to Septage Management in Indonesia

Despite lots of efforts having been made to improve wastewater treatment by the government of Indonesia, issues related to septage management have not received appropriate attention from either the central government or local governments. The government launched a domestic water and sanitation program through Presidential Decree No. 2/2015 as part of the National Medium-Term Development Plan (RPJMN) for 2015-2019. This plan aims to achieve 100% access to water and sanitation, commonly known as 'universal access', by 2019. The policy also aims to eliminate the number of illegal settlements in slum areas. For wastewater, the target is to ensure a proper sanitation system equipped with sewerage pipelines supported by a treatment system for 85% of the people and a basic sanitation system (simple traditional latrines) for the remaining 15%. Out of the 85% of the population with proper sanitation, 85% would be served by a proper on-site treatment system while the rest 15% would be served by a centralized or off-site system. Thus, improving the performance of on-site sanitation systems plays a vital role in achieving this target.

A large number of government agencies are responsible for managing the sanitation sector. Since 2000s, the central government has focused on policy development, standard setting, capacity building, and transferring most of the planning, development, financing and management responsibilities to local governments. The major stakeholders related to wastewater and septage management are: (i) National Development Planning Agency (BAPPENAS) and National Steering Committee for Drinking Water and Environmental Health (AMPL); (ii) Ministry of Public Works (MPW); (iii) Ministry of Health (MOH); (iv) Ministry of Environment and Forestry (MOEF); (v) Local Environmental Agency (BLH); (vi) Local Public Works; (vii) Spatial Planning Agency; (viii) Municipal or District Cleansing Department (Dinas Kebersihan); (ix) Local Government-owned Water Utility (Perusahaan Daerah Air Minum, PDAM) or Sanitation Utility (PD PAL); (x) private service providers; and (xi) the

Association of City's and District's Concerned about Sanitation in Indonesia (AKKOPSI).

3.2 Shit Flow Diagram (SFD)

A shit flow diagram was developed to illustrate the condition of sanitation in Bandung city. Making an SFD is a method that has been used widely in many countries because it is very good at showing how fecal waste (a mixture of partially treated sludge that is accumulated in a septic tank (or septage) and wastewater) flows along the sanitation service chain [14]. It was developed after discussion with local government as well as with direct survey in this study and is shown in Figure 3.

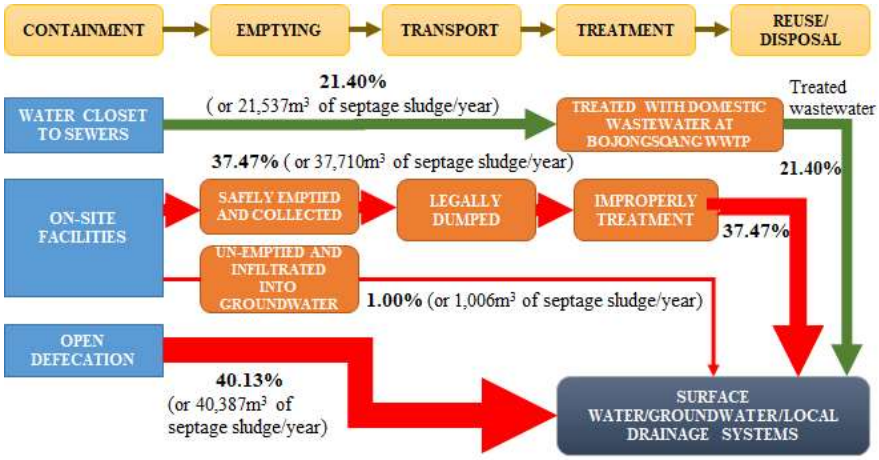


Figure 3 Shit flow diagram in Bandung City.

As illustrated in Figure 3, approximately 21.4% of the population are served by sewer systems [8]. Based on the National Standard and Regulation Number 4 from Public Works and Housing Minister, Indonesia, per capita sludge discharge per year is 40 liters. Consequently, it is estimated that 21,537 m^3 of sludge/year is being discharged into sewerage pipelines and treated together with domestic wastewater at the Bojongsoang Wastewater Treatment Plant (WWTP).

According to the data from the year 2017 from the government of West Java Province approximately 40.13% of the population discharged their domestic wastewater directly to the environment (open defecation) without any proper treatment facility. Open defecation is mainly practiced by people who live in slum areas nearby the river, which causes water quality deterioration in the

Cikapundung river, a tributary of the Citarum River. Because of excess discharge of untreated domestic wastewater, the Citarum river is classified as in the top 10 worst polluted rivers in the world [15-17]. Meanwhile, results from the household questionnaire surveys showed that only 37.47% of the population were served by septic tanks and the septage sludge generated from these tanks was properly emptied, collected by either PDAM or private companies and legally dumped at designated dumping points connected to sewer networks. This collected septage sludge was mixed with domestic wastewater and transported to Bojongsoang WWTP for treatment.

3.3 Characteristic of Collected Septage Sludge Samples

In this study, four septage sludge samples were collected from septic tanks (BDO-ST) (n = 2) and septage trucks (BDO-T) (n = 2) in Bandung. The result of the analysis of the septage can be seen in Table 1. Based on comparing with standard sludge chemical characteristics, the observed values exceeded most of the parameters in at least one sample. The samples were taken from septic tanks that had not been emptied in 5 years (BDO-ST-1) and 19 years (BDO-ST-2). In the septic tanks, the biological oxygen demand (BOD) values ranged from 4,577 to 5,370 mg/L. Several factors can influence this value. One of the factors is the septic tank's desludging period. The longer the desludging time, the higher the methane gas pile-up in the septic tank. This methane gas is produced by several types of anaerobic bacteria (psychrophilic, mesophilic and thermophilic), which can live in wastewater between 0 to 90 °C [18]. This kind of favorable environment is well supported in the absence of a ventilation system in a septic tank. Thus, anaerobic bacteria living in the tank grow rapidly and cause an increase of the BOD value.

The characteristic of wastewater in Bandung can also be attributed to several other factors, such as the source of wastewater, the type of on-site treatment system, food habits, cultural practices, and the amount of water usage. In general, every location has a different characteristic of septage sludge, since it has a unique characteristic of habit, culture, septic tank size, etc. [19-20]. It has been reported that the BOD value for septage can reach a maximum of 78,600 mg/L in the USA and 25,000 mg/L in Europe/Canada [21]. A relatively high concentration of BOD, i.e. 21,250 mg/L, was also reported for septage sludge in Bangalore, India [22]. However, the EPA recommends that the average value of BOD for designing a septage treatment plant should be 7,000 mg/L. The information on the characteristics of septage is important in evaluating a city's lifestyle, proper septage treatment plant designs, and the performance of wastewater treatment plants. This directly affects the business model in septage sludge management.

Among the observed values for nutrients, the TN value significantly exceeded the allowable value as mentioned in the effluent standard. This high concentration of TN poses both opportunities as well as challenges, in terms of both water environment and human health. For extracting these excess nutrients, there are different technologies like nitrification-denitrification, membrane technology, etc. [23], but system set-up as well as its operation and management is costly in countries like Indonesia. However, cheaper options to use nutrients from septage sludge that are commonly opted for in developing countries are production of dry pellets as fuel source, black soldier fly cultivation and use as fertilizer in agriculture [23]. Another challenge is to raise social acceptability and market demand as there is still a stigma surrounding the disposal of septage in the backyard.

Table 1 Summary for chemical analysis of septage in Bandung.

Parameter of Analysis	Unit	Analysis Result				Standard
		BDO-T-1	BDO-T-2	BDO-ST-1	BDO-ST-2	
TSS	mg/L	14,760	1,457	3,760	9,520	310-93,378 [24]
TS	mg/L	132,082	6,248	24,947	18,816	22,000 [25]
VSS	mg/L	9,155	933	2,330	7,130	45 [25]
Ammonia	mg/L	504	139	243	258	400 [25]
Free Ammonia	mg/L	233	132	293	202	-
Total N	mg/L	3,465	262	1,109	1,254	190-300 [26]
Total P	mg/L	251	3.01	1.27	80.8	150 [25]
BOD	mg/L	18,629	2,678	4,577	5,370	840-2,600 [26]
COD	mg/L	64,688	5,175	20,700	21,894	10,000 [25]
Coliform	MPN/100 mL	$2.4x10^6$	$4.6x10^5$	$2.4x10^6$	$4.6x10^5$	$1x10^5$ [25]

Note. BDO: Bandung; T: Septage Truck; ST: Septic Tank

3.4 Performance of Desludging, Collection and Final Disposal System

3.4.1 Desludging/Septage Emptying

The result from the questionnaire survey describes the condition of people who use an on-site treatment system. The type of on-site system that was commonly seen in the survey is a septic tank with overflow to drain, even though there are some septic tanks that meet the Indonesian National Standards (SNI-03-2398-2002). The result suggests that only 49.4% of respondents in Bandung has a septic tank that is fully lined with overflow to open or ground drain and others, and meet the national standard (Figure 4).

In addition, results from the questionnaire survey showed that a high percentage of households (more than 66.81%) have not emptied their septic tank in the last 5 years (Figure 5). The mind set among the people is that they will have their septic tank emptied when it is full. Therefore, the desludging intensity is low. This also occurs in several other big cities in Asia, such as Dhaka (Bangladesh), Phnom Penh (Cambodia), Delhi (India), and Hanoi [23]. The volume of constructed septic tanks is relatively small compared to the septage generated per household (1.35% of septic tanks has volume less than 1 m^3; 54.72% has volume ranging from 2-5 m^3; and 43.95% has volume more than 5 m^3) (Figure 6).

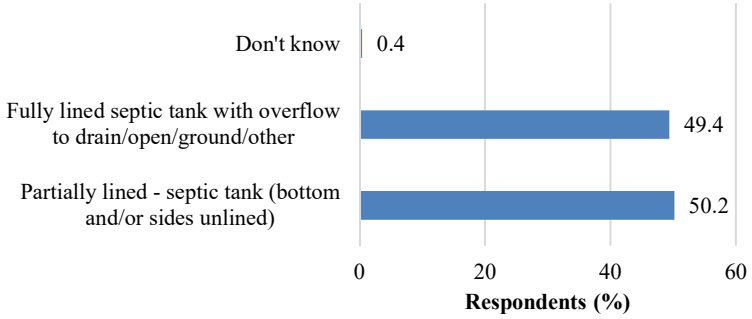


Figure 4 Septic tank conditions in Bandung.

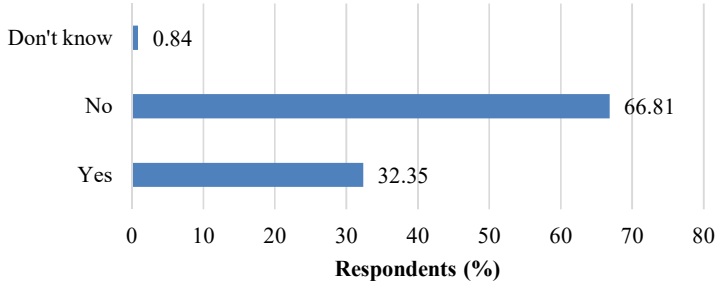


Figure 5 Percentage of emptied septic tank within 5 years.

In addition, improper design and construction are very common in this city, which often results in leakage and ultimately groundwater pollution. From the interview and focus group discussion, some respondents admitted that they built a permeable tank in order to prevent their system to get filled up too fast. They just think that the wastewater will be treated inside of the septic tank, so that there

will be no problem if the wastewater infiltrates into the ground. Finally, no ventilation pipes and access holes are there for emptying the septic tank. These knowledge gaps need to be fixed by either the central government or local governments or related institutions through introducing appropriate and detailed guidelines as well as raising public awareness.

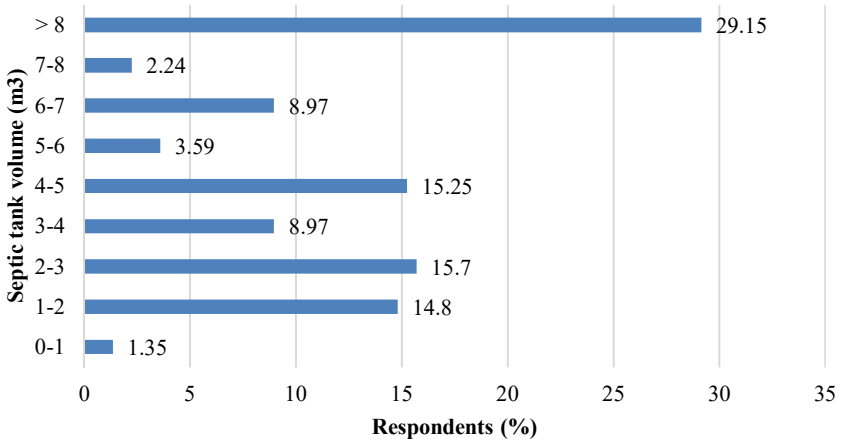


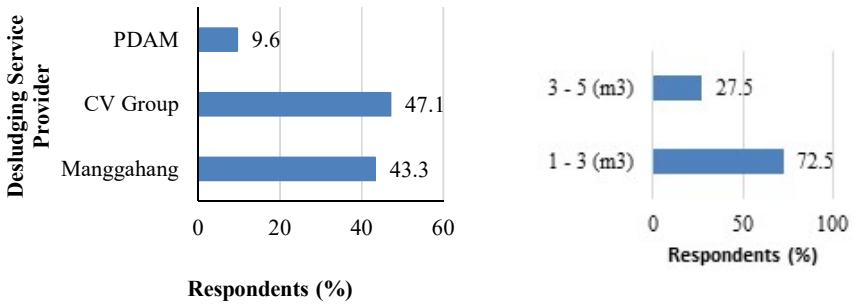
Figure 6 Distribution of septic tank volume.

3.4.2 Septage Collection and Transportation

According to Bandung Mayoral Regulation No. 46 Year 2018, septage desludging and transportation in Bandung is conducted by a combined effort of PDAM, private companies, and private non-companies (owned by individuals). There are 18 private companies, which are registered with PDAM as sludge management service providers. These 18 companies have 26 desludging trucks. In addition, there are 40 units of desludging trucks available with individual (non-company) service providers, as registered with PDAM. Therefore, the total number of registered desludging trucks in PDAM is 71, including 5 trucks owned by PDAM. However, not all of the trucks are always operational due to the requirements for regular maintenance.

People in Bandung have three choices for desludging services, as shown in Figure 7(a). About 47.1% and 43.3% of respondents from this study, desludge their septic tanks by using septage services from private companies, namely CV group and Manggahang, respectively. It seems that the majority of people, 90.4%, choose them due to their success in advertising efforts. Although PDAM also provides desludging service free of cost under the national desludging program known as LLTT in Bahasa Indonesia, the community does not use it due to lack

of information/awareness. Based on a questionnaire survey of desludging operators in Bandung it was found that about 72.5% respondents use small desludging trucks with capacity around 1 to 3 (m^3) (Figure 7(b)). These small-size septage trucks can reach households accessible only through very narrow road/streets. The other septage operators (27.5%) have trucks with capacity around 3 to 5 (m^3) (See Figure 7(b)).



(a) (b)

Figure 7 (a) Desludging service used by the community, (b) average capacity of desludging trucks.

There is another issue with the service supplied by the septage management companies in terms of lack of market penetration and service outreach. For example, the Manggahang Group (about 77% of respondents), despite being the most active in the desludging business, only desludges 1-3 houses per day due to poor marketing and advertisement strategies (Figure 8).

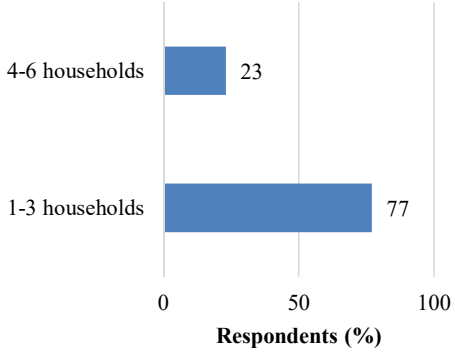


Figure 8 Number of houses that can be desludged per day.

The other desludging service providers are more creative in their advertising systems, such as advertising in newspapers and on posters, websites, and social media to expand the business. As a result, other desludging service providers (about 23% of respondents) provided service to 4-6 households per day because of these marketing strategies (Figure 8). Further, because of poor marketing strategies, many households do not have information about companies providing desludging services, which causes insufficient demand of these services to be able to make a profitable business.

3.4.3 Final Disposal of Collected Septage

PDAM, both as a wastewater and septage management service provider, now uses a combined treatment system since, at this time, Bandung city does not have a septage treatment plant. The septage sludge is carried through sewerage pipelines to Bojongsoang WWTP.

Currently, there is no problem with the wastewater plant since the volume of septage sludge is smaller than the volume of wastewater. Moreover, Bojongsoang WWTP uses stabilization ponds with a long detention time, which can handle shock loads of septage sludge. However, in the future, potential problems may arise in the operation of Bojongsoang WWTP when the volume of septage sludge increases along with the population rise. Based on the current population growth projections, Bandung city, with a population of 6,533,475, will generate approximately 140,000 m^3/year or 383.5 m^3 of septage sludge per day by 2035. The city will face a huge challenge if appropriate measures are not taken to handle this issue.

3.5 Challenges and Opportunities for the Improvement of the Septage Collection, Transport and Treatment System

By year 2010, 150 septage treatment plants were built across Indonesia, but 90% of them are no longer operational and only 4% of them treat septage sludge [24-25]. The reasons behind their non-functionality are either technical issues or they are running on very low sludge input [26]. This study found that Bandung city has a big challenge in the management of septage sludge both in technical and non-technical aspects, which can be summarized as follows:

1. On-site system technology

In Bandung, most people, including government officials, have insufficient information about sanitation issues. While people generally understand that most houses are equipped with septic tanks, they generally do not know what a septic tank does, how it functions, how to properly operate and maintain it, or even where it should be located on their property.

According to Soesanto [27], the most common problem with septic tanks are: 1) the septic tank was not built correctly so there is leakage; 2) the septic tank size does not suit the household's need; 3) the effluent flow is located too close to an influent flow; 4) there is no ventilation pipe and/or access hole for emptying the septic tank so it must be broken to get access. For the public to support a regular desludging program, they first need to understand the problem and how septage management can help to improve the water environment. Since the early 2000s, a detailed guidance is available on designing safe septic tanks issued by the central government, i.e. SNI 2398:2017 and Regulation of Public Works and Housing Minister No. 4, Year 2017. However, no concrete efforts have been made to make people aware about it. There should be a structured campaign to familiarize people with exiting standards and encourage them to follow the guidelines.

The government also needs to consider providing subsidies for low-income people, so that they can build a proper on-site system. The government may also encourage the private sector to take on a more proactive role in domestic wastewater management. The government also needs to prepare the certification of on-site technology, which can be directed to all on-site treatment technology producers. Since there is no testing methodology, it is feared that the technology produced and sold by private companies to the public most of the times does not have sufficient efficiency to meet the environmental quality standards of the government. Therefore, with the existence of such a certification mechanism, it is expected that the producers will design efficient on-site septage treatment system for households.

Furthermore, Bandung city should have a database of on-site management systems and it must be informative and easy to access for interested people. In addition, a geographic information system (GIS) tool could help the operators to manage their desludging activities with real-time monitoring. Moreover, the government of Indonesia should also have a plan to implement the scheduled desludging program with a proper inventory system in the future, so that the government can gauge the amount of septage volume to be desludged every day and its management aspects. The challenges and possible solutions of septage management can be seen in Table 2.

2. Septage collection and transport

Currently, the septage management system in Indonesia is considered not effective enough, which results in improper operation of many constructed sludge treatment plants (STP). One of the contributing factors is a desludging mechanism based solely on consumer demand or on-call demand. This gives uncertainty about the septage volume that will enter the septage treatment plants. This uncertainty directly affects the efficiency of treatment units.

Table 2 Challenges and opportunities for improvement of septage management.

Challenges	Opportunities for improvement
Most of households do not have a properly designed septic tank	• There is a need for an intensive public awareness program to improve people's understanding about sanitation utilities and more efforts are needed to ensure that septic tanks are properly designed and constructed in compliance with the standard • Provision of subsidies from the government for low-income households to build a proper on-site system
No regular desludging of most of the septic tanks; desludging happens only when the toilet is clogged	• The regular desludging program should be targeted not only at PDAM customers, but also at all communities, households • Bandung city should have regular updates about users of septic tanks, septic tank volume, topography, etc. to help the operator in managing desludging activities
Lack of space to build new septic tanks in many densely populated areas in Bandung	• In those cases, communities can build communal septic tanks or communal wastewater treatment plants, so that one installation can serve many households without requiring a huge area
Non-awareness of Scheduled Desludging Services (LLTT) introduced by PDAM	• It is necessary to promote the LLTT program managed by PDAM more effectively. Also, make PDAM customers understand that benefits of using the LLTT program is included in the water fee that customers pay to PDAM
Many septage desludging operators ignore safety procedures, e.g. not using safety clothing when desludging	• Encourage the local government to create and implement standard operating procedures (SOP) for desludging services
Trucks and supporting equipment (pipes, pumps) for desludging services are often not in good condition	• It is necessary to establish minimum required standards for desludging trucks and supporting equipment
There is no treatment plant for septage due to: - Lack of enough funds to build a septage treatment plant - Lack of demand from households	• There is a need for utilizing public-private partnerships (abbreviated as *KPBU* in Indonesian) mechanisms for funding infrastructure development • Demand creation through the instruction of regular or scheduled desludging programs to local communities

The government of Indonesia is developing a scheduled desludging mechanism, or Scheduled Desludging Services (LLTT), for ensuring a stable supply of septage-to-septage treatment plants. This program is expected to provide a

significant contribution in increasing the performance of septage management in the service areas. Generally, the concept of LLTT is carried out by determining service zones. These zones will implement LLTT according to an emptying period of 3-5 years based on Regulation of Ministry of Public Work and Housing No. 4, Year 2017.

3. Septage treatment

The differences between septage sludge from on-site systems and that from municipal wastewater indicate that septage may be 6 to 80 times as concentrated as typical domestic wastewater [28]. Its waste is also more challenging to handle, treat and safely discharge into the environment. Currently in Bandung city there is no treatment plant for septage. The septage is only flowed directly to sewerage pipes because of lack of funds to build a septage treatment plant. According to some other study reports, numerous problems may arise in the combined system between septage and wastewater [29-33]. This is an important lesson for wastewater treatment plants in Indonesia that are not designed to septage sludge. In addition, an extra challenge is finding appropriate locations for building septage treatment plants.

4 Conclusions

The national and local governments of Indonesia and Bandung city respectively have made great efforts to increase access to improved on-site sanitation and to improve the performance of the wastewater sector. However, unfortunately, appropriate attention has not been given to septage management. Consequently, there are currently no regulations concerning septage management in the urban areas of Indonesia and no practical guidelines for emptying, transport, disposal, and recycling of septage from septic tanks. Based on the results and findings from this study, the following recommendations are proposed:

1. There is a strong need to clarify the roles and responsibilities of each ministry and local government unit regarding septage management across the sanitation service chain, including establishing national guidelines and standards on septage management, detailed guidelines for appropriate operation and maintenance of septic tanks, specified roles and responsibilities of each relevant stakeholder group regarding septage emptying, collection, transport, treatment and final disposal.
3. Both the central government and local governments need to provide advocacy, capacity building and awareness raising campaigns targeting both relevant local stakeholders and residents regarding the need for appropriate septage management.
4. Local governments should improve their capacity for monitoring and enforcement of septage disposal among private service providers. In addition, local governments should develop a regular desludging program for each city

and require all households to empty their septic tanks periodically (3-5 years), which will consequently help to improve public demand for the services.

5. Finally, yet importantly, both the central government and local governments should continue to collaborate with research institutions and universities across the country to conduct research for further improving the performance of septic tanks and identify appropriate technologies for septage treatment in the local contexts.

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