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REGULAR DESLUDGING: RECONNECTA MISSING CHAIN IN ON-SITE SYSTEM OF DEPOK CITY

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ABSTRACT

The increase in population numbers lead to the high quantity of domestic wastewater and potentially contaminates the environment. Domestic wastewater management in Depok City, Indonesia was carried out by on-site system, butit was not managed properly. That is described by the high number of households did not desludge their septage and the high of idle capacity of STP.One solution is a regular desludging as a solid way to prevent anyfurther contamination and to make sure all septages should be treated in STP. The purpose of the study is to optimize the city septage desludging service as a step to design a good septage management. The findings of this study is the regular septagedesludgingservice that has to be implemented to serve 63,598 households and the need of six unit vacuum trucksto cover the city central region. The use of small vehicle and transfer station as additional facilities should be considered to cover limited area and densely population with narrow pathways.

Keywords: depok city, on-site system, regular desludging, septage management.

INTRODUCTION

Depok is a city located in West Java Province and it borders on Jakarta (the Capital of Indonesia); it has an area of 200.29 Km^2 which consist of 11districts and 63 wards. Depok City has a total population of 2,033,508 inhabitants in 2014 with the number of households amounted to 526,004 (SDC, 2015). The highof population numbers leads to the high quantity of domestic wastewater and potentially contaminates the environment.Pollution of domestic wastewater in Depok already occurred and indicated by the limits of BOD. *Faecal Coli* and *Total Coliform* of Ciliwung River and watercourse of Ciliwung River has exceeded the standard of class 1 and class 2 according to government Regulation of republic Indonesia number 82 of 2001 (Suzanna *et al*. 2012). The height parameter indicates the septage comes into the Ciliwung River. *Total Coliform* and *Faecal Coli* is one indicator of the presence of septage because of its existence exclusively only due to the presence of feces (Paruch & Maehlum, 2012).Septage derived from human waste consists of solids dissolved in the water, mostly in the form of organic matter. In addition, septage also contains a variety of microorganisms such as bacteria, protozoa, worms and viruses in large numbers (Yates, 2011). Yen-Phi *et al*. (2010) found a bacteria type of *Escherichia coli*, *Enterococcus spp* and *Salmonella spp* in septage samples.

The domestic wastewatermanagement in Depok was carried out by on-site system. The concept of on-site system consists of five connected chain activity including capture, collection, transport, treatment and reuse (Oxfam, 2016). Owners of the septic tank as a collecting tool for septage in 2015 amounted to 92.71% (SWG, 2015). Collected septage should be desludged during the specific period by the vacuum trucks of Depok City Government or private. There areabout73.19% of households who has septic tanks were neverdesludged (SWG, 2015). Septages were never desludged still contain pathogen microorganisms that can infiltrate into the soil and ground water (Yates, 2011). According to Mara (2003), the high content of pathogenmicroorganisms makes the septage need tobe treated first.Septage treatment is important to avoid the spread of waterborne disease (Semiyaga*et al*. 2015).The high number of households that do not desludging septic tank indicating an on-site system chain was broken.One solution is a regular desludging as a solid way to prevent any further contamination and to make sure all septages should be treated in STP (MPWH, 2015). Regular desludgingis an operation and maintenance activity that homeowners can support to reduce septic tank overflows, reduce nuisance conditions, and help minimize the hazards associated to human contact with sewage (Oxfam, 2016). The existence of missing chain in on-site system became the basis for this study. The purpose of the study is to optimize the city septage desludging service as a step to reconnect on-site system chain.These results should help city government to design a good septage management.In the future, the city can handle all domestic wastewater challenges and are also well on the way to enhancing environmental awareness in public.

METHODS

Research framework

Regular desludging is a scheduled approach that focused to septage desluging and transport system and how to decrease idle capacity of STP. This system will calculatethe number of households who have septic tank and the need of vacuum truck. Besides, regular desludging will analyze selected area should be servedand additional facilities to reach limited area for more effective and efficient. Flowchart of the research is shown in Figure-1.

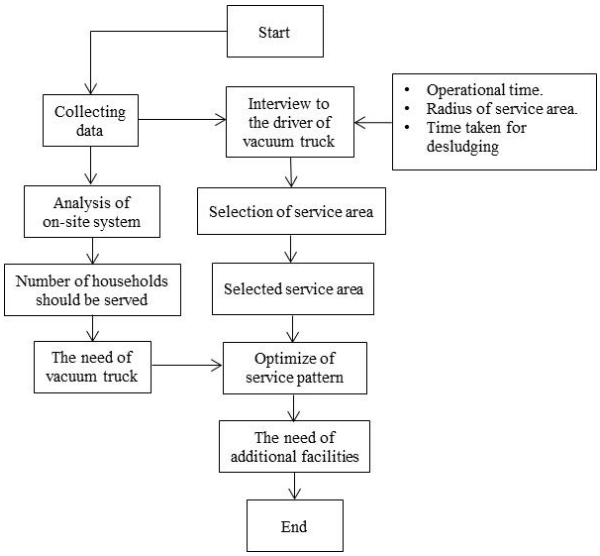

Figure-1. Flowchart of research framework.

The number of households

The number of households will be served is depend on capacity of STP,period of desludging, volume of septage in septic tank, percentage of householdswho have septic tanks(commonly, one household has one septick tank as septage collection).Volume of septage is determined base on average number of people who live in household and it was calculated by following National Standard number 02-2398-2002 (NSA, 2002).Thenumber of households was performed by using the following equation (MPWH, 2015).

$$N = \frac{Q \times P \times 365}{\%Ts \times V} \quad (1)$$

Whereas:

Q (m^3/day)	: Capacity of STP
N (hh)	: Number of households
%Ts	:Percentage of households have septic tanks.
V(m^3/hh)	: Volume of septage
P (year)	:Period of desludging

Analysis of vacuum truck needs

Volume of septage that accumulate in septic tank should be desluged and transported to STP by vacuum truck. Tank capacity and trip of truck a day should be considered to calculate number of vacuum trucks. Needs of other transporter such as smaller vehicle was not calculated and assumed that whole service area should be reached by vacuum truck. Needs of vacuum trucks can be calculated using following equation (MPWH, 2015):

$$\Sigma truk = \frac{Q}{V \times R} \quad (2)$$

Whereas:

Σtruck (unit)	: Number of vacuum trucks
Q (m^3/day)	: Capacity of STP
V (m^3/unit/trip)	: Capacity of tank
R (trip/day)	: Trip of truck

Analysis of selected service area

This analysis conducted to determine appropriate service area that can reach by vacuum trucks. Availability of access to the service area was divided into the area with limited access and the area with broad access. The area with limited access was an area that cannot be reached by vacuum trucks, while the area with broad access was an area that can be reached by vacuum trucks. The analysis was conducted by interviewing vacuum truck drivers of Depok Government concerning operational time, radius of service and time taken for desludging(Oxfam, 2016). These results will be shown in tables and maps.

RESULTAND DISCUSSIONS

Collection

Collection facility used septic tank which was secure and standards-compliant (NSA, 2002). In Depok City, septic tank quality was not identified properly, but most of septic tank built inadequate national standard. It will contaminate clean water sources and potential health effects (Devitt et al. 2016). According to BPS (2015) average number of people who live in household was four and base on National Standard number 03-2398-2002 volume of septage was 1.3 $m^3$for three years.If ownership of a septic tank in Depok is 92.71%, and capacity of STP was 70 m^3/day, the number of households should be collected are:

$$N = \frac{70 \times 3 \times 365}{92.71\% \times 1,3} = 63,598 \text{ households}$$

Desludging and transportation

Desludging and transport services in the city of Depok largely implemented by the *Unit Pelaksana Teknis Instalasi Pengolahan Limbah Tinja* (UPT IPLT) under Cleaning and Landscaping Agency (CLA).Services performed was based on community requires by phone. Septic tank desludging services in 2015 amounted to 6 m^3/day equal to 5,451 households (CLA 2015). The difference between the amount of collected septage and transported septage was 64 m^3/day or 91.4% of idle capacity and it was equal to58,147 households. The high number of households that did not perform desludging because of lack knowledge about septic tank. They thought that undesludged septic tank was good and if septic tank has been desludged it means there was a problem.

Septage transportation facilities used by Depok government were nine units of vacuum trucks with a tank capacity of 3 m^3. Vacuum trucks were equipped with a pump and hose 2-inch diameter as long as 30 meters. Average trip of septage transportation per truck was two trips per day in eight hours (working hour).If regular desludging concept will be implemented, the need of

vacuum trucks to serve 63,598 householdsshould be calculated.

Treatment

Treatment facility is located in Kalimulya Ward, Cilodong District in southern area of city with a capacity of 70 m^3/day. STP used stabilization pond technology and imhoff tank combination. The unit consists of imhoff tank, anaerobic pond, facultative pond and maturation pond. STP was not equipped with a sludge drying bed (SDB) so that the sludge was dried in an open area.

The expected treatment in tmhoff tank was not running and it operated not according to design criteria. Sludge and supernatant cannot be separated due to supernatant's pipe was cut. Actually, the treatment in imhoff tank were physical and biological processes andit was treatedby separating sludge and supernatant by its density (Mara 2003; Metcalf & Eddy, 2003). The biological process occurred during the stabilization of the sludge for 30 to 40 days in the bottom layer of the tank (Mara, 2003).But, all supernatants and sludge were discharged into anaerobic pond.

Non-optimal treatment in imhoff tank caused enhancing loading rate of anaerobic pond and furtherly affected tosludge accumulation in facultative pond and maturation pond. Accumulated sludge in the ponds should be desludged periodicallyto avoid an interfere of the processing in the stabilization pond (Agunwamba, 1993). Siltation caused degradation of stabilization pond unit and its operation was not in accordance with the design criteria (Metcalf & Eddy, 2003).UPT IPLT often to desludge pond every six months, but sludge accumulation has reached to maximum depth of pond less than six months.It needs to desludge at the most appropriate period and the least cost with a minimum interference with the pond efficiency (Agunwamba, 1993). Modifications of maturation pond into a wetland by adding a *Typha angustifolia* plant can be a solution to improve the performance of septage treatment plant and can reduce the content of heavy metals (Pedescoll *et al.* 2014).

Reuse

Reuse of treated water and cake have not been managed properly. Treated waterdisposed into the river, besides it can be used for watering the plants around STP.Sludge from stabilization pond desludged and it was dried in an open areaby UPT IPLT staff.Dry sludge or cake was taken by the local community for other uses. Reuse of cake fromdrying processof sludge has been done in the countries of Sub-Saharan Africa, one of which is used as a building material and soil fertilizer (Diener et al. 2014). If the cake reused by city, it will have an economic value and it can be another source of income for city government.

Service area

Septic tank desludging services covered the entire city of Depok. Limitation of zone service area should be done to optimize regular desludging service and it will be affecting to septage management more effective and efficient (Oxfam, 2016). Limitation of service area is divided into four categories ranging radius of less than 3 km, between 3 to 6 km, between 6 to 9 km and more than 9 km. These categories prepared according to truck drivers information by interviewing. The division is based on a radius service area can be seen in Figure-2.

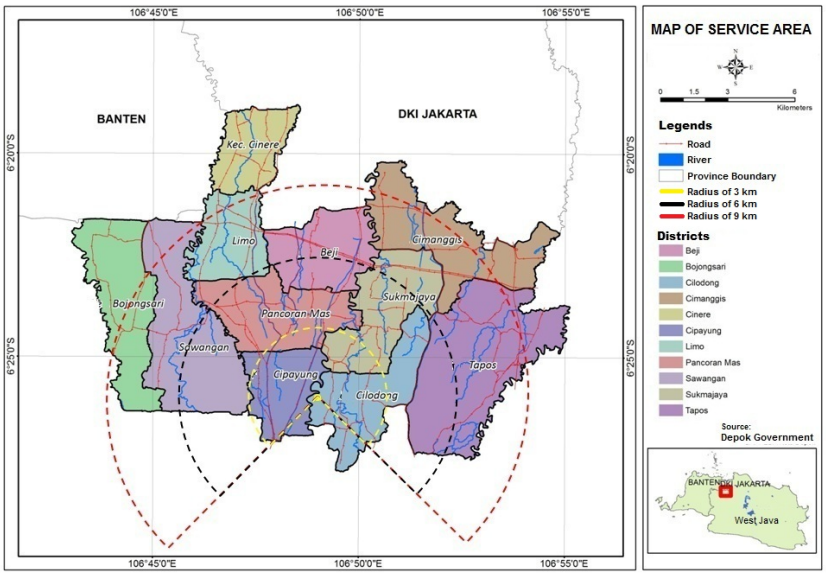

Figure-2. The service area based on the radius.

A service radius of less than 3 km took 75 minutes from STP office and return. It took a relatively fewer of service time, many trips of truck, and needs fewer trucks. The disadvantages were the numerous numbers of service area formed and the growing of land needs for treatment facilities.It will be needed nine service

areasshould be served. A radius between 3 to 6 km took 120 minutes. It took a longer time than the radius less than 3 km, but the service area formed were less than the radius less than 3 km. Number of services area will be formed were three services area. A radius between 6 to 9 km took 200 minutes and a radius of more than 9 km took 235 minutes. Both radius took longer desludging time per trip than radius less than 6 km and area formed was one service area. Total area were formed base on service radius is shown in Table-1.

Table-1. The time needed and service area by radius.

Radius (km)	**Desludging time per trip** (minutes)	**Service area**
< 3	75	9
3 - 6	120	3
6 - 9	200	1
>9	235	1

Considerations of selecting service area was based on the time taken to desludgeand number of service area formed for each radius in a day.Radius of service area more than 6 km shown that there were no significant changes with the existing condition, so that it could not be recommended. Radius less than 6 km seemed more possible to be implemented caused time taken of desluging need 120 minutes.It possible tomake four trips a day, two trips before a lunch and two trips after lunch. Table one showed that the smaller radius of servicewill be forming many services area, but time taken to desludging were fewer. Usage of radius less than 6 km were affecting to service area formed and it will be caused the service area divided into three service areas include the western, central and eastern. The western area included the District of Bojongsari, Sawangan, Cinere, and Limo. The central area included the District of Beji, Pancoran, Cipayung, Cilodong, and Sukmajaya. The eastern area included the District of Tapos and Cimanggis. Selected service area was in the central region due to STP location was in this area. The selected of service area can be seen in Figure-3.

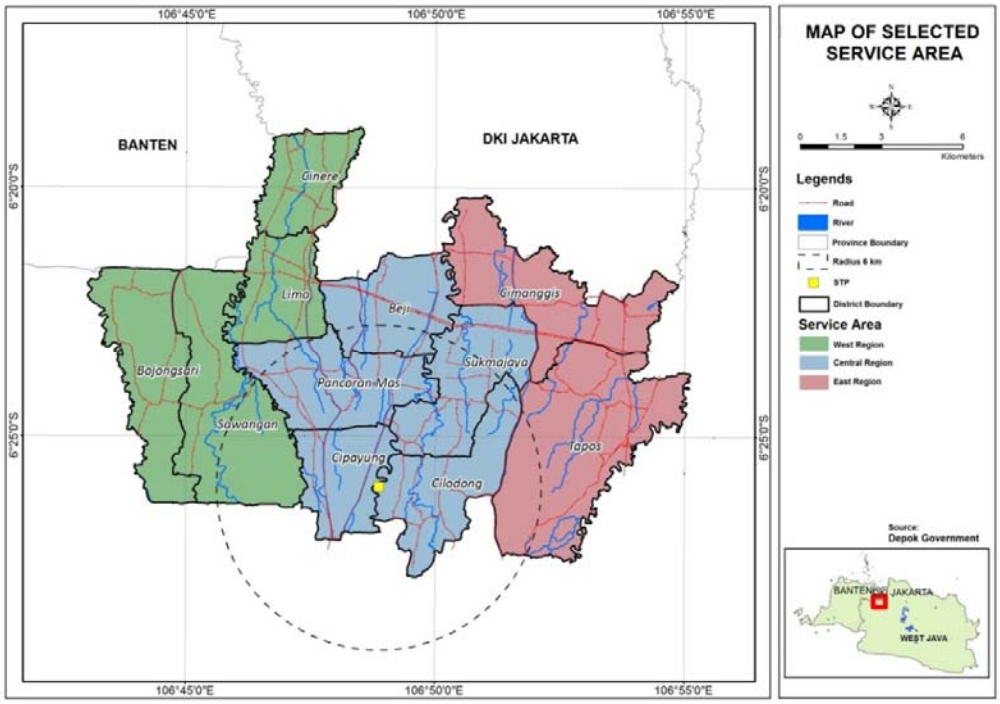

Figure-3. Selected services area.

Vacuum trucks

Desludging services and septage transport in on-site system is a must and it is a very important element (Strande *et al.* 2014). Services used motorized transport refers to a small or large vehicle equipped with a pump, hose and a holding tank. Generally, the storage capacity of a large vehicle (vacuum truck) is between 3 and 12 m^3 by equipping them with holding tanks and pumps (Tilley *et al.* 2014). UPT IPLT used a fleet of vacuum truck with tank capacity was 3 m^3. The operational time of service carried out eight hours a day, it will be formed some trips according to a service radius.

According to capacity of STP as a basic in arrangement of quantity of septage that should be transported, the number of vacuum truck can be calculated. The service radius of less than 3 km will generate 6 trips per day and the number of trucks needed four units. A radius between 3 to 6 km generated 4 trips with six unit trucks needed. A radius more than 6 km generated 2 trips with the truck needs were 12 units. The

vacuum truck needs is shown in Table-2. Table two showed that the smaller radius of service will be forming more many trips, but the number of vacuum trucks needed were fewer.

Table-2. The needs of vacuum truck.

Radius (km)	Capacity of STP (m^3)	Trip of truck	Tank capacity (m^3)	Total truck (unit)
< 3	70	6	3	4
3 - 6	70	4	3	6
6 - 9	70	2	3	12
>9	70	2	3	12

Service pattern

Desludging and transport services were started from UPT IPLT office as municipal service provider. Office location was the same sitewith STP where located in Kalimulya Ward, District of Cilodong. It began when a request from the public service came, staff of UPT IPLT recorded name and address of customer (commonly, he/she asked the customer to be ready when the service will be conducted at the same day). He/she ordered to the driver of vacuum trucks to prepare his truck and departed from theoffice to the point of service soon. If that location could be reached, desludging service can be done.If the location cannot be served due to the constraints of limited access such as the access roads impassable for the truck, hose length is less, and when the location of the septic tank was not found, then the truck will be back to the office. These cases will causing wasted cost of fuel and time and it will be affected to enhance operational cost.After completion of desludging service, vacuum truck back to the office to unload of septage to the treatment unit.

Optimizing of the septic tank desludging service pattern was implemented by adding a scheduled approach or regular desludging in the pattern of service. The concept of regular desludging is the desludgingand transport services carried outperiodically (MPWH, 2015).

Service carried out without waiting for requests from the public,but it will be served every two or three years.The benefit for city of this concept is it can be minimized operational cost and upgrading on-site systems (Oxfam, 2016). The concept will not be changing existing service pattern, but it will beimprovingof septage management.

The addition of a scheduled service concept has been initiated by compiling the data of customer that has been served,customer data that has been inventoried then grouped by its region such as western region, central region and eastern region. Promotion campaign of the concept of scheduled services to customers in the central region should be conducted regularly with a target of 63,598 households. Customers who were willing to follow the service on a scheduled basis recorded the condition of the septic tank, including physical conditions, the capacity of the septic tank, and the suitability of the septic tank design to the standard according to IndonesianStandard.It is intended to give the real condition of their septic tanks and can provide appropriate measures to improve the conditionof septic tank. Furthermore, UPT IPLT and customer arranged the time and schedule of desludging and convey to customers to be ready at this time. Optimizing service pattern of septic tanks desludging and transport process can be seen in Figure-4.

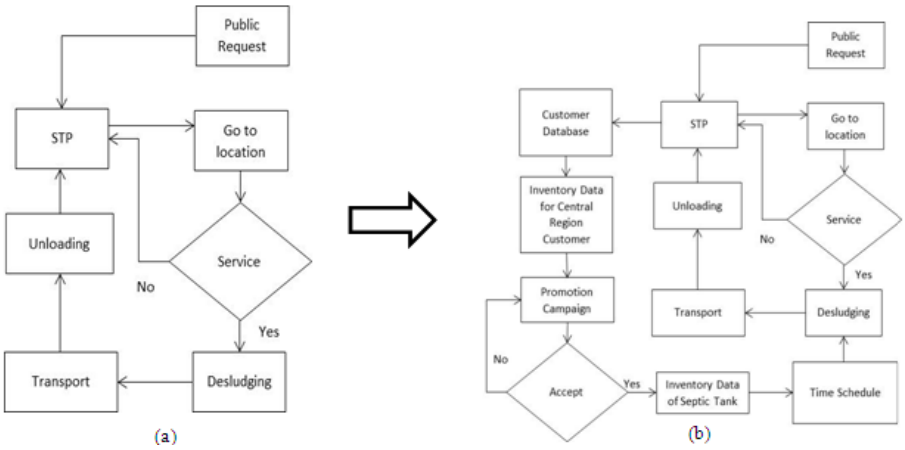

Figure-4. Optimizing of service pattern, (a) existingpattern, (b) optimized pattern.

Additional facilities

The use of another transportation facility should be considered for reaching limited areas and availability access to septic tank. Availability of access became very important because disruption of services or access could inhibit delaying septic tank desludging services. Smaller vehicles such as vacutug, molsta (motor cycle) and kedoteng can be applied special in the limited area and densely population with narrow pathways (Tilley *et al.* 2014). The use of a motor cycle can reach speeds of up to

12 km/h(Tilley *et al.* 2014), but its service radius will be effective in short distance.Generally, tank capacity of small vehicleswas 0.5 to 0.8 m^3(Tilley *et al.* 2014).Ifit operated in short distance, the average time required for septic tank desludging was 35 minutes. If the quantity of septage was 1.3 m^3, then the time required to desludge the septic tank between 70 to 105 minutes. If it is operated for eight hours, small vehicles might serve four households a day.

The use of smaller vehicles needs to be followed by the transfer station (TS) as intermediate dumping points for faecal sludge (Tilley *et al*. 2014). TS received septage from septic tank which desludge by small vehicle and after completion discharged, a vacuum truck empties the contents and takes the sludge to STP. So that, the location of TS should be easily accessible by vacuum truck. TS used may be mobile or fixed system (Strande *et al.* 2014) which served to prevent odors and facilitate the access of desludging (Boot, 2008). The number and capacity of TS were adjusted by the amount of small vehicle operated in a day. If it was operated in a day to serve four households, TS needs by one unit with a capacity of 6 m^3. If it operated was more than one unit, the number of TS should be added or the TS capacity should be enlarged. The pad and loading area of TS should be regularly cleaned to minimize odours, flies and other vectors from becoming nuisances (Tilley *et al.* 2014).

CONCLUSIONS

Optimizing of septage management is carried by scheduled services approach and commonly referred to regular desludging. It may reconnect the missing on-site system chain in Depok City. In regular desludging, the number of households should be served were 63,598 householdsin central region including District of Beji, Pancoran, Cipayung, Cilodong, and Sukmajaya. It needssix units of vacuum trucks with four trips a day.

Additional facilities such as smaller vehicles and TS should be considered to reach limited area and densely population with narrow pathways. Small vehicles might serve four households a day and TS needs one unit with storage capacity was 6 m^3. If it operated more than one unit, the number of TS should be added or its capacity should be enlarged.

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