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COMMUNAL SEPTIC TANKS AS APPROPRIATE TECHNOLOGY TO ACHIEVE SURABAYA OPEN DEFECATION FREE (ODF)

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ABSTRACT: Sanitation access is one of the important things in sustainable development. With reduced open defecation, it is expected to be able to achieve a high level of public health. However, the current condition in Surabaya, some people are still defecating in open places like open ditches and yards. This condition occurs for several reasons, such as the unavailability of land and the high cost of treating wastewater. Therefore, it is necessary to build a communal septic tank to create a healthier environment. The dimensions of the communal septic tank are actually regulated in National Standard (SNI) 03-2398 -2002 about Procedure for Planning Septic Tanks with Infiltration Systems. However, for the application, it must be aware with field condition, such as the width of the road, the presence of drainage canals water supply pipes, and the depth of the ground water level. Therefore, the dimensions of communal septic tanks were calculated with the number of house connection based on the field condition. As SNI 03-2398-2002 provides merely for 2, 3, 4, 5, and 10 house connection for communal septic tanks, this assessment proposes a standard of 8 house connections as field conditions will not allow rigid dimension as mentioned in the Standard. Eight house connections will allow the implementation of septic tanks in small foot-path as in densely populated sub-district with 2 to 3 meters width, the water table of 2 to 3 meters depth, and allow easy adjustment due to other local infrastructures like water supply pipe and the small path along local creeks.

Keywords: Open defecation, Field condition, SNI, Septic tanks

1. BACKGROUND

Goal number 6 of Sustainable Development Goals 2015-2030 is to achieve universal access to clean water and sanitation, including access for women and elderly people. Septic tanks are common on-site technology to treat black and grey water, both in urban and rural development. The technology is accepted at large as its construction cost is relatively cheap and while the technology is to provide the best available technology despite seepage due to poor construction. Soedjono [1] mentioned that seepage from septic tanks increased water-born related diseases. Minimum distance requirement of the septic tank from dug wells is easily achieved in rural areas but would be difficult in urban areas due to high house density [2].

Surabaya City as the capital of Jawa Timur Province has a total area of 33.048 ha which comprises Surabaya West, Surabaya Central, Surabaya South, Surabaya East, and Surabaya North. Based on Surabaya Statistical Office 2016, its population was 3.027.265 with a density of 7.996 persons/km^2.

Based on STBM-Indonesia 2017, there were 38 sub-districts or *kelurahans* which were ODF whereas total coverage of sanitation system in Surabaya was 98%. Based on Surabaya Health Agency [3], there were 2.390 houses in West Surabaya which still practiced open defecation (OD): 505 houses in the legal property while 1.885 were illegal. The same case was in Central Surabaya where 2.576 were OD with 1.350 in legal property and 1.226 was illegal. There were 2.786 OD houses in South Surabaya: 1441 legal and 1.345 illegal. There were 3.164 OD houses in East Surabaya with 1.628 legal and 1.536 illegal, while in North Surabaya there were 4.661 OD houses with 2.808 in the legal property while 1.803 were illegal. Totally, there were still 15.527 OD houses where 7.732 houses at the legal property while 7.795 were at the illegal property. Based on the data, communal septic tanks could be one of the best appropriate technology solutions for wastewater treatment to serve a dense population of Surabaya. It is not only low construction, but also households involve would provide individual closet [4].

According to Indonesian Standard of SNI 03-2398-2002 regarding Septic Tanks; it is possible to combine or separate the greywater from the blackwater. Tanks dimension of the combined system is obviously larger as mentioned in Standard. Septic tanks are allowed to serve a maximum of 10 houses and it must be de-sludged every three years. The Standard assumes that each house comprises of 5 persons. Availability of land

is very challenging as very dense sub-districts with local small housing may not have adequate space. The Standard must be flexible to allow adjustment of tanks dimension to accommodate the availability of land. This assessment is aimed to find the suitable location of communal septic tanks in Surabaya based on the Standard, but it is adjusted on land availability.

2. SCOPE OF THE STUDY

2.1 Study Area

The survey was conducted at East Surabaya in 7 districts of Tambaksari, Gubeng, Rungkut, Tenggilis Mejoyo, Gunung Anyar, Sukolilo, and Mulyorejo. A number of sub-district, community-like accusation (RW), and neighborhood-like accusation (RT) are shown in Table 1.

Table 1 Districts, Sub-districts, community-like accusation (RW), and neighborhood-like accusation (RT) in Surabaya

No.	District	No. of Sub-district	No. of RW	No. of RT
1.	Tambaksari	8	78	664
2.	Gubeng	6	52	418
3.	Rungkut	6	73	399
4.	Tenggilis Mejoyo	4	25	156
5	Gunung Anyar	4	29	178
6.	Sukolilo	7	67	363
7.	Mulyorejo	6	53	287

Source: Surabaya In Numbers, 2015, [5]

East Surabaya has a total area of 91.18 km^2 with a population of 779.250 people. Populations in each district are shown in Table 2.

Table 2 Area, number of population, and population density of each District in East Surabaya

No	District	Area (km^2)	Population (person)	Population Density (person/ km^2)
1.	Tambaksari	8.99	217.054	24.144
2.	Gubeng	7.99	137.821	17.249
3.	Rungkut	21.08	104.042	4.936
4.	Tenggilis Mejoyo	5.52	61.470	11.136
5.	Gunung Anyar	9.71	57.646	5.937
6.	Sukolilo	23.68	115.855	4.893
7.	Mulyorejo	14.21	85.362	11.136

Source: Districts in Numbers 2016 and Statistik Daerah Kecamatan 2016, [6]

2.2 Data Collections

Primary and secondary data were collected especially information regarding wastewater treatment with off-site sanitation system. Activities conducted during surveys included:

- Households survey regarding land ownership; including ODF status from the local health clinics (Puskesmas),
- Preliminary judgment regarding off-site systems to treat domestic wastewater using communal septic tanks, community wastewater treatment plants (IPAL), and MCK system (septic tanks to treat black and grey water),
- On-site mapping using GPS and google maps for OD houses where the three technologies mentioned above could be selected,
- Reconfirming the total house connection would be served: 2 to 10 connections.

2.3 Time Schedule

The survey was conducted in 60 days, including weekends, after notice of acknowledgment was given by Surabaya Government.

3. RESULTS AND DISCUSSIONS

3.1 Technology Options

Septic tanks are in fact inappropriate to be used in the high -populated city, but municipal septic tank mostly applied since the available area for a septic tank is limited. On the other hand, each house is in a close range area. The potency of soil and groundwater contamination issue caused by water infiltration from municipal septic tank treatment can be fixed according to Modul 05 [7]. If septic tank location planning is relatively near to well or any other water source and if it is not possible to be placed any further (according to [8]), then the retention time must be 3 days. This detention time is used with the estimation that pathogenic microbes will die outside human intestine within 3 days.

Community-based sanitation in Surabaya is supported by the community group of users and maintainers (KPP). Operation and maintenance of the unit need to keep the lifetime of the plants. The treatment units should be supported by realistic operational and maintenance cost to provide sustainable services [9].

3.2 Locations of Implementations

According to Ministry Regulation of Public Works number 04/2017, municipal wastewater distribution on-site system is applied for 2 to 10 houses. Location priority determination is done by:

a. Location with the highest houses with no toilets.
b. Communal septic tanks are not available for road width of fewer than 2 meters while the tanks are to serve of more than 5 houses.
c. Existence of drainage channel and water supply pipes may hinder the location selection.

The result from the determination of municipal septic tank location can be seen in Table 3. The situation in the research location can be seen in Figure 1 to Figure 3.

Table 3 Results of communal Septic Tank Location Determination

No	Location 1	Existing Conditions	A citizen with no Septic Tank	Number of Householders	Distance to Septic Tank (m)	Note
1	Labansari RT 2 RW 4 Kelurahan Dukuh Sutorejo	- Number of SR = 10 SR - Type of street = Jalan Kampung (paving) - Width of street = 2,3 m - Street condition (pipe installation check) = there is PDAM pipe alongside the river (along with the side of the street) - Septic tank to well distance (ownership) = there are municipal well 10 m from the planned septic tank. - Water ground level depth = 2 m - Water source = PDAM	Musija	6	32	
			Musripin 1	5	30	
			Musripin 2	5	17	
			Munasri	4	32	
			Irawati	5	15	
			Agustin	6	40	
			Mundik	4	50	
			Novi	4	70	Rent house
			Denik	5	75	
			Musriat	4	80	
2	Labansari RT 3 RW 4 Kelurahan Dukuh Sutorejo	- Number of SR = 9 SR - Type of street = Jalan Kampung (paving) - Width of street = 2,3 m - Street condition (pipe installation check) = there is PDAM pipe along side the river (along with the side of the street) - Septic tank to good distance (ownership) = there is no well - Water ground level depth = 2 m - Water source = PDAM	Arofah	2	60	
			Muis	3	48	
			Sholicah	6	48	
			Khairul	4	42	
			Sutrisno	4	46	
			Murtaji	3	68	Has no toilet
			Summoning	2	35	
			Sulistari	4	10	Municipal WC outside the house 5 houses, 4
			Suparti	5	12	
3	Kalisari Damen RT 3 RW 3 Kelurahan Kalisari	- Number of SR = 9 SR - Type of street = Jalan Kampung (aspal) - Width of street = 3 m - Street condition (pipe	Abdul Hasan	2	50	WC
			Gufron	6	50	
			Muhaimin	4	50	

Table 3 continued

		installation check) = there is PDAM pipe along side the river (along with the side of the street) - Septic tank to good distance (ownership) = there is no well - Water ground level depth = 3 m - Water source = PDAM	Rosila	5	50
			Sujono	2	50
			Soleh	4	25
			Misni	5	30
			Miftahul Huda	6	15
			Yasin	7	32
4	Kalisari Damen RT 3 RW 3 Kelurahan Kalisari	- Number of SR = 7 SR - Type of street = Jalan Kampung (aspal) - Width of street = 3 m - Street condition (pipe installation check) = there is PDAM pipe along side the river (along with the side of the street) - Septic tank to well distance (ownership) = there is no well - Water ground level depth = 3 m - Water source = PDAM	Ashari	7	15
			Kumala	4	25
			Suadah	4	30
			Ong Waskito	2	35
			Khusnul	4	32
			Saifudin	4	37
			Ongko	4	32

Fig.1 Sub -district Dukuh Sutorejo 10 SR (Jalan Labansari RT/RW: 02/04)

Fig.2 Sub -district Dukuh Sutorejo – 9 SR (Jalan Labansari RT/RW: 03/04)

Fig.3 Sub-district Kalisari – 7 SR dan 9 SR(Jalan Kalisari Damen RT/RW: 03/03)

3.2.1 Septic tank dimensions based on SNI 03-2398-2002

SNI 03-2398-2002 is a National Standard about Septic Tank with Recharge System Procedure that contains tables of septic tank dimension. Septic tank dimension is chosen according to the number of municipal septic tank user in the tables (SNI 03-2398-2002). The number of the maximum user according to SNI is 10 KK (1 KK = 5 people) with 3 years drainage provision and the system used is a separated system. Table of septic tank dimensions can be seen in Table 4.

Table 4 Separated Septic Tank Dimensions (*Black Water)* with 3 years desludging

No	Number of Users	Wet Zone	Sludge Zone	Freeboard Zone	Tank Length	Tank Width	Tank Height	Total Volume
	KK	m^3	m^3	m^3	m	m	m	m^3
1	2	0,4	0,9	0,3	1	0,8	1,3	1,6
2	3	0,6	1,35	0,5	1,8	1	1,4	2,45
3	4	0,8	1,8	0,6	2,1	1	1,5	3,2
4	5	1	2,6	0,9	2,4	1,2	1,6	4,5
5	10	2	5,25	1,5	3,2	1,6	1,7	8,7

Source: SNI-03-2398-2002, [8]

3.2.2 Adjustment dimensions of septic tanks

In general, rectangular septic tank is designed according to design criteria in SNI 03-2398-2002 with some important criteria like minimum width and length of 0.75 m 1.5 m, respectively, and if the tank length is longer than 2,4 m or tank volume is bigger than 5,6 m^3, then the tank will be separated in 2 compartments.

Septic tank dimension calculation is based on the number of SR that has not mentioned yet in SNI 03-2398-2002, on the other hand, the calculation also based on real field condition. Field condition is considered an important factor in the calculation. In previous research, there were some technical aspects that have to be considered in choosing treatment technology, such as clean water coverage, the layout of houses, groundwater level, and topography.

According to Farida and Damayanti [10], in choosing wastewater treatment system, is based on some factors, such as available water source, soil permeability, groundwater level, ground elevation, and society capability to pay.

This research conducts in one of the sub-district in East Surabaya, considering field condition such as street width between 2-3 m, groundwater level 2 -3 m, PDAM pipe alongside the street, and street location along the river. Eight houses (equal 40 persons) are to be connected to communal septic tanks based on the above consideration.

The design of the communal septic tanks would have a hydraulic retention time of 3 days, with 1.5 widths and 1.6 depth. Based on Modul 05 [7], if septic tank to be built location plan is relatively near well or water source and if it is not possible to be placed any further (according to SNI 03-2398-2002 qualification), then the detention time must be 3 days. This detention time is used with the estimation that pathogenic microbes will die outside human intestine within 3 days (more than 0.5 days of Indonesia Design Criteria). With the assumption of 35 l of sludge/person.year, then for 40 persons in 3 years would sludge volume of 4200 liters.

With the assumption of total flushing of 10 l/person.day, then for hydraulic retention of 3 days for 40 persons would need a volume of 1200 liters. When sludge volume is combined with flushing then the volume of the communal septic tank is at least 5400 liters. If septic tank depth is 1.6 meter, then the width and length would be 1.2 meters and 2.8 meters, respectively. The free board could be designed for at least 0.3 meters.

Septic tank dimension determination can be calculated with two ways, such as, manual calculation or using tables according to [8]. Based on these two ways to determine the dimension for septic tank planning, the result can be seen in Table 5.

Table 5 Separated Septic Tank Dimension (*Black Water)* 3 Years Drainage

No	Number of Users	Wet Zone	Sludge Zone	Freeboard Zone	Tank Length	Tank Width	Tank Height	Total Volume	Source
	SR	m^3	m^3	m^3	m	m	m	m	
1	5	1	2,6	0,9	2,4	1,2	1,6	4,5	SNI
2	8	1,2	4,2	1,008	2,8	1,2	1,6	6,408	Calculation
3	10	2	5,25	1,5	3,2	1,6	1,7	8,7	SNI

4. CONCLUSIONS

As SNI 03-2398-2002 provides merely for 2, 3, 4, 5, and 10 house connection for communal septic tanks, this assessment proposes a standard of 8 house connections as field conditions will not allow rigid dimension as mentioned in the Standard. Eight house connections will allow the implementation of septic tanks in small foot-path as in densely populated sub-district with 2 to 3 meters width, the water table of 2 to 3 meters depth, and allow easy adjustment due to other local infrastructures like water supply pipe and the small path along local creeks.

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6. REFERENCES

[1] Soedjono, E.S., Fitriani, N., Yuniarto, A. and Wjiaya, I.M.W. Provision of Healthy Toilet for Low Income Community based on Community Empowerment in Kelurahan Kebonsari, Surabaya City, towards Indonesia Open Defecation Free (ODF) in 2019. Proceedings of the 3rd International Conference on Construction and Building Engineering (ICONBUILD), 2017.

[2] Sudarmadji D.H.. Tangki Septik dan Peresapannya sebagai Sistem Pembuangan Air Kotor di Permukiman Rumah Tinggal Keluarga. Jurnal Teknik Sipil, Vol. 9, No. 2, 2013.

[3] Dinas Kesehatan. Studi Environmental Health Risk Assessment (EHRA) Kota Surabaya. Dinas Kesehatan Pemerintah Kota Surabaya, 2015.

[4] Nurhidayat A. dan Hermana J. Strategi Pengelolaan Air Limbah Domestik dengan Sistim Sanitasi Skala Lingkungan Berbasis Masyarakat di Kota Batu Jawa Timur. Prosiding Seminar Nasional Manajemen Teknologi X, 2009.

[5] Badan Pusat Statistik. Surabaya Dalam Angka 2015. Badan Pusat Statistik Kota Surabaya, 2015.

[6] Badan Pusat Statistik. Kecamatan dalam Angka 2016. Badan Pusat Statistik Kota Surabaya, 2016.

[7] Kementrian Pekerjaan Umum. Materi Bidang Air Limbah Diseminasi dan Sosialisasi Keteknikan Bidang PLP (Modul 05. Perencanaan Pengelolaan Air Limbah Setempat). Direktorat PLP-Direktorat Jenderal Cipta Karya, 2013.

[8] SNI : 03-2398-2002 – Tata Cara Perencanaan Tangki Septik dengan Sistem Peresapan .

[9] Soedjono, E.S.,Fitriani, N., Setiawan, A., Mulia, G.J.T., Ningsih, D.A. Study on Communal Wastewater Treatment Plants (CWWTPs) in Gresik, Indonesia. The 2nd International Symposium on Civil and Environmental Engineering (ISCEE), 2018.

[10] Farida D. dan Damayanti A. Strategi Pengelolaan Air Limbah Permukiman di Kecamatan Woha Kabupaten Bima. Seminar Nasional 2012-Waste Management, 2012.