Sustainability study of domestic communal wastewater treatment plant in Surabaya City

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Submission date: 23-May-2022 10:38AM (UTC+0700)
Submission ID: 1842160167
File name: Sustainability_study_of_domestic_communal_wastewat.pdf (390.77K)
Word count: 3600
Character count: 20669

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2017 IOP Conf. Ser.: Earth Environ. Sci. 70 012012

(http://iopscience.iop.org/1755-1315/70/1/012012)

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Abstract. Sanitation is one of the critical infrastructure sectors in order to improve community health status. The Ministry of Public Works of the Republic of Indonesia to define that word sanitation include: domestic waste water management, solid waste management, rain water management (drainage management) as well as the provision of clean water. Surabaya city as the capital of East Java province and Indonesia's second largest city with a population of 2,853,661 inhabitants in 2014 (the second largest after Jakarta), but the people who have been served by the sanitation infrastructure systems were expected at 176,105 families or about 26.95 % of the population of the city is already using sanitation facilities. In the White Book Sanitation of Surabaya City in 2010, Surabaya City sanitation development mission is to realize the wastewater management of settlements in a sustainable and affordable by the community. This study aims to assess the sustainability of the wastewater treatment plant (WWTP) domestic communal in the city of Surabaya. The method in this research is quantitative method through observation, structured interviews and laboratory testing of the variables analyzed. Analyses were performed using a technique Multidisciplinary rapid appraisal (Rap-fish) to determine the level of sustainability of the management of communal WWTP based on a number of attributes that easy scored. Attributes of each dimension includes the technical, environmental quality, institutional, economic, and social. The results of this study are sustainability index of environmental quality dimension at 84.32 with highly sustainable status, technical dimension at 62.61 with fairly sustainable status, social dimension at 57.98 with fairly sustainable status, economic dimension at 43.24 with less sustainable status, and institutional dimension at 39.67 with less sustainable status.

1. Introduction

Today there are many people in Indonesia who have difficulty accessing clean water and sanitation due to the limitations of the existing infrastructure. In accordance with the Millennium Development Goals (MDGs), the Government has set a target in 2015 that as many as 68.87% of the total Indonesian population should have access to improved drinking water sources, while access to adequate sanitation facilities is as much as 62.41% [1]. Based on data from the Central Statistics Agency (BPS), for the period 2011 to 2014 Q1, the proportion of households to sanitation is 61.04% for basic sanitation in urban and rural areas. But it is merely a quantity not quality. When viewed from the quality is still

51.02% of the families in Indonesia have access to improved sanitation [2]. Report of the Health Research Ministry of Health in 2013 showed that the proportion of households with access to improved sanitation facilities in Indonesia in 2013 amounted to 59.8 %. When compared with the results Riskesdas 2007 and 2010, the proportion of households Indonesia have access to improved sanitation facilities tend to increase (2007: 40.3%; 2010: 51.5%; 2013: 59.8%).

In urban areas easily seen their means of wastewater that flowed through the channels, where wastewater from the household immediately flowed into channels in the area around the settlements to the water bodies nearby creeks and rivers. Besides flowed into the channels that exist, there is an approach to business processing household waste water is to use a communal domestic WWTP. More and more domestic communal WWTP that creates a variety of problems associated with sustainability, because during this time the concept of management of communal WWTP less domestically involving all stakeholders and not be seen from various aspects. Under these conditions certainly needed a study to formulate the concept of effective management to achieve sustainability of domestic WWTP communal [3].

Surabaya city as the capital of East Java province and Indonesia's second largest city, and the city is quite important in eastern Indonesia continues to experience population growth, and to experience growth in population lifestyles. Based on the report Surabaya in Figures 2015 published by BPS Surabaya, Surabaya total population reached 2,853,661 inhabitants in 2014 (the second largest after Jakarta). The population is so big no wonder the Surabaya City development results in more buildings for the centers to attract people outside the city of Surabaya to enter and stay in the city of Surabaya well as seasonal residents and permanent residents. Population growth demanded accretion residences, ranging from the very simple, which is in river side or channel up to luxurious. Urban development is not integrated with the surrounding area will pose complex problems such as environmental health problems, pollution, water supply and disposal of domestic wastewater.

Systems and conditions of the disposal of domestic wastewater in the city of Surabaya, based on information from Surabaya City Health Office, the conditions and the level of sanitation services related to the problem of sewerage in the city of Surabaya is still less qualified technical and health. Some locations have supplied domestic waste disposal facilities, but there are some that can't be used anymore. This is due to lack of awareness of society to live a healthy life as well as the cost factor for the operation and maintenance of sanitation facilities. Based on number examined in each health center can be concluded that, people who have been served by the sanitation infrastructure systems were expected to total 176,105 households, or about 26.95% of the population of the city is already using sanitation facilities. Therefore we need an assessment of the sustainability of wastewater management in particular settlements WWTP domestic communal in Surabaya who can provide fill to related parties.

2. Literature Review

Wastewater resources from domestic activities such as from urine, bathing, washing appliances, washing clothes and other kitchen activities before being discharged into waterways should be processed first in sewage treatment plants. The basic principle is that the waste water released into the environment is not dangerous for the health of the environment. The waste water is not managed properly can have very wide, for example, can poison drinking water, poison pet food, the cause of the imbalance of river ecosystems and soon [4]. Each body of water whose quality has been affected by human activities may be regarded as wastewater. Domestic wastewater can be from the residence, industry or agriculture. Domestic wastewater includes a wide range of contaminants that can be potentially dangerous or concentration, which can lead to degradation of water quality. Potential contaminants include soap and detergent from the bathroom, food scraps and grease from the kitchen and other human activities that involve the use of water. Household waste is waste generated from household activities and activities of man routine sanitation [5].

Environmental pollution in the water body is most often caused by domestic wastewater. Therefore, the handling of domestic waste water needs to be done through wastewater treatment with the aim to lower the concentration and load of pollutants before being discharged into the environment [6].

Domestic waste water management strategies need to consider the environmental, social, economic and cultural. So the technology and systems used in the processing of domestic waste water should be inexpensive and socially acceptable and environmentally friendly [7]. Domestic wastewater management program that is now being developed in urban areas is a centralized processing system with the involvement of the community as empowerment in the form of sewerage piping system that is processed in a communal domestic WWTP. According to the Ministry of Public Works, in the form of communal WWTP piping system that drains waste water from households connected to the piping system and the processing is done centrally. Treatment sludge dewatering pipe network and processed former WWTP, periodically needs to be cleaned and drained, so it needs to be managed by local non-governmental groups [8].

Meanwhile, according to (Balkema et al, 2002), indicators of sustainable development criteria on domestic waste water management includes several things, among others;

1. Technology, one of the functional indicators that affect the wastewater treatment system includes the technical requirements that include the ability of the system to expand the processing capacity, accept fluctuations in the quality of the effluent quality and reliability of the system. Operating system expensive and complicated will affect the sustainability of the system, because it involves the human resource capacity to manage the system.
2. Financing, economic sustainability implies financing undertaken by the community aimed at the interests of the community itself with a value that does not exceed the benefits. Sustainability indicators used domestic waste water treatment systems on the economic aspects could include investment costs, operating and maintenance including the affordability of financing by the people or parties.
3. Institutional, Institutional is an indicator of the sustainability of domestic waste water treatment system of socio-cultural aspects that give an important role. Domestic waste water treatment systems are very diverse in need of regulations and institutions in accordance with the implemented system. Institutional itself generally serves as decision-makers and regulators, development and implementation of operational and service.
4. Community participation, involvement and community involvement in the development both in the planning and implementation be an actualization of the availability of people to contribute in every stage of development. Ignorance, behaviors / habits and perceptions will affect the domestic waste water treatment systems. Different socio-cultural conditions will have a different perception of the concept of waste and sanitation, so the existence of domestic wastewater which is more accepted by society will stimulate increased awareness and social responsibility towards the environment in the vicinity.
5. Environment, one indicator of the sustainability of domestic waste water treatment system is good or bad quality of the waste generated by the system. The quality of wastewater that will either give less environmental pressure against the media receiver wastewater. Some countries set limits wastewater quality with certain standards with several physical parameters, chemical, biological and presence of other living creatures [9].

3. Methods

In analysing the sustainability of one of the methods used are Rapid Appraisal for Fisheries (Rap-fish) is a technique for assessing the sustainability of fisheries using a number of attributes that are multidisciplinary to evaluate the comparative sustainability based on various dimensions revealed to be a number of attributes / indicators to be done scoring [10]. Rap-fish used in calculating the sustainability of communal WWTP, is a modification of Rap-fish developed by the University of British Columbia, Canada and used to assess the sustainability fishing. Sustainability status assessment using software techniques Rap-fish with Multidimensional Scaling (MDS), which has many advantages, including a simple, easily valued, fast and cost required relatively inexpensive. In addition, this technique may explain the relationship of the various aspects of sustainability and also defines a flexible regional development [11].

Indicators of sustainable development criteria of domestic wastewater management includes several things including technology, financing, institutional, community and the environment. Rap-fish modified are used to determine the level of sustainability of the management of communal WWTP based on a number of attributes that easy scored. Attributes or indicators of any dimension or variable (technical, environmental quality, institutional, economic, and social) will be evaluated and may be selected to reflect sustainability, and can be fixed or can be replaced when the latest information was obtained. Attributes in the technical aspects include the physical condition of the WWTP, the suitability of the location of the WWTP with the planning, the production capacity of the WWTP and the removal efficiency of contaminants. Attributes environmental quality aspects can be seen from the WWTP effluent parameters on the fulfilment of quality standards by East Java Governor Regulation No. 72 Year 2013, namely the parameters pH, BOD5, COD, TSS and Oils and Grease. Attributes in the institutional aspects include local institutions, the role of government and regulations. Attributes in the economic aspects include physical construction costs and operating and maintenance costs. Attributes include participation in social aspects and public perception. An assessment of the attributes of each dimension is done through observation, literature studies, laboratory tests and the results of the questionnaire. Examples of attributes on a technical dimension and weight criteria of assessment can be seen in Table 1.

Table 1. Dimensions and attributes WWTP sustainability assessment communal

Dimension / Attributes	Low	High	Criteria
Technical			
Physical Condition	1	3	(1) not according to plan (2) according to plan but a lot of mistakes (3) in the planning horizon
Conformity Layout	1	3	(1) not according to plan without explanation (2) does not fit no explanation planning (3) appropriate planning
Capacity	1	3	(1) 0-50% of inflow planning (2) 51-99% inflow planning (3) debit entry according to plan
Efficiency	1	2	(1) Not according to plan (2) Based on planning

Whereas in determining the sustainability status communal WWTP use categories as submitted by (Suyitman et al, 2009). Tabulation category status of WWTP sustainability are presented in Table 2[12].

Table 2. Category of WWTP Sustainability

Index Value	Category
0,00-25,00	unsustainable
25,01-50,00	less sustainable
50,01-75,00	fairly sustainable
75,01-100,00	highly sustainable

4. Results

The study on the sustainability of wastewater domestic communal in the city of Surabaya was conducted in Krembangan WWTP where located in the northern city of Surabaya. Based on Rap-fish analysis, sustainability index on each dimensions displayed in a graphic image. For example, sustainability index for technical dimension can be seen in figure 1.

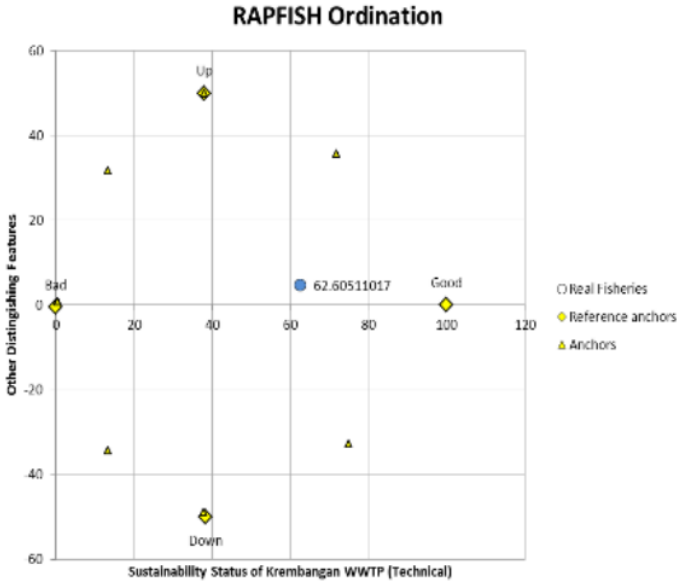

Figure 1. Sustainability Index of Krembangan WWTP (technical)

In addition, that analysis also displayed leverage atrributes and Montecarlo analysis. Leverage is used to see which most sensitive attribute to changes in the value of sustainability dimension. The highest value is the most the most sensitive attribute. Leverage attribute for technical dimension can be seen in figure 2. The Montecarlo analysis was used to compare the sustainability value of the MDS analysis and then see the difference in value to account this study. The value of Montecarlo analysis can be seen in figure 3. Then, detailed results of the analysis on each dimension presented in Table 3.

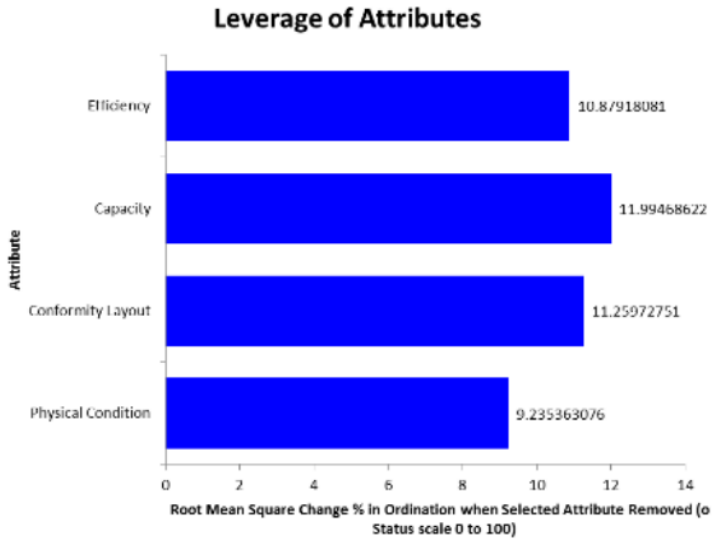

Figure 2. Leverage attributes of Krembangan WWTP (technical)

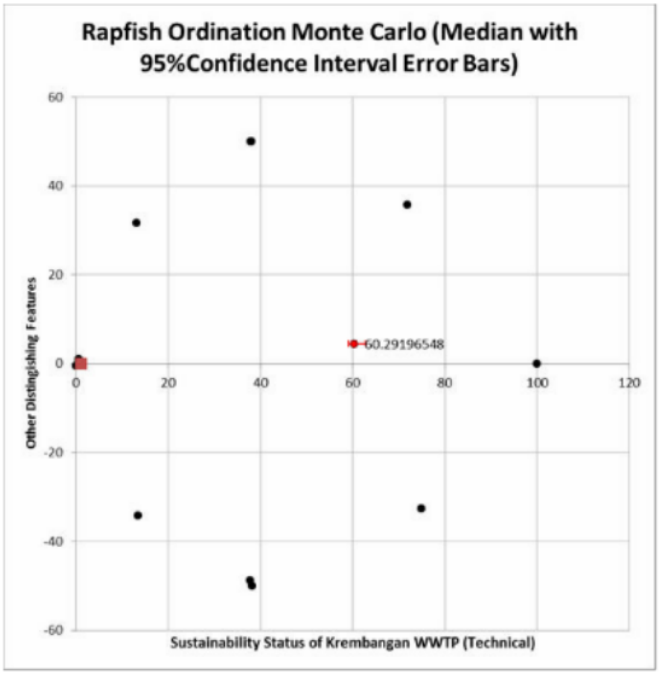

Figure 3. Montecarlo Index of Krembangan WWTP (technical)

Table 3. Sustainability index on each dimension

Location	Dimension	Indeks (%)		Deviation	R^2	Stress
		MDS (Rapfish)	Monte Carlo			
Krembangan WWTP	Environmental Quality	84.32	81.25	3.07	0.9582	0.1304
	Technical	62.61	60.29	2.32	0.9636	0.1289
	Social	57.98	56.37	1.61	0.9679	0.1291
	Economic	43.24	41.98	1.26	0.9674	0.1307
	Institutional	39.67	39.35	0.32	0.9734	0.1239

The results of the analysis with MDS methods and analysis with Monte Carlo method produces a very small difference as in column 4, not more than 5%. This proves the level of confidence in the total index (Multidimensional), confidence in the value of the index every dimension, and the effect of errors that can affect the whole process of analysis with MDS method is exceeding 95%. From Monte Carlo analysis concluded that (1) the impact of mistakes towards making a score on each attribute is very small; (2) the error caused by because of the understanding, differences of opinion, or judgment of a researcher different from each other, is relatively small; (3) data entry errors or missing data, or the value of "stress" is too high, it is very small; (4) error procedures that could affect the stability of the MDS

analysis process is also relatively small. The results of the analysis (Table 2) shows that each dimension and multi-dimensional value "stress" is much smaller than the provision which states that the value of "stress" on the analysis by the method of MDS is sufficient if the obtained value <0.25. Because the smaller the value of "stress" which earned means the better the quality of the analysis performed. In contrast to the coefficient of determination (R2), the quality of the analysis results are better if the coefficient of determination is greater (close to 1). Thus, from the second parameter (the value of "stress" and R2) shows that all the attributes used in the analysis of the sustainability of the shore zone management system is good enough in light of the five dimensions of development are analyzed [13].

The index value of sustainability dimension of environmental quality, economic, social, technical, and institutional can be illustrated in the kite diagram as shown in Figure 3.

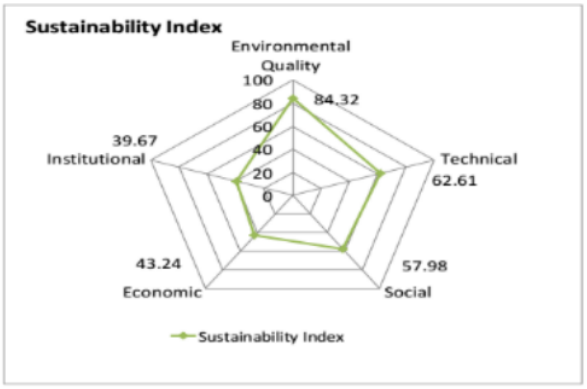

Figure 4. Kite diagram of Krembangan WWTP sustainability index

5. Conclusion

Based on the analysis method Rap-fish, the sustainability status of communal domestic WWTP Krembangan, Surabaya are environmental quality dimension at 84.32 with highly sustainable status, technical dimension at 62.61 with fairly sustainable status, social dimension at 57.98 with fairly sustainable status, economic dimension at 43.24 with less sustainable status, and institutional dimension at 39.67 with less sustainable status.

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