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THE STRATEGIES TO REDUCE THE SPREAD OF NITROGEN FROM DOMESTIC WASTEWATER TREATMENT TO THE STREAMS IN SURABAYA CITY, INDONESIA

*I Made Wahyu Wijaya, Eddy Setiadi Soedjono, Agus Slamet

Department of Environmental Engineering, Faculty of Civil, Environmental and Geo Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

*Correspondence Author: Received: 22 Oct. 2018, Revised: 20 Nov. 2018, Accepted: 10 Dec. 2018

ABSTRACT: Wastewater is belong to one of the parts of sanitation objects. According to the studies, there is 7,98% of area was categorised as very high risk sanitation while 12,88% got high risk sanitation. There is still 1 % of the society practicing open defecation in the sewerage, and 0,27% to the land. As the part of sanitation, provision of wastewater treatment is one of the efforts to reach the universal access of 100-0-100, which means achieving 100% served by proper sanitation. The pollution in the mainstream is caused by the untreated domestic wastewater, which is directly discharged to the river. The wastewater services in Surabaya City by 2015 is 97,53% with 43 domestic wastewater installed. Surabaya City has some rules to manage and control the domestic wastewater. The effluent of domestic wastewater treatment is controlled by the rules with some parameters. The nitrogen content of the effluent in some domestic wastewater treatment was analysed according to APHA. The strategies were described according to the local sanitation strategic in Surabaya City. This study shown that there were three out of seven units of ABR have higher concentration of ammonium comparing with the national standard. Surabaya City has Sanitation Development Plan 2017, which is clearly describing the strategies plan for the domestic wastewater development 2017-2021. These strategies including the implement of related local rules, increase of wastewater services, increase of knowledge, participation and awareness of the society, increase the provision and access of sanitation supporting facilities, and optimization of sludge treatment in Surabaya City.

Keyword: ABR, Community-based sanitation, Domestic wastewater, Environmental management, Nitrogen removal, Sanitation

1. INTRODUCTION

Environment problem still becomes an important issue in the urban area along with the dynamic economic and development growth. As the center of economic, urban area achieves high urbanization and increases the demand for resources, such as food, water, electricity, goods, land, etc. The impact is pressure on the environment-support capacity in receiving the waste from the people's activities. According to the Sustainable Development concept, improvement of environmental protection should be integrated with the development process. Surabaya as the second largest city and one of economic and business center in Indonesia with the population reach about 2,8 million in 2010. As a metropolitan city, urban management is strongly important to create a better living condition heading to Sustainable Development Goals. The rapid growth of population in the urban area has significantly influenced the rate of water consumption and combined with increasing wastewater generation.

The sanitation system is the most important system for the society that should be provided properly because it's directly related with the human's health [1]. Some of the sanitation issues which exist in the urban area, including wastewater management, solid waste management, drinking water distribution, and open defecation. According to Environmental Health and Risk Assessment (EHRA) 2015, only 1% of the people in Surabaya who still doing open defecation, about 91% has their own toilet, and the rest is usina g a public toilet. This result is shown that the good awareness of people in Surabaya. In term of sewerage services, there are 18% of the households have not connected yet with the sewerage system or wastewater system.

Domestic wastewater effluent becomes a contributor to diverse water pollution. It is discharged from the households and became the main contributor of wastewater as well. Some of the problems caused by wastewater, such as eutrophication, increasing treatment cost, decreasing the recreational value of water, health risks to humans and livestock, loss of oxygen and undesirable changes in the aquatic ecosystem. In

order to prevent the pollution risks, wastewater treatment urgently needed the before the wastewater discharged to the environment [2], [3]. Most of the domestic wastewater is generated as a result of living habits, human disposal, residual liquid product, and waste from artificial installation. Wastewater treatment should be considered as part of ecological sustainability [4]. Many aspects are very closely related with the wastewater treatment, such as wastewater characteristic, space availability, technology, human resources, cost, and policy. As the part of sanitation, provision of wastewater treatment is one of the efforts to reach the universal access of 100-0-100, which means achieving 100% served by proper sanitation.

Regarding domestic wastewater management, the government of Surabaya City applies the decentralized wastewater treatment system (DWTS). There are many DWTS has been applied in many areas in Surabaya. The lack of available space and preferring to appropriate technology for the society, become the reasons for using DWTS. Anaerobic baffled reactor (ABR) with some modifications is the most treatment plan that using by the society. This appropriate technology is low cost and easier to manage by the society. An ABR can serve about 50-100 households. The effluent is discharged to the mainstream or reused as dewatering. Some problems come up with the application of ABR, such as a low user in case of the high cost to build a connection to DWTS and in case of effluent quality that is still containing an amount of nutrient, especially ammonium. The using of ABR is increasing year by year, so it needs to be improved to produce better effluent in term of nutrient. Biological nitrogen removal has been widely used as a promising technology in removing nitrogen from wastewater. Conventional technology still retains the basic principle of complete nitrogen cycle through nitrification and denitrification [5]. Anammox is a sustainable and cost-effective alternative to the basic method of nitrogen removal. Anammox has been identified as a new biotechnology for nitrogen reduction from wastewater. It has advantages of reducing greenhouse gas emission, low carbon consumption, the low energy needed and high performance. The effluent of several units of ABR is already checked out and compared with the previous research to understand the nutrient content. The characterization of the effluent, in case of nutrient, is one of the important factors for assessment of the performance of ABR [6].

Water management in Indonesia has been strongly supported by the government in all levels, communities, and academia. A bottom-up approach has been researched as one of the program decision processes that is based on the needed of society. This system starts from the lowest level of government that is sub-district then going up to the national level. The provision of sanitation facilities is belonging to the program which is proposed by the society. The main objective of the system is to match up the work plan of central government with the social needs in low level, in term of timing and budgeting.

The application of technology cannot be separated from the local regulation or policy itself. This research will be focused on nitrogen content in the effluent of ABR and the strategies of domestic wastewater development in Surabaya City.

2. METHODS

This study divided into 2 parts: characterization of the nitrogen content in domestic wastewater and describing the local regulation and policy related to domestic wastewater management in Surabaya City. The measurement of ammonium and nitrate was done according to Standard Method [7]. There were 7 locations of ABR spread out in Surabaya City for collecting wastewater samples: (a) Medokan Semampir, (b) Genteng Candi Rejo, (c) Tegalsari, (d) Genteng, (e) Sukolilo, (f) Wonocolo, (g) Dukuh Pakis. All samples were analyzed in the Laboratory of Water Management, Institut Teknologi Sepuluh Nopember, Surabaya. All regulations and recent policies will be collected from the government, Surabaya Sanitation Strategic Report 2017 and referring to related previous research.

3. RESULTS AND DISCUSSION

3.1 Domestic Wastewater Development in Surabaya City

Wastewater belongs to one of the parts of sanitation objects. The pollution in the mainstream is caused by the untreated wastewater, which is directly discharged to the river. Besides, the practice of open defecation also strongly pollutes the mainstream. Especially in the settlement, which is exist beside the river, still some households do not has proper disposal system. On 2015, the condition there was an increase of the using of private toilet and septic tank. The Government of Surabaya City has released a map, which is showing the distribution of sanitation risk for wastewater in Surabaya City for 2016. The data was divided by low category (blue), middle category (green), high category (yellow) and very high category (red) for 163 sub-districts in Surabaya City. The data shown

that about 7,98% the area was categorised as very high risk sanitation while 12,88% got high risk sanitation. The rest was stated as middle and low risk sanitation [8].

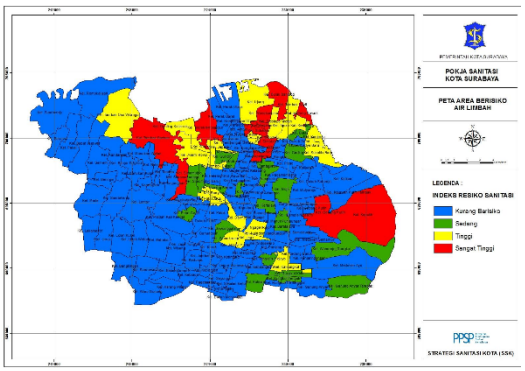

Fig 1. Map of area with sanitation risk in Surabaya City (Source: Surabaya Sanitation Strategic Plan 2017)

Based on the study of Environment Health Risk Assessment (EHRA) 2015, 91% of the society stated the use of the private toilet, while 7,63% are using a public toilet, other 1 % are still doing open defecation in the sewerage, and 0,27% to the land.

There is 8,6% of the households are connected with the sewer as domestic wastewater discharging, 85,4% are using a septic tank, 3% are directly discharging to drainage and 2,9% of others. Overall, the wastewater services in Surabaya City by 2015 is 97,53%. Until 2016, Surabaya City has built 43 units of communal domestic wastewater treatment (off-site system) which is spreading out over 18 districts. Tabel 2 shown the number of on-site and off-site system in Surabaya City.

A previous research has been conducted in triggering the community to use the proper toilet with the septic tank attached in their house. About 7 septic tanks were built in 7 houses and the financial support was directly distributed to each family in partial method. The lesson-learned of this program was financial support is really important for the family who does not has a proper toilet because of the financial problem. In this case, the triggering was used to reach the open defecation free (ODF) target according to National Long-Term Development Plan of Indonesia.

According to Balkema [9]–[11], there are three keys of sustainability, including for wastewater development, such as economy, environment, and social culture. The environment sustainability is referring to the ability of environment to support and sustain the human life.

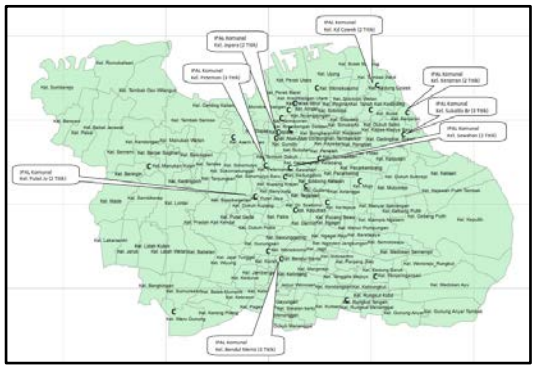

Fig 2. Map of Communal Wastewater Treatment Plant (C) Distribution in Surabaya City (Source: Surabaya Sanitation Strategic Plan 2017)

Table 2. Recent condition of domestic wastewater treatment system facilities in Surabaya City.

No	System	Unit	Number/ Capacity
On-site system			
1	Communal septic tank (<10 households)	Unit	0
2	Public toilet	Unit	114
3	Sludge collector (truck)	Unit	1
4	Final sludge treatment	m^3/day	400
Off-site system			
1	Communal septic tank (<10 households)	Unit	0
2	DWWTP communal scale	Unit	43
3	DWWTP city scale	Unit	0
4	DWWTP regional scale	Unit	0

Source: Surabaya Sanitation Strategies Planning 2017

Regarding the economic problem for the low-income community, the partial method can be like giving a deposit to initiate the installation and the user paid by instalment for 6-12 months based on their economic ability. The community will be involved to all of the installations. This program is also expected to increase the awareness and knowledge of the community about the importance of having health and proper toilet.

In environmental side, the wastewater effluent and open defecation still become the source of river pollution in Surabaya City [12]. More than 30 years, Surabaya has been using river water as the main source of raw material for drinking water production.

Fig 3. One of the ABR unit, which is attached in the public toilet

A previous research [13] found the average water quality in Kalimas River, such as pH ± 7,5, dissolved oxygen (DO) ± 3,5 mg/L, chemical oxygen demand (COD) ± 36,8 mg/L, biological oxygen demand (BOD) ± 21,25 mg/L, orthophosphate (PO_4) ± 0,234 mg/L, nitrate (NO_3) ± 2,32 mg/L, and ammonium (NH_4) ± 0,88 mg/L. Those results were exceeded the Government Regulation No. 82/2001, which for the class I river category, the maximum is 2 mg/L for BOD, 10 mg/L for COD, and 50 mg/L for TSS.

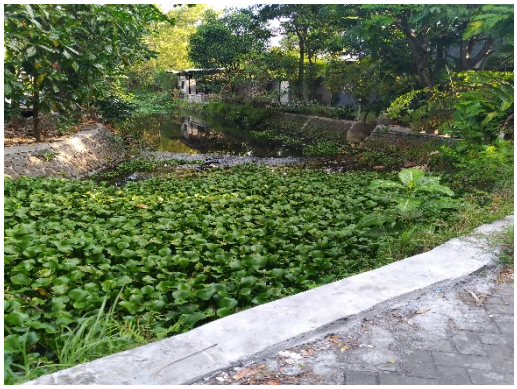

Fig 4. View of eutrophication in one of drainage in Surabaya City

Controlling the effluent quality is urgently needed to against the pollution rate to the river. The regulation can be the tool that can control the effluent quality.

In managing the wastewater, Surabaya City is referring to some regulations from the centre government and local government, such as:

- The Rule of Government of Indonesia (Peraturan Pemerintah Republik Indonesia) No. 82/2001 about the management of water quality and controlling of water pollution
- The Rule of Ministry of Environment and Forestry (Peraturan Menteri Lingkungan Hidup dan Kehutanan Republik Indonesia) No. 68/2016 about quality standard of domestic wastewater. In this standard, some parameters are clearly define with the maximum concentration in the effluent, such as pH 6-9, BOD 30 mg/L, COD 100 mg/L, TSS 30 mg/L, oil and grease 5 mg/L, ammonia 10 mg/L, and total coliform 3000/100 mL [14].
- The City Rule of Surabaya (Peraturan Daerah Kota Surabaya) No. 12/2016 about the management of water quality and controlling of wastewater.
- The City Rule of Surabaya (Peraturan Daerah Kota Surabaya) No.1/2016 about the retribution of wastewater management
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3.2 The Nitrogen Content in Domestic Wastewater in Surabaya City

Since the used of ABR as domestic wastewater treatment, the effluent quality is controlled. Most of the effluent discharged directly to the mainstream, the other are using for dewatering. The presence of nitrogen in form of ammonium or nitrate in the effluent will be strongly risk the water body. A lot of nitrogen with phosphate in the water will increase the rate of eutrophication that can affect the aquatic life. Based on the previous study, amount of 1-2 mg/L of total nitrogen and 0.03-0.1 mg/L of total phosphorus will cause eutrophication [15]. Nitrogen discharge to the main water is danger for both of human and aquatic life. Nitrate can cause serious problem when diverse to the water, such like depletion of oxygen in the water and eutrophication [16]. Several ABR have been checked out by measuring the effluent characteristic, especially ammonium and nitrate. This part is compared with the effluent standard of the regulations. The effluent was taken from the outlet or last compartment of the ABR unit. Fig 5 and Fig 6 show the results and comparison with the effluent standard.

Based on the results, there were three ABR units that the effluent is containing ammonium higher comparing with the standard. The highest ammonium concentration was found in the effluent of ABR in Genteng area with 38,91 mg NH4-N/L while the lowest was found in Genteng Candirejo. The ABR in Genteng Candirejo has five compartments and was found well maintain. The local community carries out the maintenance and budgeting as well. The effluent from this ABR is used for dewatering and catfish breeding. In addition, the ABR is modified by adding two filter installations before and after the baffled process, respectively. However, those other concentrations still have risk to encourage the eutrophication rate if diverse to the river.

Theoretically, organic nitrogen is converted to total ammonium nitrogen under anaerobic conditions, and its amount is converted to nitrate due to a small amount of oxygen. The concentration of long-term exposure to aquatic organisms is much higher than the safety limit of 1.0 mg/L [17]. Organic and inorganic forms of nitrogen can generate eutrophication in lake, river, estuarine and coastal area. Nitrogen sources in domestic wastewater are food waste, soap, and fertilizer [18]. In complete nitrogen cycle, ammonia is oxidized to nitrate, creating an oxygen demand and low dissolved oxygen in the water. Nitrogen in the form of ammonia is toxic to fish and exerts an oxygen demand on receiving water by nitrifiers [19], [20].

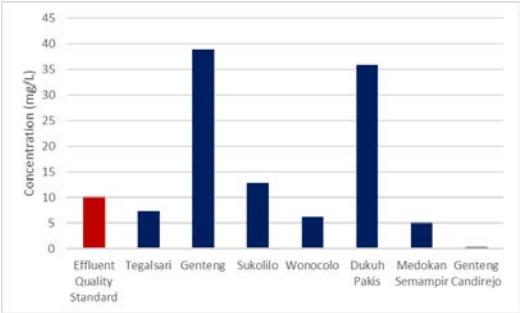

Fig 5. The concentration of ammonium (NH_4) in the effluent of ABR unit in Surabaya City

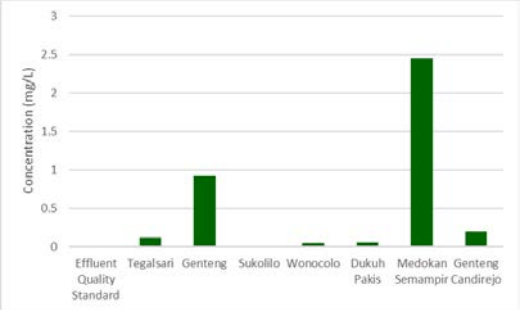

Fig 6. The concentration of nitrate (NO_3) in the effluent of ABR unit in Surabaya City

3.3 Development Strategies for Domestic Wastewater in Surabaya City

Generally, the development in Indonesia has conducted by using top-down and bottom-up approach. A top-down approach starts from the central government to the lowest level of local government while bottom-up is the opposite. Previous research by Soedjono [21] found the implementation of bottom-up approach in wastewater development in Jawa Timur Province, which is Surabaya City is the capital. The development planning was started from the lowest level called RW where the community is belong. Some of the proposal, such like access road, water storage, house reconstruction, and communal wastewater treatment unit. This proposal will be submitted to the higher level in sub-district, district, regency, regional and national level. The proposals from all area will be discussed and prioritized based on the urgency and budgeting. The interesting of this system was the representatives, in the beginning, were not women representation. It was a male-dominated forum while the basic human right was not discussed. The role of women in development plan should be discussed in further study.

According to Sanitation Development Plan 2017 of Surabaya City, the strategies of wastewater development in Surabaya City are:

1. Implement the local rules in term of domestic wastewater management in Surabaya City. This strategic aims to improve the healthiness and cleanliness of the city and prevent the environment pollution caused by domestic wastewater.
2. Improving the knowledge and skill of the society in using proper toilet. The target of this strategic is to increase the ownership of proper toilet and expected to 100% served by the end of 2019.
3. Increasing the access of domestic wastewater with community-based. Increasing the number of WWTP Unit from 43 to 63 units by the end of 2021.
4. Increasing the number of wastewater facilities in regional and city scale. The Government of Surabaya is trying to provide four units of wastewater treatment plant in regional scale by the end of 2021.
5. Optimization of sludge treatment unit with scheduled sludge service. This strategic aims to optimize the sludge treatment service from 100 m^3/day to 400 m^3/day by the end of 2021.
6. Increasing the awareness of the society in wastewater management and keep their environment around.

4. CONCLUSIONS

According to the studies, there is 7,98% of area was categorised as very high risk sanitation while 12,88% got high risk sanitation. There is still 1 % of the society practicing open defecation in the sewerage, and 0,27% to the land. The wastewater services in Surabaya City by 2015 is 97,53% with 43 domestic wastewater installed.

Surabaya City has some rules to manage and control the domestic wastewater. The effluent of domestic wastewater treatment is controlled by the rule with some parameters, such as Ph, BOD, COD, DO, TSS and nutrients (N and P). There are three out of 7 units of ABR have higher

concentration of ammonium comparing with the national standard.

Surabaya City has Sanitation Development Plan 2017, which is clearly describing the strategies plan for the domestic wastewater development 2017-2021. These strategies including the implement of related local rules, increase of wastewater services, increase of knowledge, participation and awareness of the society, increase the provision and access of sanitation supporting facilities, and optimization of sludge treatment in Surabaya City. Specifically about the improvement of wastewater treatment plant to increase the nitrogen removal become the challenge of further research.

5. ACKNOWLEDGMENTS

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6. REFERENCES

[1] Soedjono E.S., Fitriani N., Yuniarto A., and Wijaya 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. AIP Conference Proceeding, Vol. 1903, Issue 1, 2017.

[2] Faisal M., Mulana F., Gani A., and Daimon H., Physical and Chemical Properties of Wastewater Discharged from Tofu Industries in Banda Aceh City, Indonesia. Research Journal of Pharmaceutical, Biological and Chemical Sciences, Vol. 6, Issue 4, 2015, pp. 1053–1058.

[3] Lasut M.T., Jensen K. R., and Shivakoti G., Analysis of constraints and potentials for wastewater management in the coastal city of Manado, North Sulawesi, Indonesia, Journal of Environmental Management, Vol. 88, Issue 4, 2008, pp. 1141–1150

[4] Wijaya I.M.W. and Soedjono E. S., Domestic wastewater in Indonesia: Challenge in the future related to nitrogen content. International Journal of GEOMATE, Vol. 15, Issue 47, 2018, pp. 32-41

[5] Ma B., Wang S., Cao S., Miao Y., Jia F., Du R., Peng Y., Biological nitrogen removal from sewage via anammox: Recent advances, Bioresource Technology, Vol. 200, 2016, pp. 981–990.

[6] Wijaya I. M. W., and Soedjono E. S., Physicochemical Characteristic of Municipal Wastewater in Tropical Area: Case Study of Surabaya City, Indonesia. IOP Conference Series: Earth and Environmental Science, Vol. 135, Issue. 1, 2018.

[7] APHA/AWWA/WEF, Standard Methods for the Examination of Water and Wastewater, Standard Methods, 2012, p. 541.

[8] Pemerintah Kota Surabaya, Strategi Sanitasi Kota Surabaya 2017-2021. Indonesia: ppsp.nawasis.info.

[9] Purnomo A. and Khairina N., Planning of Decentralised Wastewater Treatment in RW 9 Genteng Subdistrict, Surabaya City. Procedia - Social and Behavioral Sciences, Vol. 227, 2016, pp. 791–798.

[10] Balkema A. J., Preisig H. A., Otterpohl R., and Lambert F. J. D., Indicators for the sustainability assessment of wastewater treatment systems. Urban Water, Vol. 4, Issue 2, 2002, pp. 153–161.

[11] Wijaya I. M. W., Soedjono E. S., and Fitriani N., Development of anaerobic ammonium oxidation (anammox) for biological nitrogen removal in domestic wastewater treatment (Case study: Surabaya City, Indonesia). AIP Conference Proceeding, Vol. 1903, Issue 1, 2017.

[12] Razif M. and Persada S. F., The fluctuation impacts of BOD, COD and TSS in Surabaya's rivers to environmental impact assessment (EIA) sustainability on drinking water treatment plant in Surabaya city. International Journal of ChemTech Research, Vol. 8, Issue 8, 2015, pp. 143–151.

[13] Damanik D. A. and Karnaningroem N., Model Prediksi Kualitas Air di Sungai Kalimas, 2002, pp. 1–7.

[14] KLHK, Peraturan Menteri LHK No. 68 Tahun 2016 tentang Baku Mutu Air Limbah Domestik. 2016.

[15] Yang X., Wu X., Hao H., and He Z., Mechanisms and assessment of water eutrophication. Journal of Zhejiang University SCIENCE B, Vol. 9, Issue 3, 2008, pp. 197–209.

[16] Rossi F., Motta O., Matrella S., Proto A., and Vigliotta G., Nitrate removal from wastewater through biological denitrification with OGA 24 in a batch reactor. Water, Vol. 7, Issue 1, 2015, pp. 51–62.

[17] Ling T. Y, Dana M. J., Bostam S., Nyanti L., Domestic Wastewater Quality and Pollutant Loadings from Urban Housing

Areas. Iran Journal of Energy and Environment, Vol. 3, Issue. 2, 2012, pp. 129–133.

[18] Chislock M. F. Doster E., Zitomer R. A., and Wilson A. E., Eutrophication : Causes , Consequences , and Controls in Aquati c Ecosystems. Nature Education Knowledge, Vol. 4, Issue 4, 2013, pp. 1–8.

[19] Akpor O., Muchie B., Environmental and public health implications of wastewater quality. African Journal of Biotechnology., Vol. 10, Issue. 13, 2011, pp. 2379–2387.

[20] Hauck M., Maalcke-Luesken F. A., Jetten M. S. M., and Huijbregts M. A. J., Removing nitrogen from wastewater with side stream anammox: What are the trade-offs between environmental impacts?. Resources, Conservation and Recycling, Vol. 107, 2016, pp. 212–219.

[21] Soedjono E. S., Fitriani N., Rahman R., and Wijaya I. M. W., Achieving Water Sensitive City Concept Through Musrenbang Mechanism in Surabaya city, Indonesia. International Journal of Geomate, Vol. 15, Issue 49, 2018.