Assessment of Criteria and Subcriteria in Determining the Selection of Domestic Wastewater Treatment Plant Technology in Situ Manggabolong, South Jakarta

Meta Pradoningrum, Setyo Sarwanto Moersidik and Mochamad Adhiraga Pratama

July 20, 2022

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Meta Pradoningrum*, Setyo Sarwanto Moersidik [1] and Mochamad Adhiraga Pratama [2]

[1,2]Faculty of Engineering, University of Indonesia, Depok 16424, Indonesia
*e-mail: pradoningrum@gmail.com

Abstract. *The DKI Jakarta Provincial Government plans to build a Domestic WWTP (Wastewater Treatment Plant) as an effort to maintain the surface water quality of Situ Manggabolong. However, there has been no decision on what WWTP technology to choose. Meanwhile, the decision to choose the right WWTP technology is complex because many criteria and sub criteria influence each other. To answer this challenge, it can be solved with the ANP (Analytic Network Process) method. ANP requires a questionnaire from an Environmental Engineering Expert. The weight ranking results from this questionnaire will produce one appropriate WWTP Technology. The ANP method has not been applied in Indonesia in the context of selecting WWTP Technology. This paper is part of the thesis, where the purpose of this paper is three alternatives of domestic WWTP technology. Then this paper will be continued to the thesis to achieve the goal, which is one appropriate Domestic WWTP technology. The result of this paper is three alternative Domestic WWTP technology, alternative I with Aerobic Biofilter technology, alternative II with Anaerobic Baffle Reactor Technology + Aerobic Biofilter and alternative III with Up Flow Anaerobic Sludge Blanket + Aerobic Filter Technology.*

Keywords: WWTP Technology, ANP, Expert, criteria, sub criteria

Introduction

The lake/situ has a function, including as a flood control. However, as happened in Situ Manggabolong, apart from being a flood control, Situ Manggabolong is used as a dumping ground for domestic wastewater from surrounding settlements. Based on Lake Surface Water Quality Monitoring data published by the DKI Jakarta Provincial Environmental Agency in 2019, Situ Manggabolong is categorized as heavily polluted. So that Situ Manggabolong cannot be used as its designation as class III, which is used for freshwater fish farming, irrigating crops, and other designations that require the same water as these uses. This condition urges the DKI Jakarta Provincial Government, to plan the construction of the domestic wastewater treatment plant in Situ Manggabolong.

There are many criteria that must be considered in selecting the appropriate WWTP technology. In this decision-making process, criteria must be considered as well as their interrelated relationship of one criterion to another. To deal with this challenge, multi-criteria decision-making techniques (MCDM) are very useful, since they use a structured and logical approach to modelling complex decision-making problems [6]. The MCDM method is a decision-making method for establishing the best alternatives from several alternatives based on certain criteria [13]. From many of MCDM methods available, which allow interaction and feedback from elements in the criteria (inner dependence) and between criteria (outer dependence) is only ANP (Analytical Network Process) method [14].

This paper aims to assess the criteria and sub criteria that are the basis for prioritize three WWTP technology set-ups for the secondary treatment. This paper is part of the thesis. In the thesis methodology, the three technology that have been selected in this paper will then be selected one of the most appropriate technologies based on the results of questionnaires to 10 environmental engineering experts. Preparation of questionnaires and processing of data on the results of subsequent questionnaires using the ANP method.

Materials and Methods

Study Location

The study location is in Inlet Situ Manggabolong with the WWTP service area covering 2 RW and 13 RT, namely RW 07 (RT 04 to RT 11), RW 16 (RT 03, RT 04, RT 05, RT06, RT 07 dan RT 09), Srengseng Sawah Village, Jagakarsa District, South Jakarta. The total population in the service area is 8248 people. The wastewater discharge for Qminimum, Qaverage and Qpeak, respectively, is 250.4 m^3/day, 791.8 m^3/day, 899 m^3/day.

Research Methodology

As an initial stage, secondary data collection from relevant Government Agencies was conducted, including population data, situ Manggabolong surface water quality data, research location maps, topographic maps and data of service area. Primary data were obtained from the wastewater characteristic test of ten samples, with a parameter test method referring to SNI. The parameters tested include pH, BOD, COD, TSS, NH_3, Total Coliform, Oil and Grease. With this data, the percentage of organic waste removal will be known to achieve the quality standard value of domestic wastewater which refers to [8].

To determine the right alternative domestic WWTP technology, a literature study of the criteria and sub criteria that influenced the selection process of Domestic WWTP technology was conducted. Criteria and sub criteria are selected based on the existing conditions of the study site. Table 1 shows the criteria and sub criteria selected in this study. Furthermore, an assessment of several alternative WWTP technology was conducted based on criteria and sub criteria. Of the three alternative WWTP technology chosen, then each alternative is made a domestic WWTP processing scheme along with the calculation of the dimensions and percentage of organic waste removal until the processed results are achieved according to quality standards. The results of this study are recommendations for three alternative WWTP Technology that can be applied in Inlet Situ Manggabolong.

Results and Discussion

The characteristics of domestic wastewater at the study site are as follows:

Table 1: Wastewater characteristics at ten sampling site points

Wastewater Parameters	Quality Standard of Effluent [8]	1 (mg/l)	2 (mg/l)	3 (mg/l)	4 (mg/l)	5 (mg/l)	6 (mg/l)	7 (mg/l)	8 (mg/l)	9 (mg/l)	10 (mg/l)
pH	6-9	7.1	6	6	7.1	6.8	6.9	6.7	7	7	7
BOD	30 mg/L	80,5	32,2	241,6	161,1	241,6	64,4	161,1	80,5	80,5	96,6
COD	100 mg/L	160	372	300	672	310	212	562	564	431	273
TSS	30 mg/L	42	50	29	90	40	19	154	128	40	76
Oil and Grease	5 mg/L	1684	154	398	324	110	24	112	32	74	638
Ammonia	10 mg/L	18	31	30	20	23	21	39	47	21	15
Total Colifrom	3000 jml/100 ml	1600	255	48000	1600	2430	250	350	28	350	45

Referred to table 1, it can be calculated that the average BOD/COD ratio is 0.440. In the biodegradable zone with a BOD/COD ratio value of 0.400-0.500, the average waste can be biodegradable biologically [14]. In this case, secondary sewage treatment with aerobic treatment will be applied. Furthermore, biological aerobic technologies are selected based on specified criteria and sub criteria, as well as processing commonly applied in Indonesia. Criteria and sub criteria are selected based on the existing conditions of the planning site. The criteria obtained from the literature study include environmental, engineering, economic, social, and institutional criteria. From all these criteria were selected only four criteria. The institutional criteria are eliminated because the institutional criteria represent who will carry out the maintenance of the WWTP regularly both in terms of technical and cost. Meanwhile, the plan to build a WWTP at the research site has certainty from the party who will carry out routine maintenance. Based on literature study, the criteria selected in determining the assessment of WWTP technology are environmental criteria [6], [2], engineering criteria [2], economic criteria [5], [2], [6], [10] and social criteria [6], [10] The criterion of engineering represents the complexity of construction and another civil sector. Environmental criteria represent the reliability of WWTP technology, land needs, sludge production, efficiency removal of organic waste, etc. Economic criteria represent to the maintenance, operational and investment costs of WWTP technology. Social criteria represent the impact of WWTP to the residential around the WWTP.

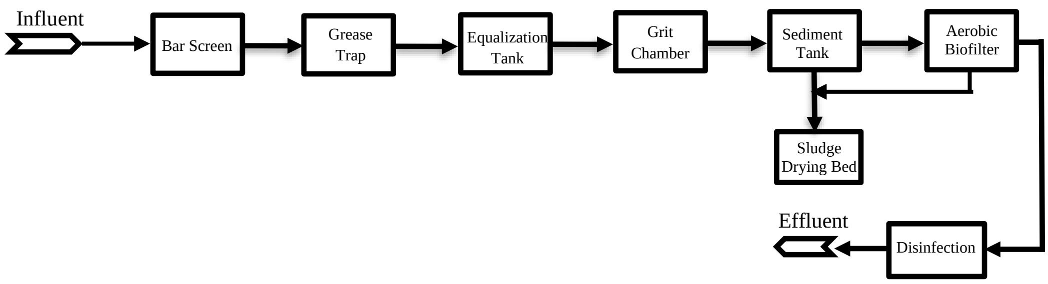
Table 2 presents several alternative WWTP technologies that have conformity with the selected criteria and sub criteria.

Table 2: Alternative Technologies assessed based on criteria and sub criteria

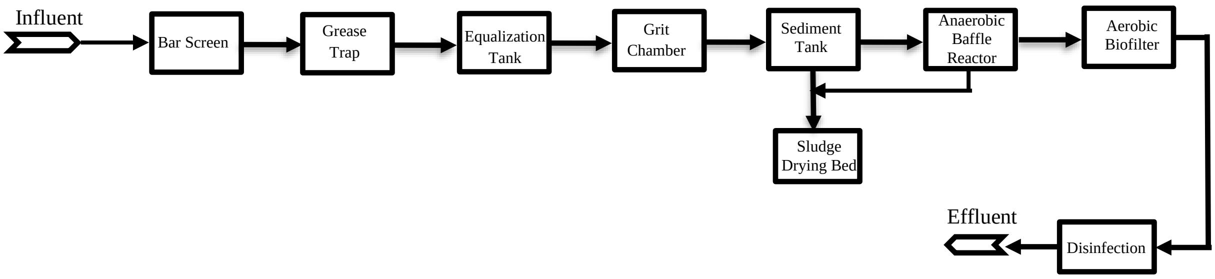
Technology	Treatment	Cluster	Sub Cluster	Reference
*Moving Bed Biofilm Reactor (*MBBR)	Biological Aerobic Treatment	Environment	Organic matter and suspended solids efficiency removal, global warming potential, effluent quality, sewage sludge production, land requirements, reliability	[2] [6] [7] [10]
		Economic	Investment cost, operating and maintenance costs	[2] [5] [6] [7] [10]
Trickling Filter	Biological Aerobic Treatment	Environment	Organic matter and suspended solids efficiency removal, global warming potential, effluent quality, sewage sludge production, land requirements, reliability	[2] [6] [7] [9] [10]
		Economic	Investment cost, operating and maintenance costs	[2] [5] [6] [7] [9]
		Engineering	Construction complexity, operational and maintenance	[2] [7] [9]
Extended Aeration	Biological Aerobic Treatment	Environment	Organic matter and suspended solids efficiency removal, effluent quality, reliability	[2] [6] [7]
Activated Sludge	Biological Aerobic Treatment	Environment	Organic matter and suspended solids efficiency removal, global warming potential, effluent quality, sewage sludge production, land requirements, reliability	[2] [6] [7] [10]
Anaerobic Baffled Reactor (ABR)	Biological Anaerobic Treatment	Environment	Organic matter and suspended solids efficiency removal, reliability	[2] [6] [7]
		Economic	Investment cost, operating and maintenance costs	[2] [5] [6] [7] [10]
		Engineering	Construction complexity, operational and maintenance	[2] [7]
UpFlow Anaerobic Sludge Blanket (UASB)	Biological Aerobic Treatment	Environment	Organic matter and suspended solids efficiency removal, land requirements, reliability	[2] [3] [4] [5] [6] [7] [10] [11]
		Social	Public acceptance, visual impact, odours, noise	
		Engineering	Construction complexity, operational and maintenance	[2] [3] [4] [7] [11]
Biofilter Anaerob	Biological Anaerobic Treatment	Environment	Organic matter and suspended solids efficiency removal, reliability	[2] [6] [7]
Biofilter Anaerob-Aerob	Biological Aerobic-Anaerobic Treatment	Environment	Organic matter and suspended solids efficiency removal, effluent quality, land requirements	[2] [6] [7] [10]
		Economic	Investment cost, operating and maintenance costs	[2] [5] [6] [7] [10]
Biofilter Aerob	Biological Aerobic Treatment	Environment	Organic matter and suspended solids efficiency removal, effluent quality, land requirements, reliability	[1] [2] [5] [6] [7] [10]
		Engineering	Construction complexity, operational and maintenance	[1] [2] [7]

At the study site, the location of the WWTP construction plan is around residential areas and the available land is quite limited, which is 800 m^2. So that the WWTP technology chosen is not only from meeting the specified criteria but also prioritizing technology that requires less land and that is acceptable to the community. Referred to table 2, the compliant technologies are ABR, Biofilter Aerobic and UASB. From the three alternative WWTP technologies that have been selected, the overall WWTP processing system scheme is further determined (see figure 1).

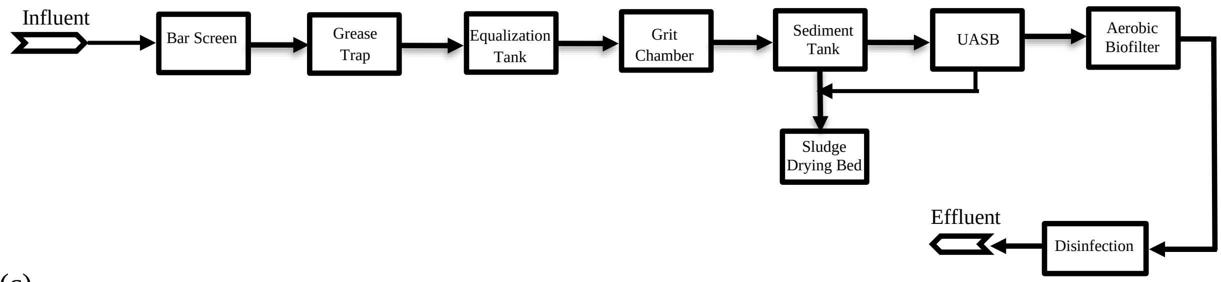
Based on the calculation of the removal efficiency, the overall removal efficiency of the WWTP alternative I, alternative II and alternative III respectively is BOD removal ±88%, ±98%, ±98%, COD removal ±91%, ±98%, ±89%, TSS removal ±93%, ±99%, ±89%, NH3 removal ±83%, ±86%, ±98%, Total Coliform removal ±45%, ±45%, ±45%, oil & grease removal ±98%, ±98%, ±98%.



(a)



(b)



(c)

Figure 1: WWTP of three technology (a) WWTP Alternative I use Biofilter Aerob Technology (b) WWTP Alternative II using ABR dan Aerobic Biofilter (c) WWTP Alternative III using UASB Technology dan Aerobic Biofilter

Each alternative consists of pre-treatment, primary treatment, secondary treatment, tertiary treatment (alternative II) and disinfectant. In alternative II, tertiary treatment is applied, because ABR technology cannot remove NH_3 to the local standard value of wastewater quality. Hence, necessary to add 1 unit of aerobic technology, the Aerobic Biofilter unit. In pre-treatment, grease trap removal conducted, in primary treatment (sedimentation) efficiency of BOD, COD and TSS removal conducted. The secondary treatment is designed to removal BOD, COD, TSS, NH_3, while in tertiary treatment it is designed to totally removal coliform. The total dimension calculation of all WWTP units in alternative I, alternative II and alternative III respectively is 122 m^2, 364 m^2, 534 m^2.

Conclusions

The recommendations for biological wastewater treatment that can be applied in Situ Manggabolong are AF, ABR, and UASB. These three technologies are able to remove organic material with treatment results in accordance with local regulation, [8]. However, for ABR technology, an additional AF unit is needed to removal NH_3. So that in the processing system using ABR (Alternative II), the calculation of the total dimension area of the processing unit is greater than alternatives I and III. Based on the results of the analysis and calculations of the three WWTP technologies, it is concluded that these three technologies can be applied in Situ Manggabolong both from the effectiveness in remove BOD, COD, TSS, NH_3, also requires less land area.

Although best efforts have been made in this research, this study have some limitations. With a sample size of 10 domestic wastewater, it is considered small for wastewater analysis. The more domestic wastewater samples taken, the more the wastewater characteristic data will be representative of the actual conditions. Because sampling was conducted during the Covid-19 pandemic, so there were also limited quantities of sample and was do more carefully so that there is no spread of the covid virus through wastewater.

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