MBBR technology for water treatment east flood canal as a raw water source of DKI Jakarta

W S Pradafitri1,*, S S Moersidik2 and C Abdini1

1 School of Environmental Science, University of Indonesia, Kampus UI, Jl. Salemba Raya IV, RW.5, Kenari, Senen, Kota Jakarta Pusat 10430, Indonesia
2 Environmental Engineering, Faculty of Engineering, University of Indonesia, Jl. Margonda Raya, Pondok Cina, Beji, Kota Depok 16424, Indonesia

E-mail: wednespradafitri@gmail.com

Abstract. Population growth increases the need for raw water supplies. Poor quality, quantity, and continuity of raw water conditions impacts the scarcity. The problem can be solved by water treatment technology. East Flood Canal (BKT) is one of the infrastructure facilities in DKI Jakarta province has potential to become a source of raw water supply. This study aims to analyze the appropriate pre-processing technology to improve the water quality of BKT. Analytical Hierarchy Process method was used to determine the appropriate pre-treatment technology to improve the water quality of BKT. There are 3 alternative technology options, such as MBBR (Moving Bed Biofilm Reactor), MBR (Membrane Bioreactor), and Bank Filtration, while the criteria are the environment, social, and economic. The questionnaire were weighted, reviewed consistently, and analyzed descriptively. The results showed that the MBBR technology earns the highest weight of 0.51, MBR is 0.38, and the BF is 0.12. Based on environmental and social aspect, MBBR needs the smallest area, hence it can be easily approved by the people. In economic aspect, the investment of MBBR is more expensive, however the operational is affordable. In conclusion, MBBR technology is the most appropriate technology for water treatment of East Flood Canal.

1. Introduction
Water is one of the natural resources that most essential for every living creatures. Water is common property resources, as public goods and can be managed by society on a sustainable basis [1]. Currently, the water resources problem threatens the world population. 30% of world population in 40 countries experiences problem of water resource scarcity, Indonesia included. In 2025, approximately 2.7 billion of lives or 30.33% population of the world will have raw water deficiency [2]. Limitations of the amount of water that can be explored and consumed, while the population of Indonesia continues to increase causing raw water demand tends to increase drastically.

One of the cities in Indonesia experiencing shortage of raw water is DKI Jakarta. Increasing population and economic development very rapidly caused the need for raw water supply meet the needs of daily living increases. However, the increased demand for raw water cannot be fulfilled by the availability of raw water supply. As a result, Jakarta deficits of clean water. Jakarta's water supply is depend on several sources outside Jakarta, such as 81% of Jatiluhur Reservoir, 14% from Tangerang

* To whom any correspondence should be addressed.
Regional Water Company (PDAM) Tangerang, and 5% from Krukut River [3]. Some components of water resources in DKI Jakarta can be an alternative source of raw water to meet the water needs of the community, such as rivers, lakes, reservoirs, canals, and etc. In fact, the condition of the water resources component does not currently meet the quality standard criteria. Almost all the rivers in DKI Jakarta are in seriously polluted condition. Source of river pollution in DKI Jakarta comes from point source and non point source. Meanwhile, the composition of waste diversity that contaminates water in the form of grey water and black water can be generated from domestic activities (households) as well as various other socio-economic activities [4, 5]. The problem of poor water quality and inadequate quantity can be overcome by utilizing water source in DKI Jakarta area.

One of the potential water sources for DKI Jakarta is the East Flood Canal. East Flood Canal (BKT) is an infrastructure established by the Provincial Government of DKI Jakarta to tackle and realize flood-free Jakarta in the eastern region of DKI Jakarta due to local rain. East Flood Canal water quality data of BBWSCC test results from 2013 to 2015 [6] shows that there are several parameters of BKT water that exceed the quality standard of Government Regulation (GR) 82 in 2001, including BOD, COD, phosphate, and ammonia. However, BKT’s abundant water volumes have the potential to increase water supply in DKI Jakarta. Therefore, there is a need to study the precise water pre-treatment approach using the Analytical Hierarchy Process (AHP) method with alternative technology of Moving Bed Biofilm Reactor (MBBR), Bank Filtration (BF), and Membrane Bio Reactor (MBR) water quality of BKT so that become sustainable raw water source in DKI Jakarta area.

2. Methodology

The study was conducted for three months (October 2017 to December 2017). The research was conducted in East Flood Canal, upstream side (Cipinang River), East Jakarta. This section was chosen because it is the only point of BKT channel that comes from the Ciliwung River through Cipinang River. The research method used is qualitative method. The water quality was tested based on Indonesia National Standard with key parameter of raw water based on Government Regulation no. 82 year 2001 class I and II regarding Treatment of Water Quality and Pollution. The parameters are namely BOD, COD, ammonia, pH, and total coliform. The method of Analytical Hierarchy Process (AHP) was used to determine the best technology scenario for BKT river treatment. The weight of AHP was obtained through questionnaire result of Analytical Hierarchy Process (AHP) that was distributed to the experts. The first scenario of pre-treatment of BKT water is Moving Bed Biofilm Reactor (MBR). Second scenario is Bank Filtration (BF). Third scenario is Membrane Bio Factor (MBR). Selected experts have to possess the knowledge and experience regarding the water pre-treatment technology. The number of sample for stakeholders (experts) is 5 respondents from various backgrounds [7]. The approach of pre-treatment to improve the quality of BKT water was researched based on the criteria of economy, social, and environmental. The decision of pre-treatment based on expert judgement was process with the aid of Microsoft excel to calculate the weight of each criteria.

3. Result and Discussion

3.1 Water Quality in BKT

The result of laboratory test shows a number of parameters water quality of the upstream of East Flood Canal exceed the standard quality GR No. 82 year 2001 class 1.

| No. | Parameter | Unit | CP1 | CP2 | CP3 | CP4 | Average |
|-----|-----------|------|-----|-----|-----|-----|---------|
| 1.  | BOD       | mg/L | 4.40| 4.40| 4.60| 4.40| 4.45    |
| 2.  | COD       | mg/L | 75.06| 84.07| 84.93| 89.23| 83.32   |
| 3.  | Phosphate | mg/L | 0.505| 0.569| 0.746| 0.646| 0.62    |
| 4.  | Nitrite   | mg/L | 0.294| 0.285| 0.247| 0.304| 0.28    |
Based on the four samples in Table 1, the highest BOD level is on CP3 which is 4.60 mg/L. The high concentration of BOD on CP3 point because that location is the channel and the point accumulated waste that flows from Cipinang River from many sources (domestic, industry and construction activity). The increase of COD happens from CP2 point to CP4, because those points are lose with a cement factory (PT Jayamix) thus contributes the chemical waste to the upstream of BKT. The high phosphate level is because in CP3 point, the dometic waste such as residents’ waste (faeces) (blackwater) and food waste from households (greywater) and market as well as agricultural activities in upstream side of BKT Cipinang River have been accumulated. The result of this research corresponds with [8] which stated that water that has been positively contaminated with *E. coli* cannot be consumed as potable water.

The water quality parameters on the upstream of BKT (Cipinang River) that exceed the standard quality are majority due to the activity of the residents’ surrounding the water. The residents’ activity produces waste such as greywater, black water, and trash. These waste originated from point source and non-point source. Waste from point source are mostly originated from the residents’ household domestic waste while non-point source waste is produced from various service and trade activity surrounding the riverside. This is in line with the literature which stated that the composition of various waste that contaminates a water body such as greywater and blackwater are produced by domestic activities (household) and many others social economy activity and gives impact to the quality and hydrologic condition of a river basin [9,10,4].

### 3.2 Water pre-treatment technology for BKT

Figure 1 shows the highest weight criteria for technology of pre-treatment for BKT water is the environmental aspect with value of 0.72, while social aspect is 0.16 and economy aspect is 0.10. Environmental aspect become really important to be considered in an application of the technology pre-treatment for BKT water because it is the key of sustainable technology. The implementation of technology on the surrounding BKT upstream area can impact to the surrounding environment due to the waste that produced by the treatment process. Waste from the water treatment can be in a form of
liquid or solid. Both of this waste types can pollute the surrounding environment if not treated before deposited to the environment, including disturbing the live of residents’ surrounding BKT river. Waste from water treatment can raise health and envir

onmental problems in an area [11].

The next analysis result shows the priority level of each aspects based on sub-criteria (see Figure 1). Figure 1 indicates that on environmental aspect, the highest weight is sub-criteria of land needed with value of 0.51. Sub-criteria of land compatibility on social aspect has the highest value of 0.13. For economy aspect, the highest weight is the sub-criteria of investment cost of 0.06.

The land needed is selected based on these aspects, such as: can be developed for long-term planning (increase of capacity, development of sewage system), access that will support the operation and maintenance, has distance that will not impact to the smell and environmental aesthetics to surrounding houses, and no objection from the society. The implementation of surface water treatment influences the land usage for the area of the planned capacity. The area needed for the three technology needed for BKT water is as below (Table 2):

Table 2. Land Requirements of each Water Treatment Technology

| No. | Technology            | Land area (m²) |
|-----|-----------------------|----------------|
| 1   | MBBR (alternatif 1)   | 12 c           |
| 2   | MBR (alternatif 2)    | 22 b           |
| 3   | BF(alternatif 3)      | 25 a           |

Source: aFontus Water [12]
bHai & Yamamoto, 2011 [13]
cGrischek et al., 2003[14]

MBRR technology needs the smallest land compared to MBR and BF technology. The upstream area of BKT has dense housing, thus it is hard to implement a technology that needs large area if that technology want to be developed. The small needs of land for a technology agrees with the research [14] which stated that the selection of technology of water treatment plant from domestic sources has to be done in a small area.

The social aspect of land compatibility on a technology implementation on the area surrounding the riverside of the upstream of BKT is important. The development of water treatment technology in a dense housing area will influence the activity of the surrounding household. Other than housing, on the river side of the upstream of BKT there are also other human activities, such as industrial and trading as well as open green space. The social aspect to the society is the relocation, health and the reception from the society. The influence of land compatibility to society’s social aspect is similar with the research [15,16,17] that the implementation of water treatment technology on an area will influence the social and economy condition of the society in that area, such as the way of life of the people (interaction), relocation, air pollution, health and technology reception by the society.

On the sub-criteria of economy aspect, sub-criteria with the highest weight is the investment cost with value of 0.06. Based on the calculation using benefit-cost ratio analysis, the investment cost that has to be spend to construct MBRR technology is Rp 67.792.741,00, while the investment cost for MBR is Rp 66.000.000,00. BF technology has the lowest investment cost compared to MBR and MBRR technology. This agrees with research [18] which stated that MBRR alternative is categorized as a sustainable technology alternative based on financial factor because it gives benefit.

Based on the aspects of environmental, social and economy, thus the alternative technology with the highest weight is MBRR (0.51). The consideration from the experts that MBRR is the right treatment technology for BKT is because the required area for the construction of this technology is small. The minimum required area for MBBR is suitable with the statement from [19,20] that MBRR can be implemented on a small area. From economic side, the investment cost of MBRR is more expensive, however, the operational and maintenance cost are affordable. This is similar to research that MBRR technology is effective to treat water with low maintenance cost thus decrease the operational cost.
4. Conclusion
Based on the result of the study in environmental, social and economy aspects, as well as the perception of the experts through AHP method, the right approach for pretreatment for BKT water is MBRR technology with the weight of 0.51. The treatment of BKT water with that technology provides solution for PDAM water sources for DKI Jakarta area. The limitation of this research is the study of environmental, social and economy regarding the water treatment technology used is only performed on the upstream area of BKT. Thus, further research is needed to understand the potential of the middle and downstream of BKT as the water source of PDAM for DKI Jakarta area.

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