Design of Water Treatment Facilities for Integrated Areas of Office and Residential Buildings in Jakarta

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Abstract

The scarcity of clean water is one of the main problems faced by big cities like Jakarta. With the density of population and office buildings, it is difficult to fulfill clean water. One of the difficulties in meeting the need for clean water is PT BM, which is a state-owned company that is building an area containing offices and residences for employees. The water requirement per day for the area is 370 m3/day, while the water supply available is from regional drinking water company only 100 m3/day. The deficiency of 270 m3/day of clean water can be met by reprocessing wastewater from office buildings and residential in the areas. The wastewater treatment system in this study uses a reverse osmosis system. The results of the research prove that the treated water of reverse osmosis can be used along with the water from drinking water company for building's clean water.

Keywords

Wastewater reuse, Greywater, Blackwater, Reverse Osmosis, Centralized Treatment

1. Introduction

Residents of Jakarta in the year 2019 amounted to 10.557.810 people and during the day that number will increase with the arrival of workers from cities around Jakarta like Bekasi, Tangerang, Bogor and Depok (BPS Jakarta 2020). With the increase in population, the need for resources has also increased, one of which is the need for clean water. In Jakarta, there are several alternatives for clean water sources that are used to meet daily needs, namely using drilled wells or being member to drinking water providers. The use of drilled wells must be carried out with due observance of regulations regarding groundwater use. For a piped clean water service system in Jakarta, Region Drinking Water Company collaborates with its private partners, namely PT Pam Lyonnaise Jaya or PALYJA (western region of Jakarta) and PT Aerta Air Jakarta (eastern region of Jakarta) (Rembulan et al. 2020).

In the report on the Grand Design for the Provision of Drinking Water and Domestic Wastewater Services (2017), Jakarta has a clean water deficit in 2020 of 5.659 liters/second, this water deficit will continue until 2029. With this deficit of drinking water supply in Jakarta making many customers including offices short of supply of drinking water for their needs. PT PALYJA as a drinking water supplier for West Jakarta has 2 sources of raw water supply, namely from Jakarta as much as 14% and outside Jakarta as much as 86% with such a percentage it can be concluded that the water resources from Jakarta itself are very small and very dependent on other regions. For West Jakarta, PT PALYJA's supply of drinking water cannot be 100% fulfilled (Fact Sheet 2019).

PT BM, which is currently building an integrated area of 20 hectares in West Jakarta, will include several tall buildings and vertical residences that require large amounts of drinking water per day. Currently, the water supply for PT BM is only about a quarter of the total demand. The lack of water needed by PT BM requires it to find alternative sources that can be used to meet the needs of the building including for hand wash and ablution, one of the alternative is wastewater reuse. Wastewater treatment technology is currently developing commercially with various functions depending on the purpose of treatment. Furthermore, this new technology is expected to reach the use of wastewater to be reused as drinking water and save the use of clean water (Kobayashi et al. 2020). The development of wastewater

treatment technology is also necessary because it is related to the increasing need for water, the development of a wastewater treatment system is expected to develop with a larger and more complex capacity (Oh et al. 2017).

1.1 Objectives

Based on the background and problems arising from the lack of water availability for buildings, the objectives of this study are :

1. Calculation of water demand for office building and residential.
2. Analyzing reverse osmosis systems for treating domestic wastewater (greywater and blackwater) into clean water for buildings, such as for hand wash.
3. Analyzing the reject water from reverse osmosis so that it can be reused for building water needs.

2. Literature Review

2.1. Wastewater

Domestic wastewater generally divided into two, greywater and blackwater. Greywater is the total volume of water generated from washing food, clothes and dishware, as well as from bathing, but not from toilets. Greywater contains surfactants (anionic, cationic and amphoteric) coming from shampoos and detergents, and high concentrations of chemicals from soaps (such as sodium, phosphorous, surfactants and nitrogen), as well as suspended solids, turbidity and organic matter (Tilley et al. 2014, Barisci and Turkay 2016). Greywater typically constitutes about 75% of domestic wastewater and may be returned to the water cycle and reused for many types of household use including flush water after a milder treatment as compared with treatment of conventional domestic wastewater for the same purpose (Baykal 2019). Since the greywater from ablution meets the quality standard as clean water, it's also functioned as a dilution to blackwater in the wastewater treatment plant (Salikha, et al. 2020).

Blackwater is the mixture of urine, faeces and flushwater along with anal cleansing water (if water is used for cleansing) and/or dry cleansing materials. Blackwater contains the pathogens of faeces and the nutrients of urine that are diluted in the flushwater (Tilley et al. 2014). Guney and Kaygusuz (2019) state that the microbial contamination associated with blackwater means that it needs to be treated to a very high level, especially with disinfection. Treated blackwater is most suited for sub-surface irrigation of landscape and combination between greywater and blackwater can be used for toilet flushing.

2.2. Wastewater Treatment Plant

Wastewater treatment plan collect wastewater (greywater and blackwater) from the building for a multi-step treatment process. The wastewater plant consists of compartments with contrasting environmental conditions including changing concentrations of antibiotics, metals, and other stressors that may act as drivers on microbial community assembly and resistomes (Ju et al. 2019). Based on the Regulation of the Governor of Jakarta Province Number 122 of 2005, a wastewater treatment plant is a mandatory requirement for obtaining permits to constructing new buildings and permits to using buildings. This wastewater treatment plant is used to collect wastewater and to carry out initial treatment. This means that every building that will be built or that has been built in Jakarta must have a wastewater treatment plant as the main equipment for treating wastewater. On the same governor's regulation, the wastewater must meet established standards before it can be disposed to the city canals.

2.3. Reverse Osmosis

Ziemba et al. (2020) stated that recycling greywater or other wastewaters for high-quality applications, such as hand wash, can dramatically reduce global demand for freshwater and enable safer water access for improved hygiene in the developing world and other challenging environments. One of the wastewater treatment techniques that is currently being developed is reverse osmosis. Alrehaili (2020) explain that reverse osmosis is a system to remove dissolved solids, contaminants of emerging concern and pathogens. Reverse osmosis can achieve 80-85% water recovery from wastewater with a 15-20% reject water that contain with salt and other pollutants. Reverse osmosis relies on the semi-permeable membrane used to filter feed water that is pumped by a high pressure machine.

Anis et al. (2018) explain this system generally used in the desalination process of seawater into drinking water. About 80% of the total desalination plants worldwide use reverse osmosis system because in terms of cost and energy use this system has advantages over other processing systems. In Albergamo (2020) research reverse osmosis is proved that the system can stand alone to convert raw river water without pre-treatment into drinking water. RO as water treatment is an advanced stage that supports environmentally friendly, which is useful for reducing energy use and to minimize ecological footprint (Bintang et al. 2019).

3. Methods

This research uses qualitative and quantitative methods. Qualitative method are used to find out previous studies about wastewater, wastewater treatment plant and reverse osmosis system. Quantitative data is obtained from collection data from object of study, estimate of water demand for office and residential building, laboratory test results of treated water and reject water from RO and calculate water supply compared to water demand. In general, the research methodology used is as follows :

1. Literature studies related to wastewater, wastewater treatment plant and reverse osmosis.
2. Determine the object and location. The object of this research is the buildings to be built in the integrated area owned by PT BM in Jakarta.
3. Collecting data about water demand and wastewater from buildings to be built in the area.
4. Laboratory test for treated water and reject water sampling from reverse osmosis system (from office building with a minimum height of 12 floors).
5. Calculate the availability of water with water demand for office and residential buildings.

4. Results and Discussion

4.1 Calculation of Demand Water

No.	Building		Clean Water (m^3/day)
I	**Water Needs**		
1	Training Center + hotel	8 floors; 32,420 m^2	90
2	Tower 1	12 floors; 24,424 m^2; ± 1,300 people	78
5	Tower 2	18 floors; 36,535 m^2; ± 2,000 people	120
3	Mosque	20 l/m^2/h	8.5
4	Archives Building	7 people	4.5
6	Management Office	1 unit	1
7	Flats	2 towers; 104 unit/tower	68
	Total Water Requirements		**370**
II	Water supply from PT PALYJA		100
	Water balance		**(270)**

Table 1. Water demand data

Based on The Regulation Of The Minister Of Public Works number: 14/PRT/M/2010 of 2010 about Minimum Service Standards In The Field Of Public Works And Spatial Planning, the minimum basic needs for people in a day that must be provided by the building is 60 liters/person/day. From Table 1 it can be seen that the need for water for all buildings in the area is 370 m^3/day while the supply from PT PALYJA is only 100 m^3/day, so the water shortage is about 270 m^3/day.

4.2 Utilization of Reverse Osmosis

The wastewater that comes out of the WTP will be flowed into the ultrafiltration system as a pre-treatment before being treated using reverse osmosis. The use of reverse osmosis as a follow-up treatment of the wastewater treatment plant shows that the processed water meets standards and can be use as clean water to meet building needs. And the quality of reject water from reverse osmosis as seen in table 2 show that physical and chemical parameter mostly meet the standard, but not microbiological parameter. Physically the reject RO water may looks like ordinary clean water but with the large number of micro-biology contained in it, the water cannot be used as clean water for washing hands

and other use that direct contact with humans. Its use can be directed to flush toilets and garden to reduce the use of clean water.

Parameter	Unit	Reject water from reverse osmosis*	Standard[a]
Physical			
Turbidity	NTU	0.38	25
Color	TCU	1.52	50
Total dissolved solid	mg/L	441	1,000
Temperature	ºC	22.9	± 3
Taste		Tasteless	Tasteless
Odor		Odorless	Odorless
Microbiological			
E. coli	CFU/100 ml	140	0
Total Coliform	CFU/100 ml	140	50
Chemical			
pH		7.79	6.5 – 8.5
Arsenic	mg/L	0.001	0.05
Detergent	mg/L	0.086	0.05
Iron (Fe)	mg/L	0.05	1
Fluoride	mg/L	0.93	1.5
Cadmium	mg/L	0.000218	0.005
Nitrate as N	mg/L	8.43	10
Nitrite as N	mg/L	0.80	1
Total hardness as CaCO3	mg/L	174	500
Manganese	mg/L	0.06	0.5
Selenium	mg/L	0.00057	0.01
Zinc	mg/L	0.05	15
Cyanide	mg/L	0.007	0.1
Sulfate	mg/L	86	400
Lead (Pb)	mg/L	0.00357	0.05
Mercury (Hg)	mg/L	0.000313	0.001
Organic substance as KMnO4	mg/L	16.68	10

Table 2. Reject water test result

a. Regulation of The Minister of Health No. 32 / 2017 about Hygiene and Sanitation Water
*) Laboratory test results

4.3 Fulfillment of Water Needs

From the usage of 370 m^3/day of clean water from the building about 80% or 296 m^3/day of wastewater is produced by Wastewater Treatment Plant (WTP) system. The wastewater from WTP then channeled and re-treated using RO, to produce about the same amount from WTP. The treated water from RO together with water from PT PALYJA distributed to each building. Water supply from PT PALYJA is 100 m3/day plus water from RO 296 m3/day and total water supply for the buildings is 396 m^3/day. There is excess water around 26 m^3/day, it means PT BM can reduce supply water from PT PALYJA to 74 m^3/day, so it can reduce monthly water payment. The cycle of wastewater treatment can be seen in figure 1.

Water from PT PALYJA and treated water from RO can be mixed and use as clean water that directly related to humans such as washing hands, and reject water from RO can be used for other needs that are not directly related to

humans such as for flushing toilets and garden. Each building must provide at least two water tanks to separate the water.

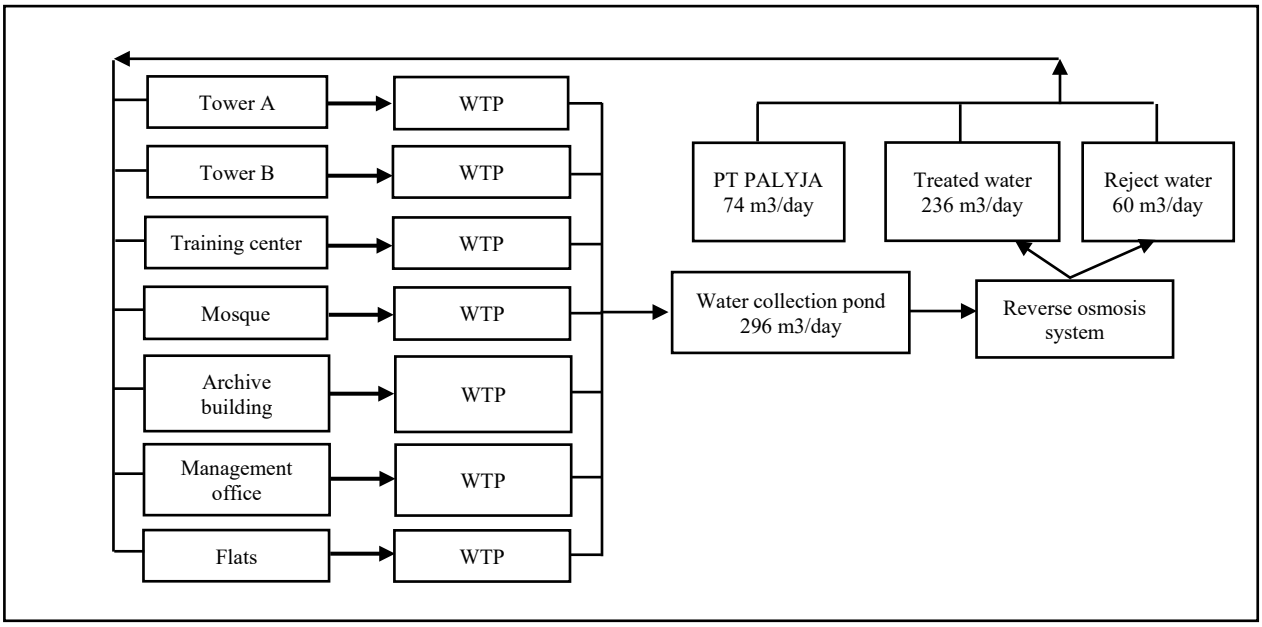

Figure 1. Schematic of wastewater recycling

5. Conclusion

Apart from water that comes from drinking water companies, the way to overcome water needs due to scarcity for office and residential buildings is to use wastewater from the building itself. Wastewater resulting from the use of water in buildings is very large, about 80% of the total use, it would be a loss if this wastewater was disposed of just like that. Treatment techniques using a reverse osmosis system can be used as an advanced treatment of standard wastewater installation systems in each building. The quality of the treated water results can meet the standards to be used as clean water for all building uses, however, reject water from the RO system can only be used as water that is not directly related to humans because there is a residual content from the processed water. Further, processing is required if the reject water is to be reused as clean building water.

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Biography

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