Feasibility study of rainwater conservation and harvesting for industrial community in North Jakarta

A W Murdiana¹, Soesilo TEB¹, and S Bismo²*
¹ School of Environmental Sciences, Universitas Indonesia, Salemba 10430, Indonesia
² Department of Chemical Engineering, Faculty of Engineering, Universitas Indonesia, Depok 16424, Indonesia
E-mail: setijo.bismo@ui.ac.id

Abstract. Rainwater harvesting has been adopted in many regions of the world when raw water supplies are insufficient for the community. A multinational company engaged in heavy equipment around North Jakarta has a rainwater pool facility that can be used to anticipate flooding during the rainy season using the Ground Catchment System method. In addition, this water source can be used to meet the company's clean water needs both for industrial and domestic needs and to reduce the use of municipal supply water (Perusahaan Daerah Air Minum, PDAM). This study aims to meet the needs of clean water, anticipate floods and droughts. This research uses a problem-solving approach to reduce the use of water from PDAM. The variables studied in this research are average water quantity, water quality, and reduction of water consumption from PDAM by replacing it with clean water from rainwater, and then assess them using qualitative and quantitative method for six months. The results concluded that the quantity of water from rainwater treatment produced during six months of research can reduce the consumption of PDAM water as much as 20%. In general, the rainwater harvesting for the needs of the industrial community in the company can be considered as a feasible solution to provide clean water substitute and to reduce PDAM water consumption.

1. Introduction
Harvesting rainwater as an alternative source of water has been practiced for centuries in various countries that often suffer from water shortages [1]. Generally, rain harvesting can be divided into two parts, the first is by collecting rainwater on the roof of the building (roof catchment) and the second is by collecting ground catchment water [2]. The abundance of rainwater harvested is determined by the topography of the catchment area (flat or sloping) and by the top layer of soil's ability to retain water [3]. A heavy equipment company located in North Jakarta has 8600 m³ of rainwater resources in a pond with a Ground Catchment System. Initially, the pool or water reservoir was made in anticipation of the rainy season because the location of the company was close to the sea and prone to flooding. Besides anticipating flood, this water reservoir can also be used as a pool for collecting rainwater. This water can then be processed adequately to be used as a source of clean water. Therefore, scientific considerations and studies on rainwater treatment as a source of clean water in order to reduce the consumption of municipal water are needed.
2. Literature Review

2.1 Grouping of Raw Water Usage
Raw water is untreated water that found in nature. In general, there are two types of raw water sources, namely groundwater, and surface water. Water on earth has always undergo four phases in hydrologic cycle (evaporation, condensation, precipitation and collection) and there are four water sources on earth: sea water, groundwater, atmospheric water and surface water [4].

2.2 Rainwater Harvesting
Harvesting rain helps to reduce surface runoff water from rain [5]. Ecologically, there are four reasons why rainwater harvesting is important for water conservation [6]. First, for increasing the need for water results in increased underground water retention. Second, the existence of water from water sources. Third, for other water sources are usually located away from the home or community of users. Fourth, water supplies can be contaminated by industrial activities and human waste activities such as the entry of minerals such as arsenic, salt or fluoride. This study uses the fourth reason because in general the quality of rainwater is relatively good.

2.3 Estimates of Water Usage
In calculating water demand estimates, the number of water users is the most important factor. The general water usage can be grouped into four based on the purpose of its use, they are water for irrigation, energy generation, industrial and public [7]. Among these water uses, the most important is the need for drinking [8]. While the purpose of water use can be grouped three parts: domestic, industry, and public [9].

3. Research Methodology

3.1 Types of Research
We conducted quantitative approach to solve the problem of water availability in the industrial community by utilizing rainwater to reduce PDAM water consumption. Quantity and quality of harvested rainwater before and after treatment were measured.

3.2 Research Focus
The purpose of this study is to assess rainwater harvesting feasibility to conserve water, to anticipate the potential for flooding during the rainy season and to reduce the use of PDAM water for industrial and domestic needs, thus reducing the water consumption cost in the company. This study focuses on the feasibility of rainwater conservation and harvesting for the needs of industrial community in North Jakarta.

3.3 Time and Location Research
The study was conducted for six months, from July 2017 to December 2017. It was carried out for six months because the researchers wanted to get rainfall volume data in the container pond in the dry and wet months (when the water was abundant). The research was done in a rainwater reservoir (containment pond) of a company located in North Jakarta. The Sketch of containment pond area can be seen in Figure 1.

Figure 1. Sketch of containment pond area (Pond).
3.4 Method of Rainwater Harvesting

Rainwater that flows on the surface of the ground flow into the rainwater catchment pond. Then the rainwater in the holding pool will be taken through the suction pump. In the flow suction pump, water is injected with coagulant and flocculants using the Dosing pump. Through a suction pump, water flowed to the deposition site (Lamella clarifier). The water from the lamella clarifier is fed into the intermediate tank, then the water in the intermediate tank is pumped into a water recycling unit to be treated into clean water. The water recycling unit consisted of an active zeolite filter, an activated carbon filter, filter bag and ultrafiltration. The treated water is then stored in the production tank and fed a chlorine mixture through Chlorine Feeder. At the end of the process, the water produced is pumped into a distribution tank and distributed to all the areas in need. Rainwater harvesting process can be seen in Figure 2.

![Figure 2. Flow of rainwater harvesting process](image)

3.5 Techniques of Data Processing

The average quantity of clean water produced monthly from the rainwater treatment during the research period, accompanied with the analysis of the water quality (acidity (pH), total dissolved solids (TDS), color, odor, and turbidity) were measured. The percentage reduction in water consumption from PDAMs in which replaced by treated rainwater was also calculated.

4. Discussion

4.1 Water Conservation

Conserving water resources has many goals. It prevents flood and drought, prevents soil erosion and sedimentation, and prevents water loss due to human intervention. It also maintains water capability and water resources and maintains water availability, so it can be enjoyed in the future [10]. This research is conducted to maintain the existence and the sustainability of natural water sources. In principle, water conservation is done by using water that falls to the ground as efficiently as possible and giving the water a proper flow time, so there is no flood in the rainy season and there is enough water in the dry season. Water conservation conducted in this research was done by collecting surface water into a containment pond and treating it into clean water.
4.2 Results of the Research
Results of the research conducted from July - December 2017 can be seen in Table 1.

Table 1. Results of the research in July - December 2017

| Month | Average of rainwater treatment per day (m³) | pH Before | pH After | TDS (mg/L) Before | TDS (mg/L) After | Odor Before | Odor After | Turbidity Before | Turbidity After | Color Before | Color After |
|-------|------------------------------------------|-----------|----------|-------------------|-----------------|-------------|------------|-----------------|----------------|--------------|-------------|
| Jul-18| 107.7                                    | 6.9       | 7.15     | 395.6             | 199             | No Smell    | No Smell   | Not Cloudy     | Clear          | Clear        |
| Aug-18| 79.9                                     | 5.9       | 7.62     | 431.6             | 81              | No Smell    | No Smell   | Not Cloudy     | Clear          | Clear        |
| Sept-18| 78.8                                   | 5.5       | 7.4      | 514.1             | 194             | No Smell    | No Smell   | Not Cloudy     | Clear          | Clear        |
| Oct-18| 42                                       | 6.3       | 6.91     | 405.8             | 94              | No Smell    | No Smell   | Not Cloudy     | Clear          | Clear        |
| Nov-18| 99.5                                     | 7         | 7.2      | 391               | 101             | No Smell    | No Smell   | Not Cloudy     | Clear          | Clear        |
| Dec-18| 122                                      | 7.2       | 7.5      | 363.4             | 177             | No Smell    | No Smell   | Cloudy         | Not Clear      | Clear        |

4.2.1 Results of Rainwater Treatment
The average clean water generated from rainwater treatment obtained from July - December 2017 per day was 88.3 m³ with an average of 107.7 m³ in July, as of August 78.8 m³, in September as much as 78.7 m³, October as much as 42 m³, November as much as 99.5 m³ and December as much as 122 m³. The volume of clean water generated from rainwater treatment from July - December 2017 can be seen in Figure 3.

Figure 3. Volume of clean water generated from rainwater treatment from July - December 2017
Lowest clean water volume was observed in October. In this month, the weather was very hot and it had less rainfall than the other months. While the month with the most result was observed in December with a volume of 122 m³.

4.2.2 Results of Parameter Evaluation (pH, TDS, Odor, Turbidity, and Color)
The analysis results of the water pH before and after rainwater treatment along with the standard maximum pH limit can be seen in Figure 4. Average pH of rainwater obtained for 6 months before treatment was 6.5 and the average water pH after treatment was 7.3. The rainwater pH range prior to treatment was 5.5 - 7.2 and the water pH range after treatment was 7.15 - 7.5. The pH of water produced after rainwater treatment is included in the category of neutral pH or good pH for clean water and drinking water. This shows that the water treatment can change the water acidity to meet the clean and drinking water quality standard.

Figure 4. Results of pH analysis
The results of TDS analysis before and after water treatment are shown in Figure 5. The average TDS of rainwater before treatment obtained for 6 months was 417 mg/L and the average TDS of water after treatment was 141 mg/L. The water TDS range before rainwater treatment was 363.4 - 514.1 mg/L and the water TDS range after rainwater treatment was 81 - 199 mg/L. TDS of water produced after rainwater treatment does not exceed the specified standard TDS quality of 1500 mg/L. Basically before and after water treatment, its TDS does not exceed the quality standard. Thus it can be said that the rainwater TDS quality was already good and rainwater treatment conducted could make the TDS even lower, in other word the treatment improved the water quality. There was no significant difference in the smell of water before and after treatment. This shows the rainwater collected in this location did not contain any pollutant that could cause any smell.

There was also no significant difference in water turbidity before and after treatment. In some cases we found the rainwater were turbid or cloudy that cleared up after the treatment. Generally when it rains, the water entering the rainwater collection pond comes from various regions and carries various kinds of solids e.g. mud, soil and even garbage. So that even when the rainwater are abundant, the collected water cannot be directly processed due to the amount of solids. It is important to wait for the solid contamination to precipitate and settle as sediment. Some difference on water clarity before and after treatment were observed. Some turbidity in rainwater collected usually caused by the disturbance in body of water before the treatment, i.e. by rain as mentioned earlier or due to the large amount of dissolved material carried by water in the rain. The solids contained in the water need to be precipitated first before the water going into treatment.

4.2.3 Feasibility of Rainwater Utilization in Environmental Aspect

This research is one of the long efforts to anticipate the potential for flooding in North Jakarta, especially in the Cakung Cilincing area. Nearby locations with the sea and dens factory buildings in the area cause poorly functioning drains or drainage. Added by the environmental waste and the absence of water catchment areas make the area have more frequent flooding every rainy season. The company as part of an industrial area feels the need for the management of surface water, especially rainwater that often cause flood. The company built an 8600 m3 containment pond to accommodate and process rainwater into clean water that consumable for its industrial and domestic communities. This containment pond allows the reduction of the volume of surface runoff, not only in this company but also in its surrounding area. The area did not experience high flooding due to surface runoff during the rainy season. Rainwater that falls down flows directly into the reservoir pond. In addition, residents around the company no longer experience long lasted flood every rainy season, sometimes it is flooded up to 20 cm high but receded shortly after.

5. Conclusion

Overall, the rainwater harvesting is feasible and can be applied as a clean water provider. Factors that may increase the feasibility of future utilization are: first, the amount of water produced depends on the size of the containment pond, preferably the area of the container pond is adjusted to the area of this company. Containment pond can be made at some point in certain area or in combination with roof catchment harvesting system for more optimal result and even distribution area. Second, to obtain good water quality, clear provisions on the time range of solids precipitation of rainwater must be made beforehand.
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