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KETERBATASAN DALAM PEMANFAATAN LIMBAH DAUR ULANG PADA GEDUNG KANTOR DI JAKARTA

CONSTRAINTS IN THE RECYCLED WASTEWATER UTILIZATION IN AN OFFICE BUILDING IN JAKARTA

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ABSTRACT

The threat of water scarcity and the progressing technology in sewage treatment plants promote the reuse of recycled wastewater. While the practice itself is beneficial, there are still issues to be solved to utilize its full potential. This study focuses on identifying the bottlenecks or limiting factors in implementing the practice on a building scale. An office building was researched to reveal its water usage pattern. The building introduces a sewage treatment plant so the sewage can be recycled into usable freshwater. The analysis indicates the produced recycled wastewater has not been fully utilized until now. While the volume of the water demand is greater than the recycled wastewater, several factors hinder the total utilization of the reclaimed water. The recycled wastewater is mostly more than enough to cover the water usage for both gardening and toilet flushing, the usages still leave an excess of water for other purposes. Because of the constraints in water quality, finance, and public reception, the excess reclaimed water is yet to be optimally utilized. Firstly, the quality of the reclaimed water is not very convincing to be used for non-flushing human usage and cooling towers. Secondly, the high cost of the investment and the overhaul of the plumbing system (for old buildings) deters the practice of reusing the reclaimed water. Thirdly, many people still have terrible perceptions about reused wastewater thus they would hesitate to utilize it even if the reused water is technically fine.

Keywords: *recycled wastewater, sewage treatment plant, office building, water conservation, rainwater harvesting*

ABSTRAK

Ancaman kekurangan air dan semakin canggihnya teknologi Instalasi Pengolahan Air Limbah (IPAL) mendorong praktik penggunaan kembali air limbah domestik yang telah didaur ulang. Walaupun hal ini menguntungkan, masih ada beberapa isu yang harus diselesaikan untuk memanfaatkan seluruh potensinya. Penelitian ini berfokus untuk mengidentifikasi faktor-faktor yang membatasi implementasi pemanfaatan kembali limbah daur ulang pada skala bangunan. Penulis meneliti pola penggunaan air dari suatu gedung kantor. Gedung ini menggunakan IPAL untuk mengolah limbah domestiknya menjadi air yang dapat digunakan kembali. Analisis menunjukkan bahwa limbah daur ulang masih belum digunakan seluruhnya. Walaupun volume dari kebutuhan air lebih besar daripada volume limbah daur ulang, beberapa faktor menghalangi pemanfaatan secara total. Hasil daur ulang ini lebih dari cukup untuk memenuhi kebutuhan penyiraman tanaman dan toilet, sisanya dapat digunakan untuk keperluan lain. Karena adanya keterbatasan dalam hal kualitas air, keuangan, dan persepsi publik, sisa hasil daur ulang belum dapat dimanfaatkan secara optimum. Pertama, kualitas hasil daur ulang belum memadai untuk keperluan manusia non-toilet dan cooling tower*. Kedua, tingginya biaya investasi awal dan pembongkaran-pemasangan kembali sistem plambing (untuk bangunan lama) membuat kebijakan ini kurang menarik. Ketiga, masih banyak orang yang mempunyai persepsi buruk mengenai hasil daur ulang limbah sehingga ragu untuk memanfaatkannya sekalipun bila mutunya baik secara teknis.*

Kata Kunci*: limbah daur ulang, instalasi pengolahan air limbah (IPAL), gedung perkantoran, konservasi air, pemanenan air hujan*

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INTRODUCTION

Recycled Wastewater (RWW) or reclaimed water has a wide range of uses e.g. irrigation, power generation, flushing, aquifer recharge, etc (Alkhamisi & Ahmed, 2014; Kumar & Goyal, 2020). The practice is getting traction since the advancing technology produces cleaner output and there is a higher concern about conserving water. Utilizing recycled wastewater is expected as one of the panaceas in alleviating the threat of water shortage.

Its growing popularity is proven by numerous research about its necessities and advantages (Dillon, 2000; Jin et al., 2014; Luckmann et al., 2016). The Republic of Korea, for example, established a national policy to reuse treated sewage for various purposes and it has saved a lot of water albeit several improvements must be formulated (Lee & Mendoza, 2022).

The benefits of reusing recycled wastewater also come with constraints. The most obvious one is the cost of assembling a Sewage Treatment Plant (STP). Moreover, the risks of health hazards, environmental hazards, and public acceptance are looming (Alkhamisi & Ahmed, 2014).

Using reclaimed water for daily domestic activities is becoming more common. For instance, it is employed in developed countries such as Australia, Spain, and France to name a few (Valipour & Singh, 2016) or in The Netherlands (Narain-Ford et al., 2020, 2021).

STP is widely used on a municipal scale where it acts as a center that receives sewage water and distributes the RWW on a city/regional scale. However, STP also can be implemented in a single building or facility. There are already various research about its feasibility, advantages, and constraints (Bobková et al., 2023; Chen et al., 2024; Grobicki & Cohen, 1999; Manouchehri & Kargari, 2017; Shimizu et al., 2013)

One potential problem with utilizing the RWW is public acceptance (Drechsel et al., 2015). Even using reclaimed water without directly touching humans must also consider the issue. It is even more sensitive to human usage. There are a considerable number of people who are resistant to the concept (Ravishankar et al., 2018; Verhoest et al., 2022). March et al. (2004) reported a positive acceptance by the public when the latter was informed about the application of recycled wastewater for toilet flushing. However, the result could be different if the water comes into contact with human bodies such as in hand washing or bathing activities.

Promoting the utilization of reclaimed water is necessary to meet the ever-growing water demand. However, there will be resistance to the policy unless a proper approach is developed. Therefore, it is necessary to foresee the difficulties in the practice before formulating the solutions. The previous paragraph mentioned the constraints of STP implementation on a large scale like in a municipal, but the study about the constraints on a small scale or building scale is lacking. It is regrettable since more buildings install their own STP yet there is a substantial lack of research in its constraints. Thus the objective of the study is to identify the constraints that restrict the utilization of recycled wastewater in a building scale.

METHODS

The objective of the study is achieved by identifying various purposes of water demands in the building as well as their quantity. Afterward, the produced reclaimed water is measured and allocated to suitable purposes. It is distributed to maximize the reuse of STP's product so the building can save as much water as possible.

Building characteristics

The research took place at an office building in Central Jakarta, Indonesia. The initial is JBT and will be referred to for the rest of the paper. JBT started operating in 2019 and it leases office spaces. The total site area of the building is 5,816 m^2 and it comprises 36 floors and 2 basements.

The primary freshwater source of the building is supplied by the regional potable water company which distributes freshwater to the city. This state company will be referred to as The Supplier. JBT routinely buys water from The Supplier and the monthly water bills provide information about the water volume used by the building.

JBT set up an STP unit to treat the domestic sewage and converts it into the recycled wastewater (will be referred to as the RWW). The STP type is extended aeration with fill media and it has a recycling capacity of 120 m^3/day. Considering loss and inefficiency, it produces approximately 100 m^3/day. The dimensions of the treater water tank (the storage after the sewage has been treated) are 9910 mm x 3200 mm x 3050 mm which means it has 96.72 m^3 capacity. JBT also installs its plumbing system to prevent RWW comes into contact with the human body so it is utilized for gardening and flushing only. The authors mounted a flowmeter at the STP's outlet to find out the daily production of RWW from 1 April 2022 until 1 July 2022.

The building managers were interviewed to obtain information about the number of building occupants and the pattern of daily activities. They were also asked about the water requirement for the cooling tower and the gardening as well.

Water usage

The original data from JBT are displayed in Figure 1. Each line is elaborated as follows:

1. The blue line represents the water bought from The Supplier which distributes freshwater. The volume is extracted from the water bills from January 2020 until June 2022.
2. The green line represents the volume of STP's recycled water or the RWW which was utilized for the daily activity from 1 April 2022 until 30 June 2022. The RWW is distributed for toilets flushing and gardening. The authors installed a flowmeter at the STP's outlet to monitor it daily. A JBT staff checked the flowmeter data manually at 07:30 morning every day and the daily record is shown in Figure 2.
3. The light blue line represents the volume of water coming from the Rainwater Harvesting (RWH) system. The data is collected from the JBT manager's daily record.
4. The red line represents the volume of utilized backup water i.e. the water from The Supplier which is stored temporarily for further use. The data is also collected from the JBT manager's daily record.
5. The dashed black line represents the approximate number of persons who worked in JBT. The figure is derived by interviewing various persons in JBT for instance JBT managers, securities, janitors, etc. The number fluctuates depending on the state of Covid-19's outbreak severity.

The total water usage by JBT is approximated by:

$$Total\ water\ usage = water\ supplier\ (1) + STP\ (2) + RWH\ (3) - backup\ (4) \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

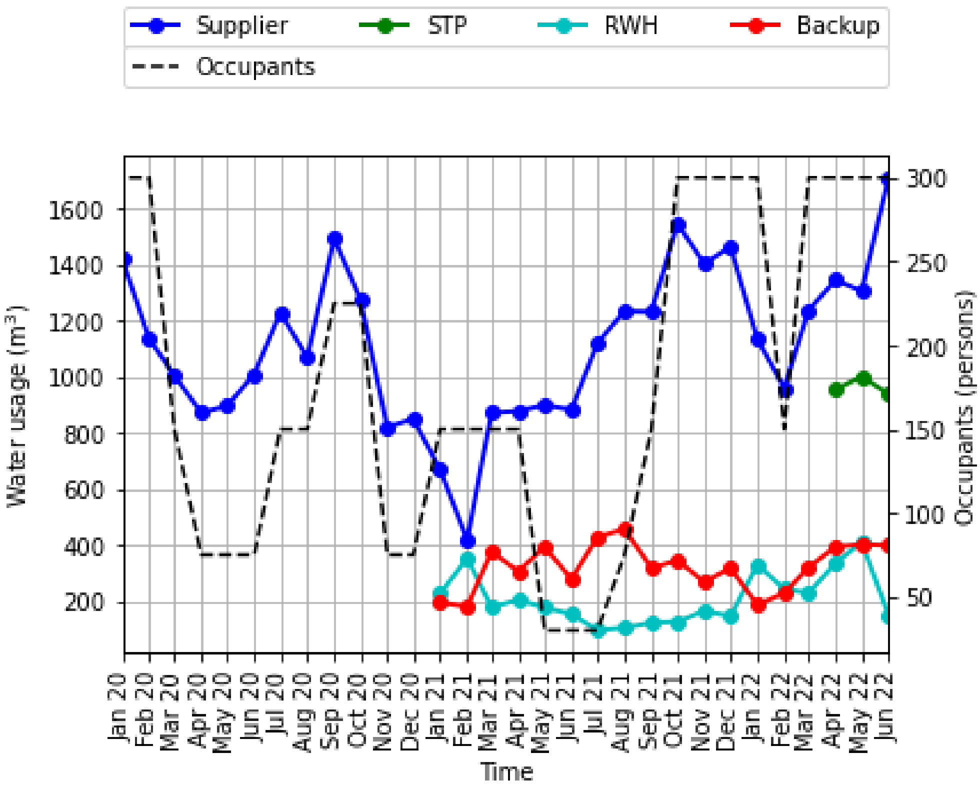

Figure 1 The factual data of the utilization quantity of various water sources and the number of JBT's occupants (January 2020 – June 2022)

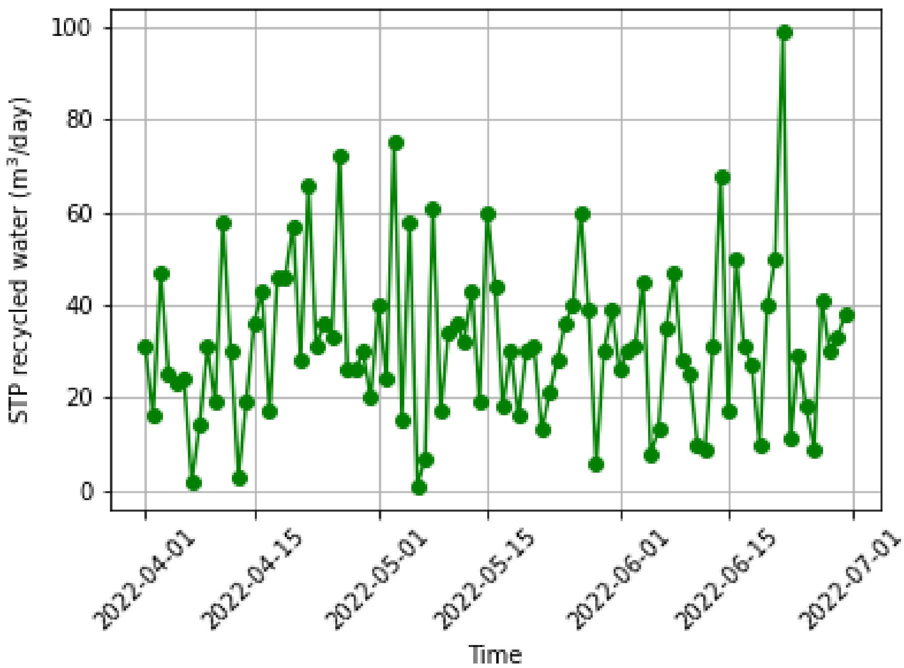

Figure 2 The daily record of STP production

Therefore, the analysis to extract the water usage rate will be carried out from January 2021 until June 2022 period when most data are complete. The only incomplete data is the STP volume which must be approximated based on the conducted direct observation. Afterward, the estimated water usage rate could be used in further analysis.

Water quality

The quality of the RWW was examined to figure out whether it is suitable for daily use. Moreover, the regular tap water from The Supplier was also examined for comparison to see if the RWW was adequate for the replacement.

The sample of the RWW was taken on 17 May 2022. It was immediately delivered to a laboratory and the result is displayed in Appendix A.

The examination result showed there is not much quality difference between RWW and regular tap water. The latter is generally better, but the difference is close and both still fall in the same class. The examination proves the RWW is safely adequate to replace water from The Supplier for flushing and gardening.

RESULTS AND DISCUSSIONS

Determination of water usage rate

The average STP recycled water used in Figure 2 is 31.84 m^3/day. During the period of measurement, the number of building occupants was approximately 300 persons. It means the daily use of the RWW is 106.12 litres/day/person. This figure will be the basis to approach the volume of the RWW before the measurement began i.e. from January 2021 until March 2022. This approach can be applied because the working hours and the domestic sewage production are approximately similar for every person.

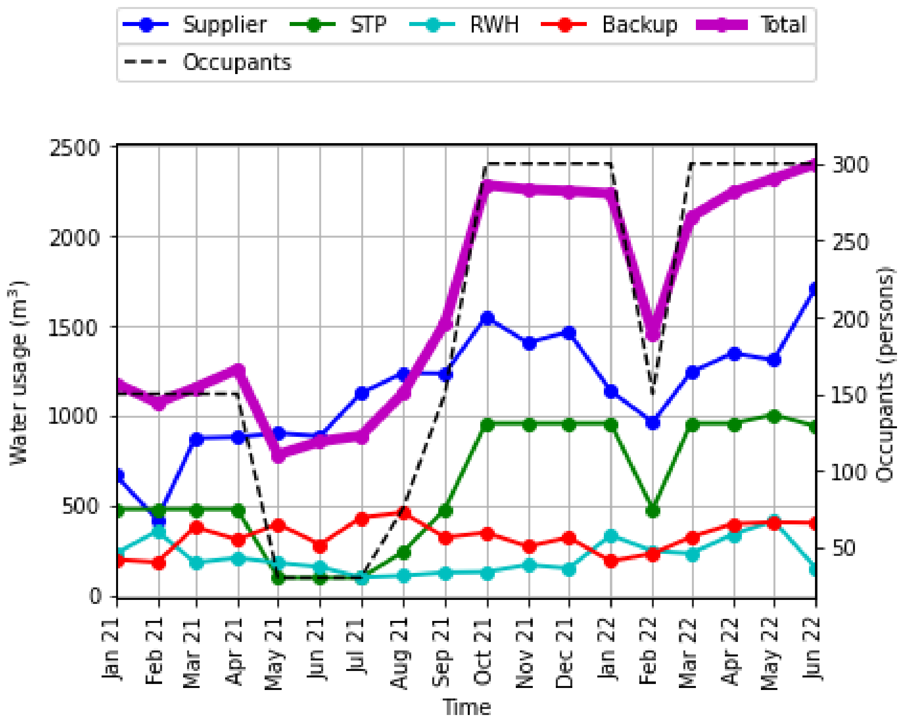

Figure 3 The utilization quantity of various water sources and the number of JBT's occupants, but overlaid with the estimated figure of STP production (January 2021 – June 2022)

The RWW volume can be estimated by multiplying the number of building occupants by 106.12 litres/day/person. The results are presented in Figure 3 with the addition of the bold purple line which represents the total water usage calculated by Equation (1).

Based on the direct observation and interviews with the building manager and occupants, JBT utilizes freshwater for four main purposes i.e. gardening, building cleaning, cooling tower operation, and the occupants' daily activities. The water is also used for pipe flushing and firefighting purposes, but the volume required is negligible. Each purpose's usage rate is assessed to determine if the RWW is already used efficiently. The methods to estimate each purpose (except human usage) are elaborated in the previous section. The water required for each activity is:

1. Gardening: 27.23 m^3/day.
2. Building cleaning: 2.75 m^3/day.
3. Cooling tower: 23 m^3/day.

The recapitulation of the water usage rate for every activity during the pandemic is displayed in Table 1. From these figures, the water required for the occupants' activities can be approached by deducting the total water usage by Equation (1) from the water requirement for gardening, building cleaning, and air conditioning. It is expressed in Equation (2) and the results are depicted in Fig. 5 with a yellow line.

Table 1 The water usage rate of JBT during the pandemic

Activity	Daily usage rate (m^3/day)	Monthly usage rate (m^3/month)
Plant watering	27.23	816.82
Building cleaning	0.50	15.00
Cooling tower	5.75	172.50
Total	33.48	1004.32

$$\textbf{Human usage} = \textbf{total water usage} - \textbf{gardening} - \textbf{building cleaning} - \textbf{cooling tower} \quad \ldots\ldots(2)$$

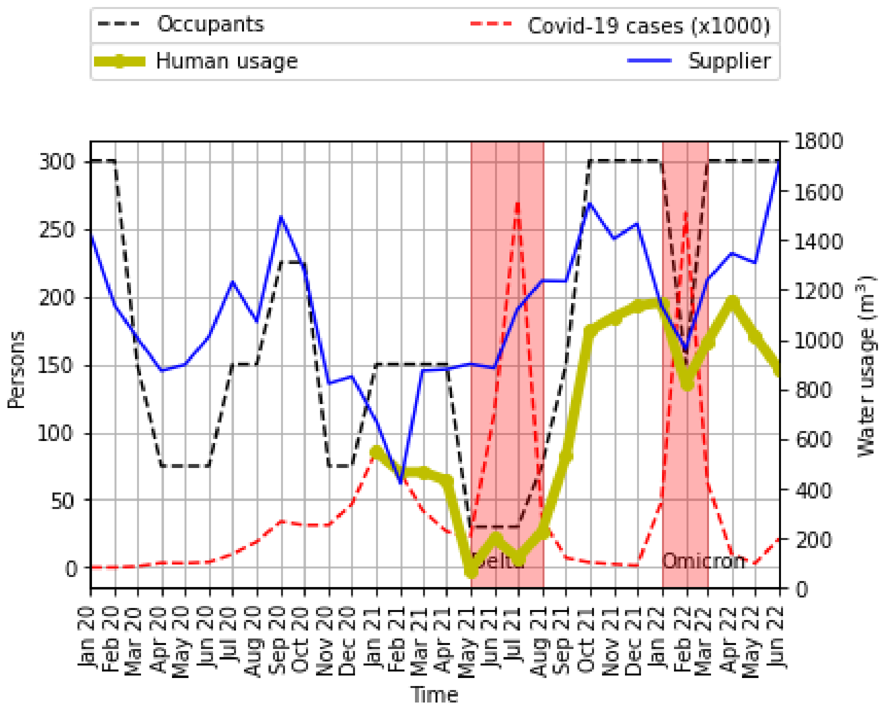

Figure 4 The correlation among JBT occupants, tap water usage, and COVID-19 cases

Figure 4 illustrates the fluctuation of the human usage's water volume and the water bought from The Supplier between January 2020 and June 2022. In this study, human usage is the non-potable water used for domestic activities e.g. toilet flushing, bathing, handwashing, laundry, etc. Its volume is only available between January 2021 and June 2022. The figure indicates the drop in the water distributed by The Supplier (blue line) and water utilized by the occupants (yellow line) when the COVID-19 spreading (dashed red line) was massive i.e. during the Delta variant and the Omicron variant outbreak in May 2021 – August 2021 and January 2022 – March 2022 (red highlight) respectively. The extensive spreading compelled the workers to work from home hence fewer people working at JBT (dashed black line) and it reduced the water demand.

The average water usage for the daily activities of JBT's occupants during the pandemic is 111.77 litres/day/person. The rate is higher than the national standard which specifies 70 litres/day/person (SNI 03-7065-2005 Guidelines on Planning of Plumbing System, 2005). This is because the Covid-19 outbreak compelled everyone to wash hands more frequently. Moreover, the rate closely approaches the water usage rate in the author's previous study (Kurniawan et al., 2022).

The allocation of the recycled wastewater (during the pandemic)

Now that the water usage rate of each building's activity has been identified ("Determination of water usage rate" subsection), the RWW (and the RWH water) can be allocated for JBT's activities. Fig. 5 depicts how the RWW can replace water from The Supplier for various purposes. The blue line is the volume of the RWW from January 2021 until June 2022. The black line is the volume of the RWW plus RWH water in the same timeframe. Various activities are illustrated with a bar chart where each activity is stacked on top of the other.

The tasks are sorted from bottom to top according to the feasibility of using the RWW instead of freshwater from The Supplier. For instance, plants accept any sort of water as long as it has sufficient quality. Meanwhile, humans are sensitive to water quality hence water for human tasks e.g. building cleaning and flushing needs to be cleaner. Mechanical electrical system is also sensitive to water quality where a defect in water quality could inflict costly damage to the system.

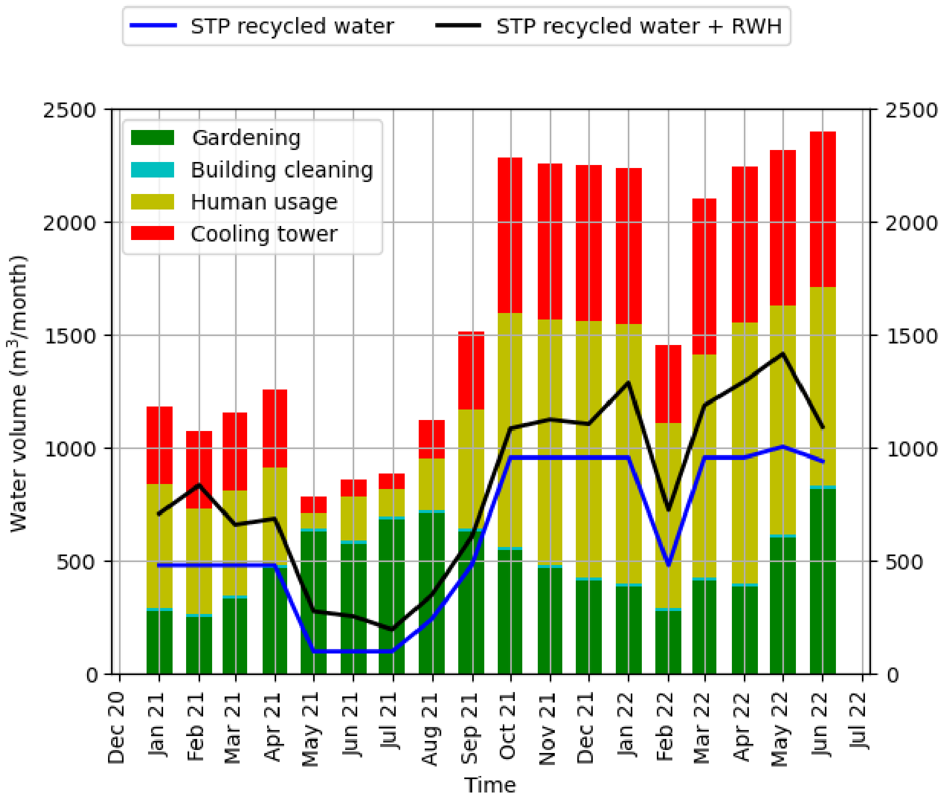

Figure 5 The illustration of how STP and RWH could replace the existing tap water usage

Figure 5 indicates the RWW is generally sufficient to cover the plant watering and JBT cleaning. It was only insufficient from May until August 2021 because the Delta variant outbreak keeps occupants out of the office (hence less domestic sewage) and the dry season obliges the JBT building manager to utilize water from The Supplier. Otherwise, there is still excess water from the STP after the gardening and JBT cleaning tasks are fulfilled.

The excess water from the STP and RWH could still be utilized for flushing. February 2021 was a rare case when the rainy season supplied water naturally and spared the management from the plant watering task. Furthermore, only a few occupants were in JBT since Jakarta was still in semi-lockdown. STP and RWH water, in general, are still partly sufficient to meet the demand for toilet flushing.

Roshan & Kumar (2020) compiled studies that estimated various indoor water-end uses in Table 2. The rate of toilet water requirement is shown in the table. Most countries in Table 2 are selected because they are relatively close geographically and culturally (Thailand and Singapore) while India and Spain are added for references only. Therefore, the flushing rate is assumed 30 litres/person/day in this study and Figure 5 is broken down to Figure 6.

Table 2 The compilation of toilet water usage in several countries

Country	**Reference**	**Toilet water usage (litre/person/day)**
Indonesia	Adriani et al. (2020)	42.6
	Hafiza et al. (2019)	37.3
Thailand	Otaki et al. (2008)	30 at most
Singapore	PUB, Singapore's National Water Agency in Roshan (2020)	26.6
India	Manna (2018)	35.1
Spain	March et al. (2004)	36

Figure 6 suggests constraints in utilizing the RWW. There is still excess water even if the RWW is also distributed for toilet usage. It means the building manager has to use it for non-flushing human usage or cooling tower operation if he is to spend the whole RWW.

Reutilizing the RWW for flushing is not a problem for JBT for it has already separated the plumbing system for flushing and non-flushing purpose. Several studies assess whether wastewater can be recycled to be reutilized for cooling towers to reduce water cost (Ma et al., 2018). The problem is whether the water quality is sufficiently operable without damaging the cooling tower installation. Several recent studies encourage the practice for they concluded that recycled wastewater can be reused in cooling towers as long as it receives proper chemical treatment (Eng et al., 2019).

The average water provided by the STP and the average water usage during the pandemic is compiled in Table 3. The RWW production rate is 106.12 litres/day/person based on Figure 3 where the average STP recycled water is 31.84 m³/day by 300 building occupants. RWH water is not considered because the focus is on recycled wastewater. Besides, it is fluctuating throughout the year and is unreliable during the dry season. Meanwhile, the estimation of both gardening and building cleaning is from direct observation while human usage is estimated to be 111.77 litres/day/person multiplied by 300 persons.

Figure 6 and Table 3 indicates the constraints where the building users cannot fully use the RWW. The table suggests the RWW is normally sufficient to cover flushing. Rain adds additional supply while reducing the plant watering demand. Consequently, there will be more water available for human usage and it potentially creates excess water since the RWW is only distributed for flushing.

Table 3 The comparison between the recycled wastewater and the water demands during the pandemic (300 persons)

Supply	Quantity (m^3/day)	Demand	Quantity (m^3/day)
RWW	31.84	Gardening	27.23
		Building cleaning	0.50
		Toilet usage	9.00
		Human usage (non-flushing)	24.53
		Cooling tower	5.75
Total	31.84	Total	67.01

The allocation of the recycled wastewater (future projection)

The future scenario is analyzed when the pandemic ends and JBT operates with 100 % of occupants working at the office. The full capacity of JBT is approximately 1200 persons, four times greater than 300 persons during the pandemic.

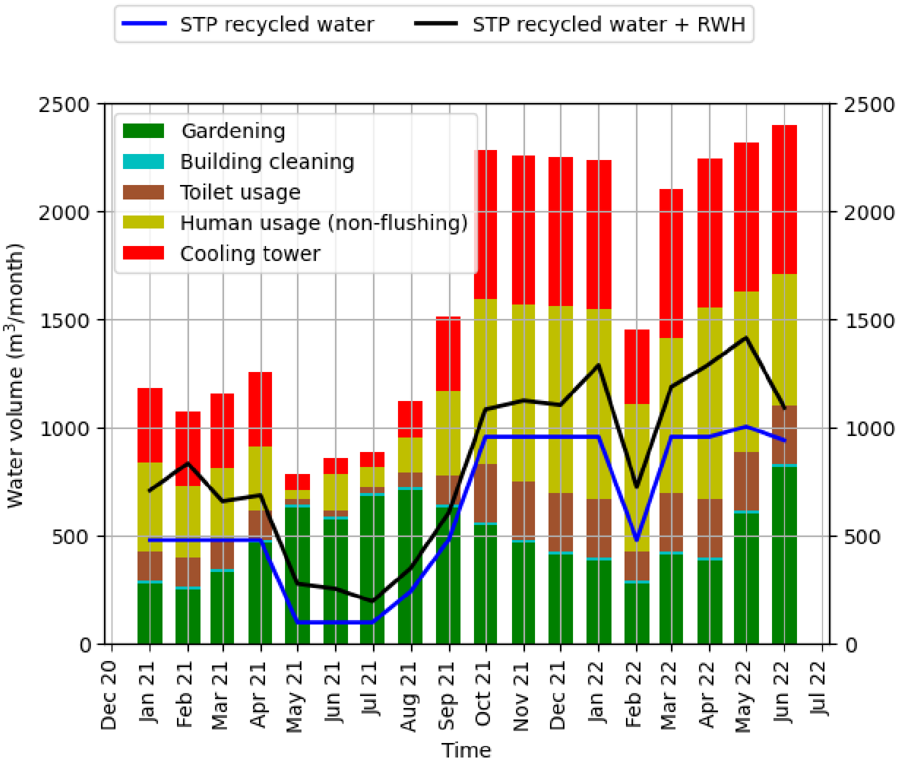

Figure 6 The illustration of how STP and RWH could cover various water usages with a breakdown of water usage into flushing usage and non-flushing usage

The difference in occupants number affects some parameters in Table 4 such as:

1. RWW: More people means more input for the STP. It is expected the volume of the future the RWW could reach 4 times the current production:
   31.84 m^3/day * (1200 persons / 300 persons) = 127.36 m^3/day
   However, since the STP can only produce 100 m3/day, the future RWW is also capped at 100 m^3/day.
2. Gardening: The planted vegetation is supposedly kept similar hence the gardening water demand remains the same i.e. 27.23 m^3/day.
3. Building cleaning: Currently, six floors are cleaned daily. When JBT is fully occupied, all 36 floors must be cleaned daily thus the water demand would be 6 times greater than the present rate:
   0.5 m^3/day * (36 floors / 6 floors) = 3 m^3/day
4. Toilet usage: It is forecasted by multiplying the future occupants of JBT by the rate of toilet water usage rate:
   1200 persons * 30 litres/day/person = 36 m^3/day
5. Human usage: The rate of 111.77 litres is the demand rate during the pandemic. In the future when people do not wash their hands as frequently, the demand rate would be lower. It is expected the figure would be 70-80 litres/day/person based on Indonesia's national standard (SNI 03-7065-2005 Guidelines on Planning of Plumbing System, 2005) or the previous research nearby (Kurniawan et al., 2022). The human usage rate is assumed to be 80 litres/day/person for the analysis.
6. Cooling tower: The water requirement for the air conditioning system is presumed to be proportional to the number of occupants. Since future occupants are 4 times greater than the current one, the water demand for the cooling tower is assumed 4 times as well.

The water balance in the future scenario is displayed in Table 4. The RWW production (100.00 m3/day) is much greater than the gardening and flushing (27.23 m^3/day + 36.00 m^3/day = 63.23 m^3/day). It suggests there will be a bottleneck where there would be an excess unused RWW of 33.77 m^3/day on average.

Table 4 The comparison between the recycled wastewater and the water demands in the future (1200 persons)

Supply	Quantity (m^3/day)	Demand	Quantity (m^3/day)
RWW	100.00	Gardening	27.23
Note: originally 127.36 m^3/day, but the capacity is only 100 m^3/day		Building cleaning	3.00
		Toilet usage	36.00
		Human usage (non-flushing)	60.00
		Cooling tower	23.00
Total	100.00	Plant +toilet	63.23
		Total	146.23

Discussions

This paper indicates several constraints that put limitations on the reuse of recycled wastewater on a smaller scale like in an office or apartment building. Unlike large STPs on a municipal or regional scale, urban building has many people in a small area. It implies STP has sewage as its input. Since the water users are inside the building as well, it is easy to distribute the treated effluent to every tap in the building. Despite its convenience, this paper points out the hindrances in fully using the abundant treated wastewater. They limit the usage of the reclaimed water so building users cannot fully utilize it regardless of its quantity.

According to the interview with the building managers, finance is another common primary constraint:

1. Larger STP capacity means a larger volume of recycled wastewater, but it also comes with a higher cost either in its initial investment or operation & maintenance. Most building owners tend to employ small/moderate STP because of cheaper costs and it is not certain if the break-even point can be reached within an acceptable time.
2. The land cost in big cities is expensive hence urban buildings will attempt to maximize the benefit from every inch of their floors, let alone for commercial buildings. It implies building owners will prioritize space for commercial activity instead of space for treated wastewater storage.
3. In the case of old existing buildings, the plumbing systems usually do not integrate wastewater recycling. Building owners have to overhaul the old plumbing systems if they want to utilize recycled wastewater. The initial investment becomes even more expensive for the deconstruction of the existing plumbing system and the disrupted

daily activity must be considered on top of the installation of the new STP. Although this case is not found in JBT, but the authors commonly find it in other buildings.

Public reception is also a determining factor and it could be a social or cultural or psychological or spiritual reason (Phiri et al., 2023; Ravishankar et al., 2018). People still have a disgusting notion about recycled wastewater regardless if it is technically hygienic or not. Another important consideration is religious activities where people routinely use water for Wudu or other religious rituals. It sounds unacceptable to use human waste products for sacred rituals when other less controversial water sources are available.

It will be beneficial to come up with solutions to utilize the potential excess RWW so that water resources can be saved. Especially for the building management, it also reduces water bills significantly. An example is upgrading the STP's output quality to allow reuse for cooling tower operation and non-flushing human usage.

CONCLUSIONS

STP is useful in converting sewage into reusable water. The general expectation is an increase in STP capacity implies greater water conservation. It is only partially true for there are many factors that limit the reuse of recycled wastewater. Without identifying them, we will not be able to use up every drop of recycled wastewater.

The analysis reveals there is an excess of recycled wastewater that cannot be used due to various causes. It is generally usable for gardening and flushing purposes, but the rest of the RWW cannot be used for other human usages and the cooling tower. There are three primary factors that form the bottleneck in utilizing recycled wastewater. They are water quality, public reception, and finance (based on the interview). Stakeholders who intend to fully use them must consider these factors.

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APPENDIX

Indonesia refers to the national legal standard as a quality standard for water (Government Regulation 22 of 2021, 2021). The standard is displayed in here. It classifies freshwater into 4 classes with Class 1 as the best quality water and it is consumable. Meanwhile, Class 4 is the worst and it is only strictly used for plant watering.

Note that some of the laboratory results could not identify the exact figure, but only estimates if it is below a certain number. In this case, the colour is set to the worst-case scenario. Moreover, the laboratory could not probe some of the parameters listed in the regulation.

Class 1	Class 2	Class 3	Class 4	< Class 4

No.	Parameter	Unit	RWW	Tap water
1	Temperature	°C	28.6	28.6
2	Total dissolved solids (TDS)	mg/L	328	198
3	Total suspended solids (TSS)	mg/L	<5	<5
4	Color	Pt-Co Unit	<1	<1
5	Degree of acidity (pH)		7.1	7.7
6	Biochemical Oxygen Needs (BOD)	mg/L	<3	<3
7	Chemical Oxygen Needs (COD)	mg/L	<10	<10
8	Dissolved oxygen (DO)	mg/L	7.1	7.1
9	Sulfate (SO_4^{2-})	mg/L	58	58
10	Chloride (Cl^-)	mg/L	45	16
11	Nitrate (as N)	mg/L	6.56	0.87
12	Nitrite (as N)	mg/L	0.004	<0.003
13	Ammonia (as N)	mg/L	<0.1	<0.1
14	Total nitrogen	mg/L	6.56	0.87
15	Total Phosphate (as P)	mg/L	<0.01	<0.01
16	Fluoride (F^-)	mg/L	<0.03	<0.03
17	Sulfur as H_2S	mg/L	<0.02	<0.02
18	Cyanide (CN^-)	mg/L	<0.002	<0.002
19	Free chlorine	mg/L	<0.01	<0.01
20	Barium (Ba) dissolved	mg/L	<0.6	<0.6
21	Boron (B) dissolved	mg/L	<0.01	<0.01
22	Mercury (Hg) dissolved	mg/L	<0.001	<0.001

No.	Parameter	Unit	RWW	Tap water
23	Arsen (As) dissolved	mg/L	<0.01	<0.01
24	Iron (Fe) dissolved	mg/L	<0.01	<0.01
25	Dissolved cadmium (CD)	mg/L	<0.01	<0.01
26	Cobalt (CO) dissolved	mg/L	<0.05	<0.05
27	Manganese (Mn) dissolved	mg/L	0.035	0.015
28	Nickel (Ni) dissolved	mg/L	<0.005	<0.05
29	Zinc (Zn) dissolved	mg/L	<0.002	<0.002
30	Copper (Cu) dissolved	mg/L	<0.03	<0.03
31	Lead (Pb) dissolved	mg/L	<0.1	<0.1
32	Chromium hexavalent (Cr- (vi))	mg/L	<0.01	<0.01
33	Oil and fat	mg/L	<5	<5
34	Phenol	mg/L	0.068	0.063
35	Fecal Coliform	MPN/100mL	390	<2
36	Total Coliform	MPN/100mL	690	<2