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WATER CONSERVATION MODEL IN HOTEL AND APARTMENT BUILDING IN SEMARANG CITY, INDONESIA

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ABSTRACT: Environmental problems such as land subsidence, seawater intrusion, and groundwater contamination are the impacts of groundwater exploitation in hotel and apartment buildings in the city of Semarang. This research was conducted on ten buildings using a four-model approach to water conservation, which includes rainwater harvesting, water-saving plumbing fixtures, the reuse of recycled water from gray water, and condensate water from air conditioners in buildings. The results showed that rainwater harvesting contributes 13.12–166.77% of the total building water demand, depending on the size of the catchment area of the building. Rainwater harvesting can be combined with infiltration wells, but the research location is relatively shallow; the groundwater depth is less than 1 meter, so infiltration wells cannot be applied. The use of water-saving plumbing fixtures accounts for 6.4% of the total building water demand. Likewise, with gray water, the reuse of recycled water from gray water contributes 59.87–69.71% of the total building water demand. Gray water is treated at STP, then flows to RWT, then flows to WTP to be treated. Gray water should not be mixed with black water so that the treatment load at the STP and WTP is not too large. Finally, condensate water from air conditioners in buildings is no less important to note; although it contributes only 1.43% of the total building water demand, it plays a role in creating green buildings.

Keywords: Water use, Conservation, Model, Hotel, Apartment

1. INTRODUCTION

Many hotel and apartment buildings in Indonesia use groundwater for building operations. Major cities in Indonesia, such as Jakarta, Surabaya, Medan, and Semarang, are recorded to still use groundwater a lot even though local regulations prohibit it. The excessive use of groundwater causes serious problems for the environment, such as land subsidence [1], seawater intrusion, and groundwater pollution [2]. Excessive groundwater extraction depletes groundwater reserves in a short period, resulting in a variety of negative environmental impacts, both directly and indirectly.

Currently, there are as many as 169 hotel buildings and 12 apartments in the city of Semarang, and every year it tends to increase. Almost all hotel and apartment buildings in Semarang City use groundwater. Excessive use of groundwater in Semarang City results in land subsidence in the northern area, which reaches 10 cm/year. Another impact of using groundwater is the occurrence of seawater intrusion and E.Coli pollution in densely populated areas. In essence, excessive use of groundwater results in a clean water crisis. The clean water crisis that occurred in Semarang City was caused by the conversion of land functions in several areas, which are water catchment areas, into commercial buildings. This triggers an increase in surface water runoff, which can cause flooding and reduced groundwater availability. So, to maintain the availability of groundwater, it is necessary to conserve water by implementing water conservation. The water conservation efforts that are most likely to be implemented in Semarang City are rainwater harvesting, water-saving plumbing fixtures, reuse of recycled water from gray water, and reuse of condensate water from air conditioners in buildings. This is due to regulations in the form of Semarang Mayor Regulation no. 24 of 2019 concerning green buildings and supported by geographical conditions close to the Java Sea.

The water conservation model in buildings has been widely applied to other buildings around the world, but the conservation models differ from one another depending on their respective geographic conditions. Some water conservation models place more emphasis on one model alone or a combination of several other water conservation models, such as rainwater harvesting [3], water-saving plumbing fixtures [4], reuse of recycled water from gray water [5], and reuse of condensate water from air conditioners in buildings [6], and some still apply a simple model by changing the behavior of water use [7-9].

2. RESEARCH SIGNIFICANCE

No research fully discusses the water conservation model in hotel and apartment buildings, but it is reviewed partially even though other water conservation potentials can be applied. Several water conservation models can be applied depending on geographical conditions and the financial strength of the building owner. This study plans a water management system with a green building concept to maintain a balance of water balance. The significance of this research is saving the use of air resources and reducing the need for the main air source, reducing the drainage load and air pollutant load by designing a management system in saving water resources and looking for alternative air resources that can be used. Based on geographical conditions, four models of water conservation can be applied in Semarang City, namely rainwater harvesting, installation of water-saving pipes, reuse of recycled water from gray water, and reuse of condensate water from air conditioners in buildings.

3. WATER CONSERVATION MODEL DEVELOPMENT IN BUILDINGS

3.1. Overview

This section describes the development of several models of water conservation in buildings, most of which have been applied by several studies around the world. The water conservation model is based on the amount of water used in buildings using an estimate based on the number of users (occupants). This method is based on the daily average water usage of each occupant and the estimated number of occupants. Thus, the amount of water used per day can be estimated, although the type and number of plumbing equipment have not been determined. This method is very practical in determining the water conservation model.

3.2. The Water Conservation Model Carried Out in the Previous Study

Four models of water conservation can be applied to buildings in the city of Semarang; this is considering that the city of Semarang is located on the alluvial plains and adjacent to the Java Sea, the groundwater level ranges from 0.5 – 1 meter, so it is very difficult to apply a conservation model other than the four those models. The four models are rainwater harvesting, water-saving plumbing fixtures, reuse of recycled water from gray water, and reuse of condensate water from air conditioners in buildings.

The water conservation model in buildings must take into account the use of water in buildings. This can be calculated based on the number of occupants of the type and number of plumbing equipment, the unit load of plumbing equipment, and water usage over time. If the number of occupants cannot be known, it is usually estimated based on the floor area and determines the occupant density per floor area. The intended floor area of the building is the effective floor area, ranging from 55 to 80 percent of the total area [10]. The use of water in buildings in the initial conditions uses the Indonesian National Standard number 03-7065-2005 concerning procedures for planning plumbing systems, namely: water use for hotels is 250-300 liters/guest/day, while for apartments it is 200-250 liters/occupant/ day.

The use of water in buildings can use the following equations:

$$Qh = \frac{Qd}{T} \quad (1)$$

Where:
Qh = average water usage (m^3/hour)
Qd = average water usage per day (m^3)
Q = duration of use (hours)

Water usage at peak hours is stated as follows:

$$Qh - max = C1.Qh \quad (2)$$

Where:
The value of the C1 constant ranges from 1.5 to 2.0 depending on the location, use of the building, and others. Meanwhile, for water usage at peak minutes, it is stated as follows:

$$Qm - max = C2.\frac{Qh}{60} \quad (3)$$

Where:
The value of the constant C2 ranges from 3 to 4.

The planned water conservation is by using rainwater harvesting, water-saving plumbing fixtures, the reuse of recycled water from gray water, and condensate water from air conditioners in buildings. Details of the analysis of water conservation in buildings are as follows:

a. Rainwater harvesting is used as a source of water for watering plants, flushing toilets, and building operations [3]. The supply of rainwater can be estimated from the area of the catchment area and the rainfall that falls. The formula for calculating the volume of rainwater stored on the roof area of a building is based on SNI 8066: 2015 [11].

$$\mathbf{V = 0.855.C.A.R} \quad (4)$$

Where:
V = volume of rainwater caught,
C = irrigation constant,
A = area of the rainwater catchment (m) and
R = daily rainfall (mm/hour).

b. Water-saving plumbing fixtures are installed by either installing water-saving plumbing fixtures or replacing existing plumbing fixtures with fixtures that use less water [4]. The volume of water required by each individual is based on several assumptions about how frequently each fixture is used in comparison to the water requirements of each plumbing fixture. The water requirement for plumbing fixtures can be seen in Table 1.

Table 1 Water requirements for plumbing fixtures [12]

Plumbing Fixtures	Conventional	Non-Conventional
WC Tank	6 liters/flush	6 liters/flush
Urinal	4 liters/flush	0.47 liter/flush
Lavatory	8 liters/minute	7 liters/minute
Shower	9 liters/minute	6 liters/minute

Note: WC = water closet

The calculation of the amount of water savings obtained can be seen from consumption standards that refer to the Green Building Council Indonesia. The water consumption standards for water-saving plumbing fixtures can be seen in Table 2.

Table 2 Water consumption standards [12]

Plumbing Fixtures	Occupancy	Factor
Women's WC	50 %	2.3*
Men’s WC	50 %	0.3*
urinals	50 %	2*
Hand Wash Duration	100 %	0.15**
Shower Usage Duration	5 %	5**
Tap Usage /day	100 %	2.5***

**average usage per person per day*
*** minutes/use*
****per day*

c. Reuse of recycled water from gray water produced from bathtubs, sinks, floor drains, kitchens, and washing machines. The composition of wastewater for gray water and black water is 70:30 [13]. The application of the use of recycled water includes watering plants at 5 liters per m^2 [10] with 20% green open space in each building [14], flushing toilets, and other building operations.

d. Reuse of Condensate water from air conditioners in buildings. Installation of pipes used to collect all condensate water collected in ground water tanks and reused for garden flushing, flushing, and for other purposes [6].

3.3. Analysis Conditions

The population of this study is all hotel and apartment buildings in the city of Semarang, especially hotel and apartment buildings that have a minimum size of more than 1500 m^2. This is based on Semarang Mayor Regulation Number 47 of 2017 concerning Certificates of Building Functionality in Article 6 paragraph (2b), which states that buildings that require certificates of proper function are certain buildings with five floors or more and/or an area of more than 1500 m², except for buildings whose permits, supervision and construction are not within the authority of the Regional Government [15]. Meanwhile, the sample selected purposively as many as 10 buildings.

Table 3 Research location

Building name	Function	number of floors	Total Building Area (m^2)
H1	Hotel & Apartment	23	43309
H2	Hotel	14	41143
H3	Hotel	12	41246
H4	Hotel & Mall	12	18852
H5	Hotel	9	15200
H6	Hotel	8	25133
H7	Hotel	9	5877
H8	Hotel & Mall	13	151372
H9	Apartment	19	53546
H10	Hotel & Apartment	22	39021

3.3.1. Analysis model

Based on the Indonesian national standard number 03-7065-2005 concerning procedures for planning a plumbing system, namely: water use for hotels is 250–300 liters per guest per day [16], while for apartments, it is 200–250 liters per occupant per day, the calculation of water use in hotel and apartment buildings is assumed to be 250 liters per person per day. If it is assumed that the effective floor area is 60% and the occupancy density is 5 m^2/person, then the number of occupants in the building can be calculated by the following equation:

$$\mathbf{No} = \frac{\mathbf{Ef\ x\ A}}{\mathbf{Od}} \quad (5)$$

Where:
No = number of occupants
Ef = effective floor area
A = total building area
Od = level of occupancy density

Table 4 Water demand in existing conditions

Building name	Total Building Area (m^2)	Effective Floor Area	Number of Occupants (person)	water demand (m^3/day)
H1	43309	0.6	5197	1299
H2	41143	0.6	4937	1234
H3	41246	0.6	4950	1237
H4	18852	0.6	2262	566
H5	15200	0.6	1824	456
H6	25133	0.6	3016	754
H7	5877	0.6	705	176
H8	151372	0.6	18165	4541
H9	53546	0.6	6426	1606
H10	39021	0.6	4683	1171

Currently, all hotel and apartment buildings use water from municipal waterworks for daily operations, while groundwater is only used as a reserve. The Municipal Government of Semarang has not issued a strict ban on the use of groundwater, but the use of groundwater is limited by strict permits and is subject to a groundwater exploration tax. The Semarang City Government will ban the exploration of groundwater (deep wells) if the clean water demand of Semarang City residents can be met by municipal waterworks. Groundwater use ranges from 20–30% of the water demand of hotel and apartment buildings.

As for cooling tower makeup water, it is only intended for buildings that have a central AC type with a water cooling system, while a variable refrigerant volume (VRV) type AC does not have a cooling tower. Calculation of cooling tower makeup water with the equation:

$$We = 0.00085.Wc. (T2 - T1) \quad (6)$$

Where:
We = water loss due to evaporation loss
Wc = Water discharge during measurement
T2 = Temperature of water entering the cooling tower
T1 = Temperature of water leaving the cooling tower

$$Wd = 0.1\% .Wc \quad (7)$$

Where:
Wd = water loss due to drift loss
Wc = Water discharge during measurement (m^3/day)

$$Wb = We / (S - 1) \quad (8)$$

Where:
Wb = water loss due to blowdown
S = Cycle of cooling tower (S = 2)

$$\text{Makeup water} = We + Wd + Wb \quad (9)$$

The amount of cooling tower makeup water in each building can be seen in Table 5.

Table 5 Cooling tower makeup water

Building name	AC type	Makeup Water (m^3/day)
H1	Split & Central	53.37
H2	Split & Central	67.61
H3	Split & Central	73.96
H4	Split & Central	60.56
H5	Split & VRV	0
H6	Split	0
H7	Split & VRV	0
H8	Split & VRV	0
H9	Split	0
H10	Split	0

The use of water that is often carried out routinely in buildings is to water plants. The use of this water uses the regional regulation of the City of Semarang No. 5 of 2009 concerning Semarang City Buildings. This regulation requires that all buildings have 20% green open space on the land area and that watering plants be used at a rate of 5 liters/m^2 [3]. The following equation can be used to calculate the amount of water used to water plants:

$$Qwp = 5 \text{ liters/m}^2 \times 0.2 A \quad (10)$$

Where:
Qwp = water use to water plants
A = land area (m^2)

Table 6 Water use for watering plants

Building name	A (m^2)	Standard (L/m^2)	Watering plants (m^3/day)
H1	2690	5	2.69
H2	4898	5	4.90
H3	5728,6	5	5.73
H4	14881	5	14.88
H5	2210	5	2.21
H6	5236	5	5.24
H7	1044	5	1.04
H8	14555	5	14.56
H9	4697	5	4.70
H10	4043	5	4.04

Water use in the existing conditions of hotel and apartment buildings in Semarang City does not carry out rainwater harvesting; rainwater is directly

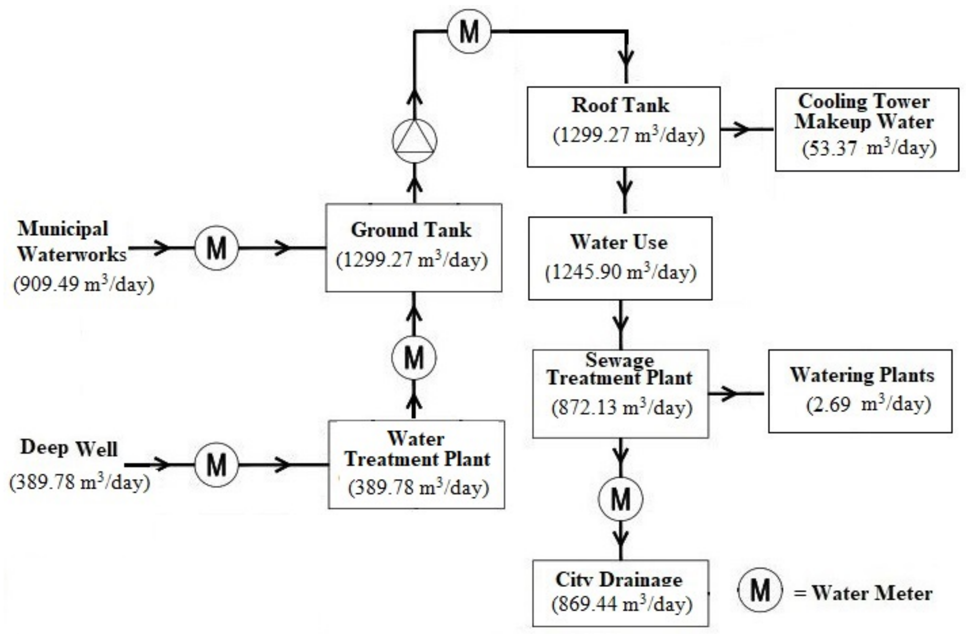

Fig.1 Existing water balance at H1 building

disposed of into the city's drainage channels, and most of them do not use water-saving plumbing fixtures, which results in relatively wasteful water use. Gray water that has been treated at STP is also not utilized optimally; it is only used for watering plants and flushing toilets, and condensate water receives no attention at all. The water balance can be seen in Figure 1.

3.3.2. Rainwater harvesting

The average rainfall in Semarang City in October 2022 will be 105.9 mm/day, the coefficient C value for hotels and apartments will be 0.70, and the potential runoff volume for each building can be seen in Table 7. Given that hotel and apartment buildings are located in alluvial plains with shallow groundwater, runoff water that infiltrates the soil is not good. The most suitable solution is rainwater harvesting.

Table 7 Runoff volume for existing buildings

Building name		C	A (m^2)	R (mm/day)	Runoff volume (m^3)
H1	0.855	0.7	2690	105.9	170.50
H2	0.855	0.7	4898	105.9	310.44
H3	0.855	0.7	5728.6	105.9	363.09
H4	0.855	0.7	14881	105.9	943.17
H5	0.855	0.7	2210	105.9	140.07
H6	0.855	0.7	5236	105.9	331.86
H7	0.855	0.7	1044	105.9	66.17
H8	0.855	0.7	14555	105.9	922.51
H9	0.855	0.7	4697	105.9	297.70
H10	0.855	0.7	4043	105.9	256.25

Currently, all hotel and apartment buildings in Semarang City do not carry out rainwater harvesting, even though the rainfall is relatively high and has great potential if used for building operations. If rainwater is used, it is stored in the RWT with groundwater to be treated first; after it becomes clean water, it is then stored in the GWT. The runoff volume cannot be utilized as a whole because rainwater is accommodated in the RWT with limited dimensions. Based on the Mayor of Semarang City Regulation No. 24 of 2019 concerning green buildings, Article 17 Paragraph 7, the dimensions of the RWT are calculated by multiplying 0.025 m by the ground floor area.

Table 8 Raw water tank dimensions

Building name		A (m^2)	Raw water tank volume (m^3)
H1	0.025 m	2690	67.25
H2	0.025 m	4898	122.45
H3	0.025 m	5728.6	143.22
H4	0.025 m	14881	372.03
H5	0.025 m	2210	55.25
H6	0.025 m	5236	130.90
H7	0.025 m	1044	26.10
H8	0.025 m	14555	363.88
H9	0.025 m	4697	117.43
H10	0.025 m	4043	101.08

Reducing groundwater use by rainwater harvesting in each building is very diverse because the dimensions of the RWT are also different. In an H4 building, for example, the utilization of rainwater reaches 166.77% of the total building water demand.

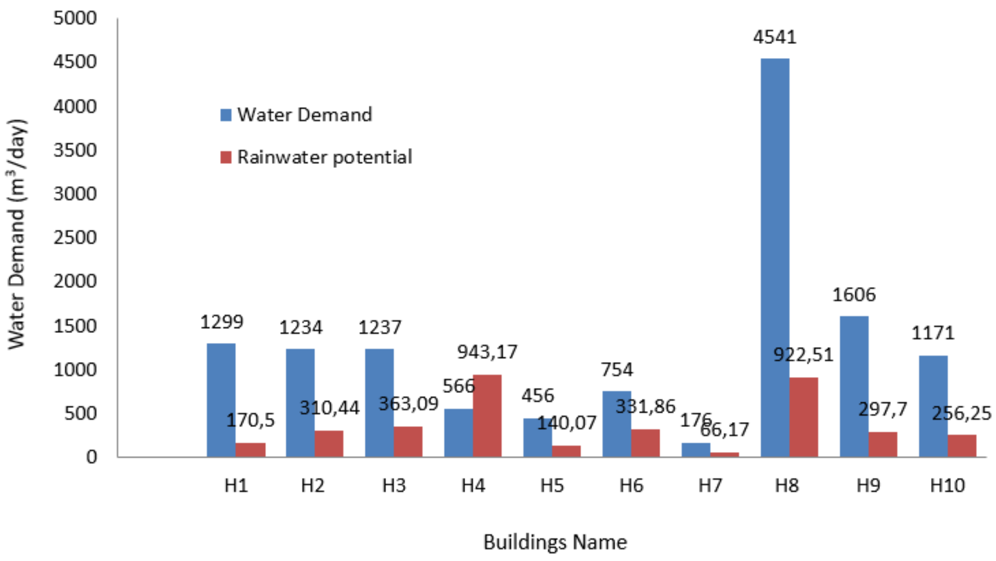

Fig.2 Rainwater potential in buildings

The use of rainwater in the H1 building is 170.50 m^3/day or 13.12% of the total water usage. The government of Semarang City prohibits all buildings on alluvial plains from using groundwater because land subsidence has occurred. Land subsidence in the study area reaches 5–10 cm/year [1]. The consequence of this policy is that hotel and apartment buildings must use only water that comes from municipal waterworks. The use of water from municipal waterworks, which was originally 909.49m^3/day, increased to 1128.77m^3/day, while the use of water from groundwater (deep wells) did not exist at all. Meanwhile, water that comes from rainwater in the form of runoff of 170.5m^3/day is utilized for rainwater harvesting, flows to RWT, and is then treated at WTP. Part of the effluent from STP is used to water plants (2.69 m^3/day), while the rest is disposed of in the city's drainage (869.44 m^3/day). The water balance can be seen in Figure 3.

3.3.3. Water-saving plumbing fixtures

The use of water-saving plumbing fixtures serves to reduce excessive water usage [5]. The selection of water-saving plumbing fixtures is very important in a building because it can reduce large expenses for water use. Based on Tables 1 and 2 above, the use of water after using water-saving plumbing fixtures in one of the hotel and apartment buildings (H1) in Semarang City can be seen in Table 9.

According to Table 9, an H1 building can save 83.13 m^3/day, or 6.40 percent, of its water by using water-saving plumbing fixtures. Water usage after using water-saving plumbing fixtures in other buildings can be seen in Table 10.

Due to the use of water-saving plumbing fixtures, the use of municipal water in the H1 building has decreased from 1128.77m^3/day to 1045.64m^3/day, a reduction efficiency of 7.36% saving water in plumbing fixtures, especially in water closet tanks, urinals, lavatories, faucets, and showers. Besides the use of water-saving equipment, building occupants are also environmentally friendly by not using excess water. The water balance after using water-saving plumbing equipment can be seen in Figure 4.

Table 9 Water usage after using water-saving plumbing fixtures

Plumbing fixture	Number of occupants	Usage duration factor	Discharge	Tap usage factor	Occupancy population	Water use (m^3/day)
Water Closet Tank	5197	2.3 UPD	6.0 LPF	-	0.5	35.86
Urinal	5197	2.0 UPD	0.47 LPF	-	0.5	2.44
Lavatory	5197	0.15 MPU	7.0 LPM	2.5/day	1.0	13.64
Faucet	5197	0.15 MPU	6.0 LPM	2.5/day	1.0	11.69
Shower	5197	5.0 MPU	6.0 LPM	2.5/day	0.05	19.49
					Total	83.13

Note: LPF = liters per flush; LPM = liters per minute; MPU = minutes per use; UPD = usage per person per day

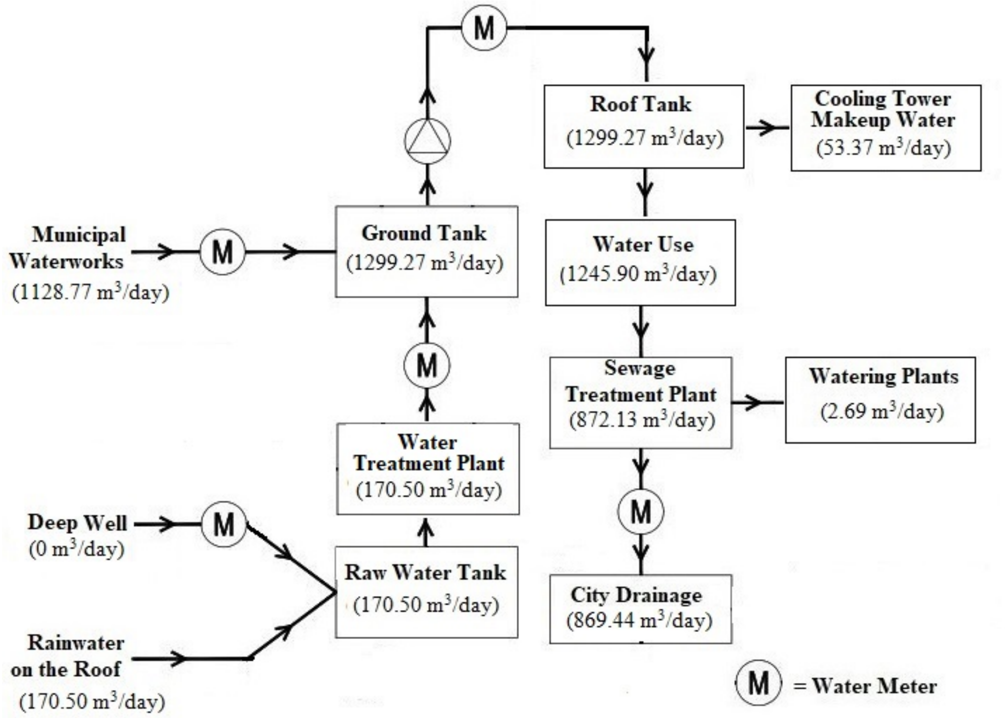

Fig.3 Water balance at H1 building after rainwater harvesting

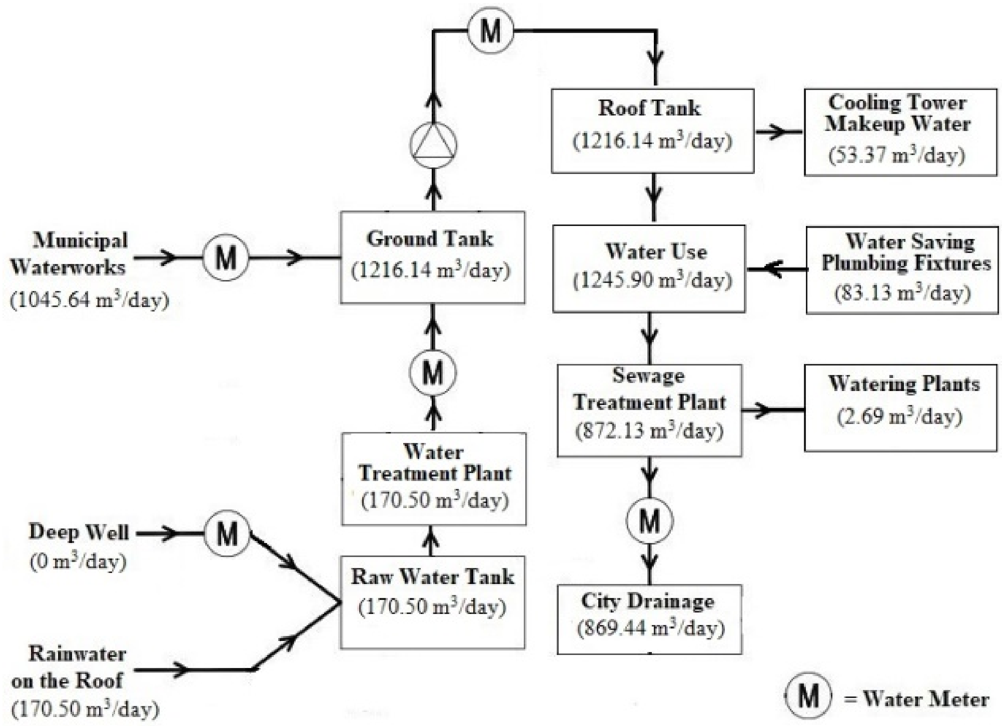

Fig.4 Water balance at H1 building after using water-saving plumbing equipment

Table 10 Water usage in buildings after using water-saving plumbing fixtures

Building name	Water use (m^3/day)		
	Before	Water-saving plumbing fixtures	After
H1	1299	83.13	1215.87
H2	1234	78.97	1155.03
H3	1237	79.17	1157.83
H4	566	36.18	529.82
H5	456	29.17	426.83
H6	754	48.24	705.76
H7	176	11.28	164.72
H8	4541	290.54	4250.46
H9	1606	102.78	1503.22
H10	1171	74.90	1096.10

3.3.4. Reuse of recycled water from gray water

Wastewater from the hotel and apartment buildings consists of black water and gray water [17]. Black water comes from human feces, while gray water comes from bathtubs, sinks, floor drains, kitchens, and washing machines. Gray water can be reused by observing strict standards for clean water quality. In general, gray water does not contain too much pollution. By treating the water at STP and then proceeding to WTP, the pollution content can be reduced below the threshold, making it suitable for reuse. The applications of the use of recycled water include watering plants, flushing toilets, and other operational uses, but it may not be used for drinking water [18] [19]. Gray water is calculated based on 70% of water use. At The Pinnacle, for example, the gray water is 869.44m^3/day. On the first day, the use of water from municipal waterworks was 1045.64m^3/day; after the reuse of recycled water from gray water on the second day, the use of water from municipal waterworks decreased to 176.2m^3/day, or a reduction of 83.15%. This happens because gray water and rainwater are stored in the RWT and used simultaneously. Water conservation is carried out in this phase by flowing the results of STP treatment to RWT and using rainwater simultaneously so that gray water can be reused and the water disposed into city drainage is 0 m^3/day. The equation below is used to determine the amount of discharged gray water. The water balance after the reuse of recycled water from gray water on the second day can be seen in Figure 5.

$$Q_{wu} = (Q_{wn} - Q_{ws}) - Q_{ct} + Q_{ws} \quad (11)$$
$$Q_{gw} = 0.7\ Q_{wu} - Q_{wp} \quad (12)$$

Where:
Q_{wu} = Discharge of water use

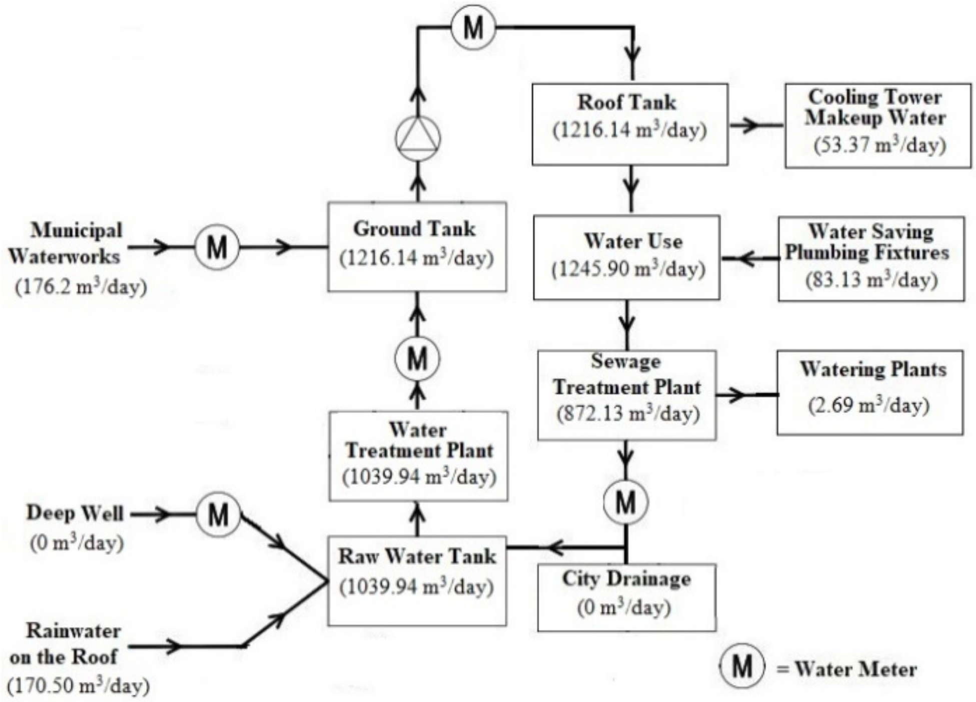

Fig.5 Water balance at H1 building after reuse of recycled water from gray water on the second day

Q_{wn} = Discharge of water needs
Q_{ws} = Discharge of water-saving plumbing fixtures
Q_{ct} = Discharge of cooling tower makeup water
Q_{gw} = Discharge of gray water
Q_{wp} = Discharge of watering plants

3.3.5. Reuse of condensate water from air conditioners

Currently, there is a large source of water that is rarely used by humans, namely the condensate from air conditioners (AC). Condensate water from AC is very good to use because the quality is not harmful to health [20], and in large quantities, it is easy to get in hotel and apartment buildings, but unfortunately, condensate water is often thrown away.

Based on research conducted in the field, the AC capacity of 0.5, 1, 0.75, and 2 HP (horsepower) produces an average of 1.54 liters of condensate water per hour. If it is assumed that the effective hours of AC usage are 10 hours, then the discharge for one AC produces 15.45 liters per day. Based on the total area of each building, the amount of condensate water produced can be seen in Table 11.

The water balance after using condensate water from air conditioners can be seen in Figure 5. The use of water from municipal waterworks, which was originally 176.2m^3/day, is reduced to 157.62m^3/day due to the use of condensate water from air conditioners of 18.59 m^3/day. The addition of condensate water from air conditioners is not very large, but it contributes to efforts to create green buildings.

Table 11 Condensate water collection

Building name	AC type	BTU/hour	Water condensate (m^3/day)
H1	Split & Central	21654500	18.59
H2	Split & Central	20571500	17.66
H3	Split & Central	20623000	17.70
H4	Split & Central	9426000	8.09
H5	Split & VRV	7600000	6.52
H6	Split	12566500	10.79
H7	Split & VRV	2938500	2.52
H8	Split & VRV	75686000	64.96
H9	Split	26773000	22.98
H10	Split	9510500	16.75

Note: BTU = British Thermal Unit

3.4 Analysis Results

Water management in hotel and apartment buildings in the city of Semarang is gradually leading to green buildings; this has been the case since the enactment of Semarang Mayor's Regulation No. 24 of 2019 concerning Green Buildings. This regulation is carried out voluntarily, but in the future, it will be made mandatory and binding on all buildings. The existence of land subsidence, seawater intrusion, and groundwater pollution add to a long list of environmental problems in Semarang City, so the Semarang City government should implement a water conservation model in hotel and apartment buildings, as shown in Figure 7.

Hotel and apartment buildings must make

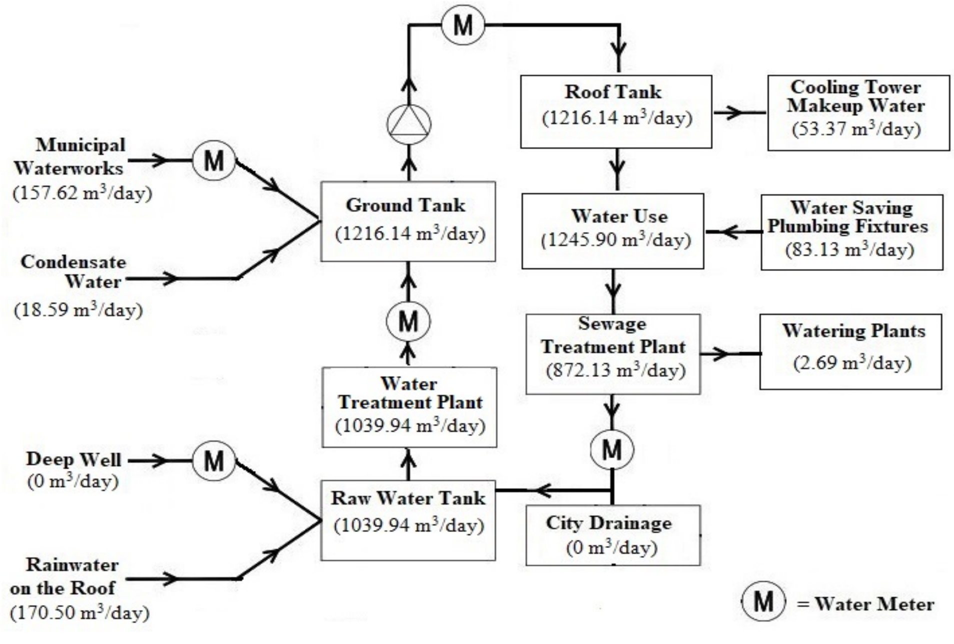

Fig. 6 Water balance at H1 building after using condensate water

efforts to conserve water to preserve groundwater resources so that groundwater pollution, seawater intrusion, and land subsidence will not occur. Preservation of groundwater resources is to support sustainable development by seeking the interests of current generations and not forgetting future generations. Water conservation models in hotel and apartment buildings in Semarang City include rainwater harvesting, water-saving plumbing fixtures, reuse of recycled water from gray water, and condensate water from air conditioners in buildings.

Figure 8 explains that each building has different green water uses. Hotel and apartment buildings such as H3, H4, H5, H6, and H7 experience a surplus of raw water. H3 building, for example, has a green water use of 31.24 m^3/day, meaning that this building has a raw water reserve of 31.24 m^3/day after conserving water, while buildings H1, H2, H8, H9, and H10 experienced a reduction in water use from their total water needs. H1 building, for example, experienced a reduction in water usage of 157.62 m3/day of total water demand or a reduction of 12.33% of total water demand. Based on the water balance in each conservation above, the discharge of green water use can be calculated by equations (13) and (14). Utilizing natural resources such as rainwater, being environmentally friendly (not wasting water), reusing recycled water from gray water, and utilizing condensate water from air conditioners can all help to reduce costs in these buildings.

$$Q_{gwu} = Q_{wd} - (Q_{rh} + Q_{ws} + Q_{gw} + Q_{cw}) \quad (13)$$

$$Q_{gwu} = Q_{wd} - (0.855\ C.A.R + 0.064.\ Q_{wd} + 0.7\ Q_{wu} - Q_{wp} + Q_{cw}) \quad (14)$$

Where:
Q_{gwu} = Discharge of green water use
Q_{wu} = Discharge of water use
Q_{wd} = Discharge of water demand
Q_{rh} = Discharge of rainwater harvesting
Q_{ws} = Discharge of water-saving plumbing fixtures
Q_{gw} = Discharge of gray water
Q_{cw} = Discharge of condensate water
Q_{wp} = Discharge of watering plants

4. CONCLUSIONS

The use of large amounts of water must be balanced with efforts to conserve it to prevent damage to the environment. Conservation efforts can include rainwater harvesting, water-saving plumbing fixtures, the reuse of recycled water from gray water, and condensate water from air conditioners in buildings. The implementation of these efforts must be adapted to the conditions of each region so that they are right on target and do not cause additional problems.

Rainwater harvesting contributes 13.12–166.77% of the total building water requirement, depending on the area of the catchment area in the building. Rainwater harvesting can be combined with infiltration wells, but because the research location is relatively shallow (the depth of groundwater is less than 1 meter), the application of infiltration wells is not suitable, so the remaining rainwater is discharged into the city

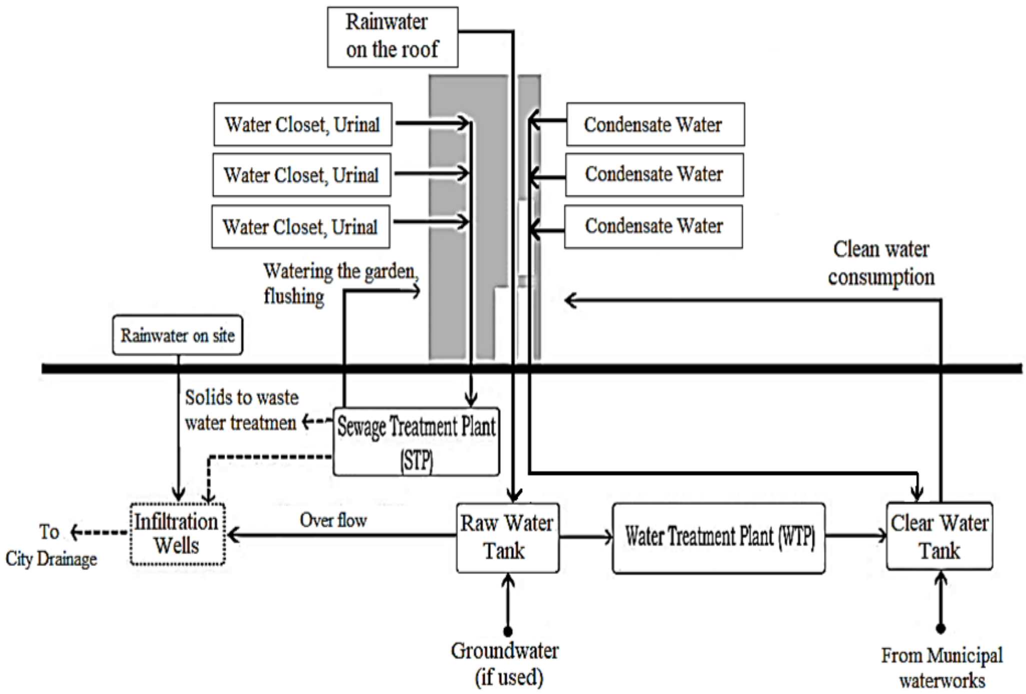

Fig.7 Model of water conservation in buildings

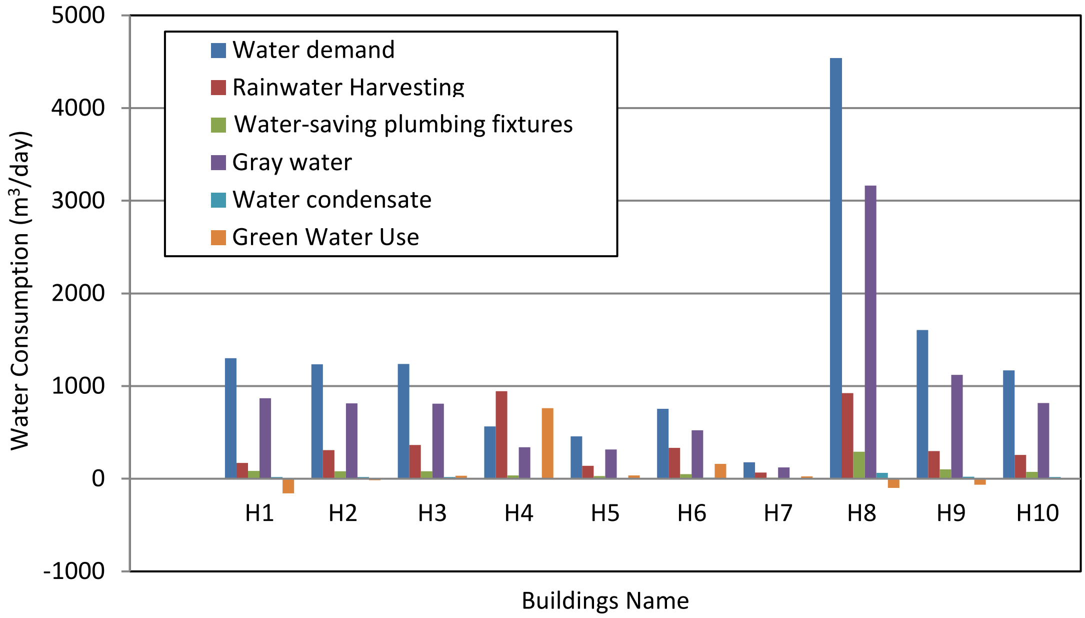

Fig. 8 Water conservation in buildings

drainage. Rainwater that is collected must be put into the RWT to be processed at the WTP first, and then it can be utilized in buildings. The use of water-saving plumbing fixtures accounts for 6.4% of the total building water needs. Likewise, with gray water, the reuse of recycled water from gray water contributes 59.87–69.71% of the total building water needs. Gray water is processed at STP and then channeled to RWT to be processed at WTP. Gray water should not be mixed with black water so that the processing load at STP and WTP is not too large. Finally, condensate water from air conditioners in buildings is no less important to note; condensate water contributes only 1.43% of the total building water needs. Although it is small, it plays a role in creating green buildings.

5. ACKNOWLEDGMENTS

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