Identification The Application of Water Conservation in Hotel

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Abstract. Water conservation aspect is a part of Green Building concept. In addition, to save more first clean water consumption, The X Hotel applied water conservation aspect, which are the WAC 3 (Water Recycling), WAC 4 (Alternative Water Resources), and the WAC 5 (Rainwater Harvesting) (GBCI, 2013). The plumbing installation system with water conservation aspects at X Hotel aims to distribute first class clean water, dispose of the wastewater to a treatment site with appropriate water requirements refers to SNI 03-7065-2005. X Hotel required 114,640 m^3/day of first class clean water, and 91,71 m^3/day of the total wastewater discharge, includes 18,35 m^3/day of black water and 73,36 m^3/day of gray water. The X Hotel has additional alternative sources of water condensate from air conditioner (AC) about 44,16 m^3/day and 52,53 m^3 of rainwater, that can be used for water closet and urinal flushing in the public area at the Hotel, after through the anaerobic – aerobic biofilter STP (Sewerage Treatment Plant) and membrane filtration unit . After the calculation, water conservation aspects application can reduce first class clean water needs with an efficiency around 10 %.

Keywords: **Hotel; water conservation ; water recycle.**

1 Introduction

The green buildings concept for sustainable development is about conducting resource efficiency, and increasing building performance operational efficiencies that enhanced management and occupant functions.

GBCI (Green Building Council for Indonesia) is a non-for-profit organization that established since 2010 and plays an important role to the development of green building in Indonesia. GBCI had the objectives to promote the implementation of green building principles in all building sectors in Indonesia, in designing, constructing and operating schemes and one of the efforts is by developing a rating system. GBCI is divided into six aspects and each aspect consists of several criteria. The aspect of green building are as follow : Appropriate Site Development (ASD), Energy Efficiency and Conservation (EEC) , Water Conservation (WAC) , Material Resources and Cycle (MRC) , Indoor Health and Comfort (IHC), and Building Environment Management (BEM). [1]

Water conservation aspect has several criteria namely WAC 1 (Water Use Reduction), WAC 2 (Water Fixtures), WAC 3 (Water Recycling), WAC 4 (Alternative Water Resources), WAC 5 (Rainwater Harvesting), and WAC 6 (Water Efficiency Landscaping) [1]

Amongst the various environmental issues, water conservation is one of the most critical global problems and one which is only increasing in importance with continuing population growth [2]. The principle of water conservation is to minimize the unnecessary and inefficient use of clean water on the site while maximizing the recycling and reuse of wastewater, including harvested rainwater/stormwater. [1].

Hotel constantly has to commit a lot of finances into obtaining clean water from the mains to meet with huge water demands. X Hotel is high rise building that located in Pangkalan Bun Central Kalimantan. The X Hotel has four-star hotel facilities which consist of the main courtyard, lobby, backyard, very important person room (VIP), meeting room, kitchen, storage room and other facilities with total number of 153 unit rooms and building area of 37.100 m^2 which certainly requires plenty of clean water for its activities in the building.

The aim of the research is to learn how wastewater generated from the hotel could be collected, treated and reuse for other nonportable purposes that referred to second class water. This study also showed perceive the amount of water conservation could be performed according to category of GBCI.

The selected water conservation categories that conducted ini this research are WAC 3 (Water Recycling) from black and grey water, WAC 4 (Alternative Water Resources) from AC (Air Conditioning) and WAC 5 (Rainwater Harvesting).

The treated water after through the anaerobic – aerobic biofilter STP (Sewerage Treatment Plant) and membrane filtration unit could be used for water closet and urinal flushing in public areas at X Hotel.

2 Method

2.1. First Class Water

Population numbers of the building is determined according to the effective area divided by occupancy load [3]. The population is comprised of the hotel's resident, employee and visitors.

First class clean water quantity requirement for the building is calculated by referring to SNI – 03-7065-2005 (Plumbing System Planning Procedures) [4] according to the building function and the number of population.

2.2 Wastewater Generation

It was assumed that total wastewater generation discharge is 80 % of first class clean water quantity [5] where the separation of wastewater generation for greywater is 80% and black water is 20% [6] The framework of the calculation is shown in equation (1) – (3).

$$Q\ wastewater = 80\%\ x\ Q\ cleanwater\ estimation \quad (1)$$

$$Q\ black\ water = 20\%\ x\ Q\ waste\ water \quad (2)$$

$$Q\ grey\ water = 80\%\ x\ Q\ waste\ water \quad (3)$$

2.3 Alternative Water from AC Condensate

The type of air conditioning system that installed in this Hotel is water chiller system that could be alternative water resources to conserve groundwater. Therefore it is necessary to calculate the discharge of AC condensate. According to the research of Bita Enarcon Engineering , the discharge of AC condensate is 0.39308 lbs/minute. The next step is to calculate the AC condensate that utilizes in each chamber of the hotel. The calculation is shown in equation (4) - (5) .

$$Qcondensate = 0{,}39308\ lbs/min\ x\ 0{,}4535924\ kg/lbs$$

$$= 0{,}1782\ kg/minute\ x\ (1000\ kg/m^3) \quad (4)$$

$$Q\ black\ water = 20\%\ x\ Q\ waste\ water \quad (5)$$

2.4 Rainwater Harvesting

Rainwater supply could be estimated from the catchment area and the intensity of daily rainfall. The formula is shown in equation (6) by referring to SNI – 03-2453-2002 [7]

$$Q = 0{,}855\ C\ x\ A\ x\ R \quad (6)$$

Q = Rainwater Discharge (m^3/hour)
C = Rational run off coefficient
R = Rainfall Intensity (mm/hour)
A = Catchment Area (m^2)

2.5 Water Conservation Aspect

The source of second class water deriving from wastewater recycle discharge, alternative water from AC condensate and rainwater harvesting. Furthermore this second class water able to use for water closet and urinal flushing in the public area at the Hotel.

3 Result and Discussion

3.1. Water Demand

The calculation of clean water requirements for first class clean water pursuant to estimation population of the Hotel. The Total population of the building (including guest room, employees, and visitors) is approximately 1.067 people. The clean water calculation, based on the population of 1.067 people, yielded a requirement of 114,640 m^3/day. The calculation clean water first class demand is shown in **Table 1**.

3.2 Wastewater Generation and Treatment

The activity of the hotel that utilizes first class clean water would generate wastewater from black water and grey water. Black water derived from the toilet which contains human waste such as feces an urine. The characteristic of black water generally countain pathogenic, nitrogen and phosphorus microorganisms [8]. Grey water as water discharge from bath water, wash basin and kitchen sink and its characteristic generally contain elements of nitrogen, phosphate and potassium [8]

By using the assumption wastewater generation 80 % of first class clean water quantity , total wastewater discharged about 91,71 m^3/day comprised of 73,36 m^3/day grey water and 18,35 m^3/day black water.

The wastewater must be treated in advance with special treatment to fulfill the standards for regulatory compliance in Indonesia. The standards that adresses greywater quality for reuse referring to Government Regulation No. 82/2001 about Water Quality Management and Pollution Control , class IV (least stingent) referring its application for plants irrigation or another use which require the same water quality as that use . [9]

Generally, wastewater characteristic from the hotel are similar to household wastewater, both contains organic materials and mineral compounds from food waste and soap . According to Sumarno [10] the physical and chemical characteristics of household wastewater are BOD (Biochemical Oxygen Demand) 110-400 mg /l, COD (Chemical Oxygen Demand) 250-1000 mg/l, TSS (Total Suspended Solid) 100-350 mg/l, ammonia 12-50 mg / l and oil and fat 50 -150 mg / l.

To ensure water quality appropriate for second class water, the characteristic of wastewater should be discovered first. A study was found that wastewater quality from the similar hotel such as four star hotel in Indonesia [11] as shown in **Table 2**.

Table 1. First Class Clean Water Demand

Building Function	Number of Population *	Water Demand Standard *(L/person/day)	Total Water Demand (L/day)
Guest Room	306	300	91.800
Meeting Room 1	55	50	2.750
Meeting Room 2	29	50	1.450
Meeting Room 3	121	50	6.050
Restaurant	237	15	3.555
Fitness Room	9	30	270
Bar / Coffee Shop	5	30	150
Ballroom	150	25	3.750
SPA	16	30	480
Prayer Room	57	5	285
Employee	82	50	4.100
	1067		114.640 L/day
	Total Water Demand (L/ day)		**114, 640 m^3/day**

Source : Researcher
* : According to Noerbambang (2005) with maximum population
** : According to SNI 03-7065-2005

Table 2. Hotel Wastewater Characteristic

Parameter	Unit	Concentration
BOD	mg/l	69,69
COD	mg/l	137,28
TSS	mg/l	125
Ammonia	mg/l	2,58
Oil and Fat	mg/l	45
MBAS	mg/l	2,78
pH	-	8

The result of those measurements as a reference for the selection for wastewater treatment technology that could be implemented in this hotel for the green environment.

The efficient removal of STP (Sewage Treatment Process) with combination anaerobic and aerobic biofilter is capable to remove organic suspended solids and most of the organic matter up to 90%. This anaerobic-aerobic treatment process is the development of anaerobic biofilter process with aerobic processes. Anaerobic-aerobic biofilter process consists of several phases [12]

The wastewater was flowed into the initial settling basin to precipitate sludge particles, sand and suspended organic impurities. Aside from being a settling basin, it's also as a flow control vessel function, as well as a decomposition tank for solid organic compounds, sludge digestion and sludge collectors. [12]

The wastewater from the initial settling basin was flowed to the anaerobic contactor tank with the low direction from the bottom to upper .

Decomposition of organic substances in wastewater was conducted by anaerobic or facultative aerobic bacteria. After a few days of operation, at the surface of filter media grow micro-organism film layers. These micro-organisms decomposed organic substances that had not been able to decompose in an anaerobic settling basin . The flow from the anaerobic contactor tank was

channeled into an aerobics contactor. The contactor tank or aerobic biofilter consists of aeration tanks and aerobic biofilter.

After the wastewater was aerated into aerobic biofilter chamber, the existing micro-organisms decomposed the organic matter and grew to the surface of plastic media that filled in aerobic biofilter chamber. Thereafter wastewater treated with STP (fabrication unit) the water quality is expected to meet the requirement for second class clean water

In the previous calculation , total wastewater discharged (black water and grey water) about 91,71 m^3/day, however after through the treatment process wastewater generation was decreased about 10 % thus the total wastewater after treated around 89,45 m^3/day. The treated water then flew into second class ground tank.

3.3 AC Condensate, Rainwater Harvesting and Water Treatment

Sewerage systems can be classified into combined sewerage and separate sewerage. Combined sewerage carries both stormwater and wastewater, while separate sewerage carries stormwater or wastewater separately. Recent trends have been for the development of separate sewerage systems. The main reason for this is that stormwater is generally less polluted than wastewater, and that treatment of combined wastewater and stormwater is difficult during heavy rainfalls. [13]

3.3.1 AC Condensate

According to formula (5) , total AC condensate generated around 44,16 m^3/day by using the assumption that the whole existing AC in this hotel are used for one full day . Afterwards AC condensate will be collected to WTP (Water Treatment Plan) for further treatment and will have flowed into second class ground tank.

3.3.2 Rainwater Harvesting

The rainwater coming from the roof through downpipe in gravity system and collected in ground tank second class. Hydrology analysis needs to be conducted to determine the intensity of rainfall. By referring formula (6) , total rainwater discharge about 105,05 m^3/day, with roof catchment area that 1005,33 m^2 , runoff coefficient 0,95 [14] and rainfall intensity about 0.11 m/hour .

Due to the limited availability of the site ,tank size needs to be selected . According to GBCI, the building should provide rainwater storage tank with the capacity minimum 20 %, 30 % or 50 % from total rainwater discharged. In this study the tank that will be chosen is a storage tank with 50 % capacity, thus the total volume of the storage tank is 52,53 m^3.

In a general way, the rainwater has a good quality being really pure, especially because of the natural distillation that it suffers, during the water cycle in the process of distillation and condensation [13]but this rainwater could be contaminated from the roof therefore need advanced treatment thus meet the requirement for second class water . After through the treatment , the water will have flow into second class ground tank.

3.3.3 Water Treatment Plant

According to the water that would be treated in WTP deriving from rainwater (52,53 m^3/day), AC condensate (44,16 m^3/day), and treated wastewater from STP (89,45 m^3/day) . WTP fabrication system will be installed in this hotel with capacity and technology that appropriate with water would be processed. Membrane filtration unit could reduce organic matter pollutant and turbidity properly. Membrane filtration has high efficiency removal as follows ; BOD 85%, COD 80%, Ammonia 15% and TSS 95% [12].

The screening process with the ultrafiltration system works automatically, which is 10-15 minutes filtering process and 1-2 minutes backwash process. The system is equipped with a solenoid valve and timing devices so that the screening processes could be adjusted according to the condition of raw water material .

After through the treatment, the water flow to the second class water and pumped to rooftank with centrifugal pump and distributed to the public area in the hotel for water closet and urinal flushing.

3.4 Water Conservation

After collected and treated, the second class water will be used for toilet and urinal flushing in public area. Public toilet in this hotel are at the ground floor, semi basement and first basement . From calculation in **Table 3** showed that total water demand for flushing about 11,35 m^3/day by assuming that maximum intensity twenty times each plumbing unit used in a day [15]

The water reuse will provide up to 10% of the 114,640 m^3/day based on population demand for first class water requirement. By implementing water conservation aspect will reduce the quantity of groundwater needed to be pumped out for the building occupants .

Generally, plumbing design for second class water is similar to first class water. The essential difference between the two is the source of water material . The first class water takes the source from groundwater and drinking company , while the source for second class water came from treated wastewater, AC condensate and rainwater harvesting.

The main objective of this research is to highligt the need of water conservation for sustainable development that supports development low carbon implementation.

High rise residential building such as hotel has sufficient wastewater potential for reuse water and it could contribute up to 10 % of the first class water demand , however,hinges on the financial cost of installing and maintaining a reuse system

Table 3. Total Water Demand for Water Closet and Urinal in Public Area

Floor	Plumbing Unit	Number of Plumbing Unit	Water Flushing Requirement (L/flush) *	Total Water Flushing (L/flush)	Total Water Flushing (L/day) *
1st Basement	Water closet	7	13.5	95	1,890
	Urinoir	4	5	20	400
Semibasement	Water closet	11	13.5	149	2,970
	Urinoir	5	5	25	500
Ground	Water closet	17	13.5	230	4,590
	Urinoir	10	5	50	1,000
	Total Water Demand (L/day)				11,350
	Total Water Demand (m^3/day)				11.35

Source : Researcher
•: According to SNI 03-7065-2005

References

1. GBCI, Greenship Untuk Bangunan Baru versi 1.2 Jakarta Green Building Council Indonesia (2013)
2. C. Cheng, Evaluating Water Conservation Measures For Green Building In Taiwan, **vol. 38**, pp. 369–379, (2003)
3. Noerbambang, S.M . Perancangan dan Pemeliharaan Sistem Plumbing (6 Ed) , Jakarta (2005)
4. Badan Standarisasi Nasional , Tata Cara Perencanaan Sistem Plumbing , SNI 03-7065-2005 (2005)
5. Hardjosuprapto, M, Penyaluran Air Buangan Volume II: ITB. Bandung, (2000)
6. Cahyadi, V. L. C. S. Perancangan Bangunan Instalasi Pengolahan Grey Water Kawasan Apartemen (Studi Kasus: Rasuna Epicentrum) (2008)
7. Badan Standarisasi Nasional , Tata Cara Perencanaan Teknik Sumur Resapan Air Hujan Untuk Lahan Pekarangan , SNI 03-2453-2002 (2002)
8. Simatupang, B. P, Pengolahan Limbah Domestik Menggunakan Metode Anaerobic Baffled Reactor (Studi Kasus: Royal Sumatra, Medan) . (2014)
9. Taroepratjeka D.A.H, Potential Greywater Quantification for Reuse in Newton Residence Apartment Bandung, Indonesia (2015)
10. Metcalf & Eddy. , Wastewater Engineering Treatment, Disposal, Reuse. Mcgraw Hillbook Company, New Delhi (2003)
11. Handayani, D. S. Kajian Pustaka Potensi Pemanfaatan Greywatersebagai Air Siram Wc Dan Air Siram Tanaman Di Rumah Tangga. Jurnal Presipitasi, **10(1),** pp 41-50 (2014)
12. Bioseven, retrieved from http://www.bioseven.co.id (2016)
13. Jensen, M.A, Feasibility of Rainwater Harvesting for Urban Water Management in Salt Lake City (2008)
14. Suripin. 2004. Sistem Drainase Yang Berkelanjutan., Andi Offset, Yogyakarta (2004)
15. Rinka, D.Y, Perencanaan Sistem Plambing Air Limbah dengan Penerapan Konsep Green Building pada Gedung Panghegar Resort Dago Golf-Hotel&Spa , (2014)