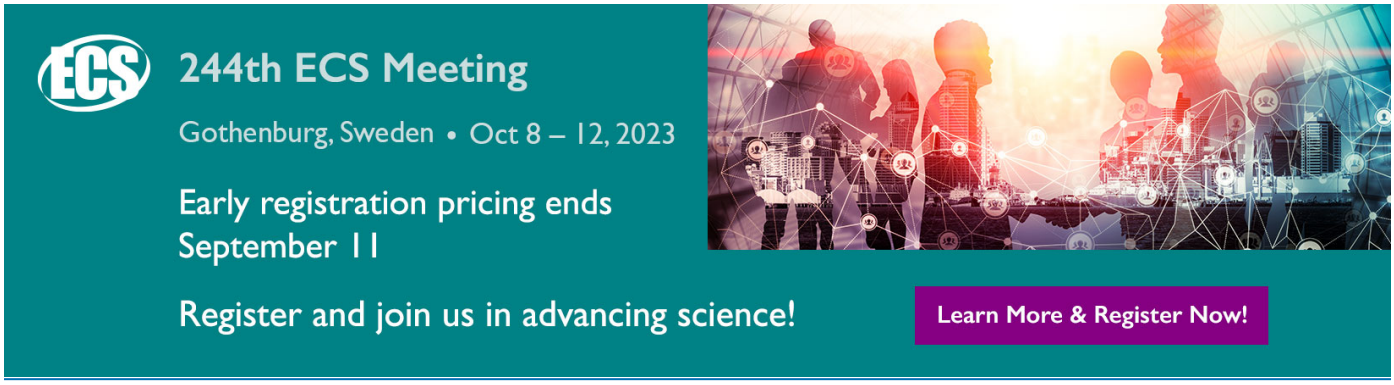
Utilization of Rainwater Harvesting for Groundwater Conservation in Educational Building



Utilization of Rainwater Harvesting for Groundwater Conservation in Educational Building

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Abstract. This study aims to obtain the optimalization of rainwater harvesting through different technologies, for future groundwater conservation to be used in dry season. This study could demand of human consumption and their activities. The analysis of stormwater run-off volume is used for capacity and quantity of infiltration well. It refers to Standard Depth Calculation from PU (Pekerjaan Umum) of infiltration well. Based on the research results, the infiltration well using porous walls material (permeable wall) with the dimension 1.5x1.5m, permeability coefficient 0,015184 m/hour, rain intensity 0,0115 m/hour, rain duration 60 minutes, the depth of well is 0,889 m. The volume of stormwater in one week with assumming two times rainy days is 4.232 liters. The infiltration well built in the study area was a well with a 2 (two) meters, so that the recharge well discharge obtained 0,216 m³/hour. The excess of stormwater was put into infiltration well is 3,192 liters. If the excess water from rainwater harvesting is accommodated into infiltration wells, must be provided 15 wells with 2 meters depth. If the infiltration couldnot accommodated the excess water, it will flow to city drainage canals. The results of this study are to estimate the potential stormwater volume, the conveyance system and the groundwater conservation system.

1. Introduction

1.1. Definition of Rain Water Harvesting

Water is a renewable and dynamic resource, meaning that the main source of water is rain which always comes in accordance with the time and season throughout the year [1]. Rainwater harvesting is a technique used to trap surface run-off effectively. In technical terms, water harvesting is a system for collecting rainwater from where it falls rather than allowing it to run off as runoff. By building water uptake structures in suitable locations, it is possible to increase groundwater recharge and water level, so that we can use this water effectively for irrigation and drinking purposes in the rainy season [2] Rainwater Harvesting is designed to carry runoff from catchment areas such as roofs to landscape areas for infiltration to support plant growth [3]. Some regulations regarding the management and utilization of Rainwater are contained in the State Minister of Environment Regulation No. 12 of 2009 concerning Rainwater Utilization, Minister of Public Works Regulation No. 11 of 2014 concerning Management of Rainwater in Buildings and Plots, and the Municipal Handbook for Rainwater Harvesting Policy issued by the United States Environmental Protection Agency (US-EPA) in 2008 [4].

1.2. Method of Rain Water Harvesting

The way of harvesting rain can be divided into two parts, the first is done by collecting rainwater on the roof of the building (roof catchment) and the second is done by collecting rainwater on the surface of the ground (ground catchment). The way of harvesting rain from the roof of the building is by flowing and collecting rainwater from the roof of the building (houses, large buildings, greenhouses, courtyard, and impermeable surfaces including roads). Storage to collect the wáter could be wáter tank or a resevoir and infiltration Wells [5].

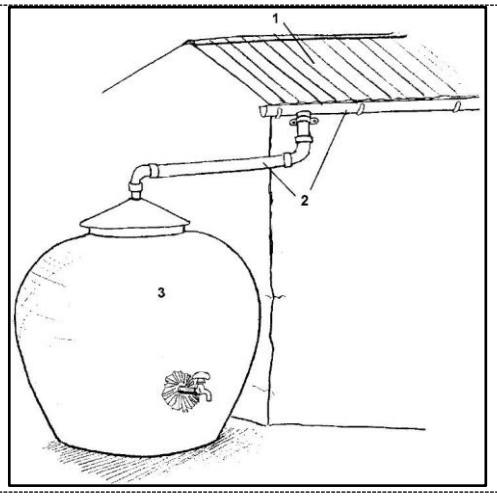

Figure 1. Three basic components of Stormwater Harvesting

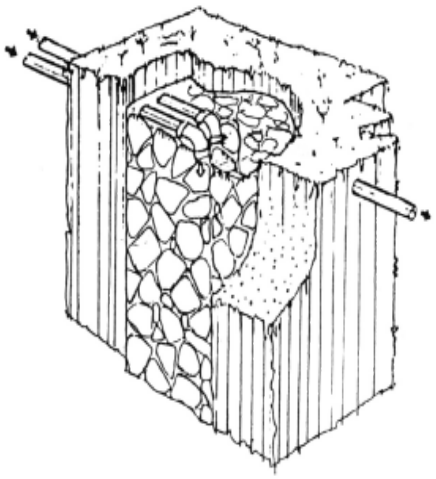

Figure 2. Infiltration Wells construction

1.3. Groundwater Recharge

When Rainwater Harvesting can no longer accommodate the volume of incoming rainwater, it is necessary to have infiltration wells to enter runoff water from the rainwater harvesting tank into the ground by infiltration wells. The infiltration well method has been widely applied to each building, both on a small scale, namely housing and on a large scale, namely in office buildings, recreation areas, on road sections, airports and others. It was even strengthened by the DKI Jakarta Governor Regulation No. 20 of 2013 concerning Infiltration Wells. Governor Decree Number 17 of 1992 which requires all buildings to have Water Infiltration Wells (SRA). Table 1 is a regulation regarding the types of recharge wells based on the extent of building cover [6].

Table 1. Shallow Infiltration Wells, Deep Infiltration Wells and Biopori Infiltration Holes based on Building Coverage Area

Types of Utilization	Building Cover Area (m^2)	Infiltration Volume per Unit (m^3)	Perceptibility per Unit (m^3 / day)	Number of Infiltration Units Required	Remarks
Shallow Infiltration Wells	50	1	-	1	Every additional 25-50 m^2 of building cover area requires an additional 1 unit or volume of 1 m^3
Deep Infiltration Wells	1000	-	40	1	Every additional 500-1000 m^2 of building cover area requires an additional 1 unit
Biopori Infiltration Hole	20	0,25	-	3	Each additional building cover area of 7 m^2 requires an additional 1 LRB unit

In the process of making water catchment wells can be designed with two application patterns [7], namely:

a) Single house model, the location of infiltration well is ussualy in the yard.
b) Collective / communal construction (used together, for more than one house / housing / house block), can be installed on the shoulder of the road.

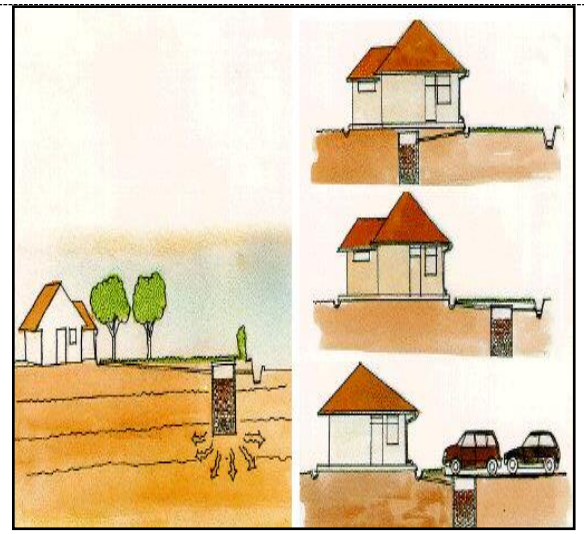

Figure 3. Infiltration Wells for single houses

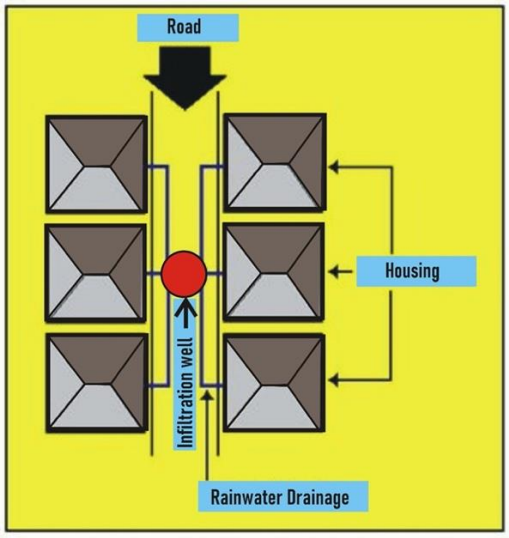

Figure 4. Communal water infiltration well

2. Method and materials

2.1. Test preparation

In this study, laboratory testing was conducted of soil samples from the study area. This soil investigation is needed to determine the Permeability Coefficient (k) which will be used as a parameter of infiltration wells construction. As knowned that soil permeability is the main parameter of determining the infiltration rate. Land with low permeability will minimum soak into the soil while the rest will flow as runoff water. Coefficient of permeability obtained the dimension and the depth of infiltration wells as well.

2.2. Design Layout

Design/layout for the placement of Rainwater Harvesting systems and placement of infiltration wells in the study area is an important parameter to be adjusted to the layout of existing buildings or existing buildings. Infiltration wells placement layout according to laboratory outcome of soil samples results. Figure 5 describe the layout of infiltration wells and rainwater harvesting tank.

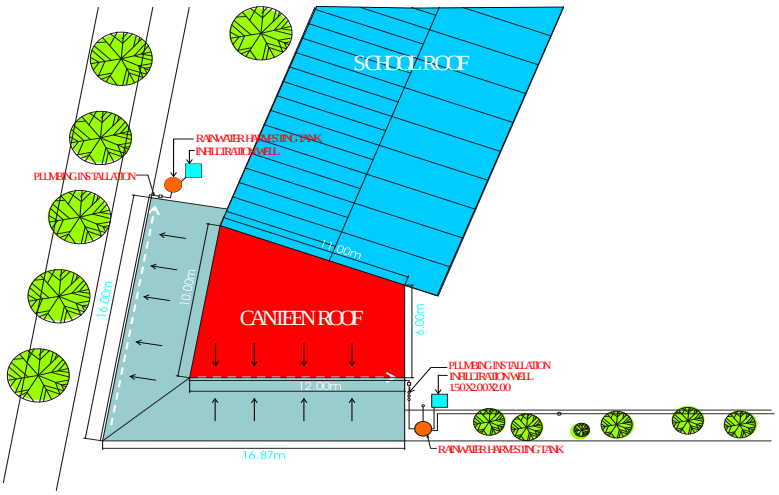

Figure 5. Layout Infiltration Wells on area study

2.3. Method

By using quantitative methods and use mathematical models. The stages carried out in this study include a literature study that discusses research on the analysis of the application of rainwater harvesting in the study area, after which the determination of data needs is carried out.

Calculation of water discharge from rainwater that falls on the surface of a building roof can be calculated using equation 1.

$$Q = C\ I\ A \quad (1)$$

Where,

Q = incoming water discharge (m3 / sec)
C = run off coefficient coefficient
I = rain intensity (mm / hour)
A = area of building roof (m2)

The Center for Settlement Research and Development of the Ministry of Works has compiled a standard procedure for the technical planning of rainwater catchment wells for plots as outlined in SNI T-06-1990 F of a method has been developed to calculate infiltration well dimensions [8].

$$H = \frac{QDIAt - DKAs}{As + DKP} \quad (2)$$

With:

I = Rain intensity (m / hr)
At = area of rainfed area, in the form of hardened roof or soil surface (m^2)
K = permeability (m / hour)
P = the circumference of the well cross section (m)
As = area of well cross section (m^2)
D = duration of rain (hours)
H = depth of well (m)

3. Results and discussion

3.1. Hydrology Analysis

Rainfall data is obtained from 5 rain stations namely Cibinong rain station, Cawang rain station, Pulogadung rain station, Sunter Kodamar rain station, Sunter III Rawa Badak. The rain data used is the

result of recording 15 years of rain from January 2004 to December 2018 (Table 2). Rain intensity taken from the calculation is the greatest rainfall intensity also after qualifying by testing the chi square method is 11.50 mm/hour.

Table 2. Maximum Rainfall Table

Year	Rainfall Data (mm)
2004	65.592
2005	105.746
2006	52.993
2007	73.299
2008	92.619
2009	43.923
2010	43.319
2011	72.264
2012	53.394
2013	59.966
2014	59.836
2015	88.906
2016	75.715
2017	74.426
2018	76.776

3.2. Soil Analysis

Laboratory test results from the three soil samples are as follows:
Permeability test results data
- Sample 1 depth of 1.0 m
- Koef. Seepage (cm / s) = 1.4568E-06
- Sample 2 depth of 1.5 m
- Koef. Seepage (cm / s) = 1,4273E-08
- Sample 3 depth of 2.0 m
- Koef. Seepage (cm / s) = 1.5184E-08

From the results of soil investigations carried out in the study area, it shows that the type of soil in the study area is clay. The seepage coefficient generated after going through the research process in the Soil Mechanics laboratory will be used to calculate the depth of the infiltration well which will be used to collect excess water from the rainwater harvesting tank in the study area.

3.3. Runoff Calculation

From the calculation of rainwater runoff volume, it is obtained the volume of rain in 1 week, assuming 2 rainy days is 4.232 Liters. With the amount of rainwater volume, the number of reservoirs needed is 8 reservoirs with a capacity of 520 liters. If you only install 2 rainwater harvesting tanks, then the total rainwater collected is 1,040 liters. The excess of 3,192 liters of rain water was streamed into infiltration wells in the study area.

3.4. Infiltration Depth

Equation 2 is used for porous walled well walls. The infiltration well that will be made is rectilinear with a side length of 1.5 m. Then the infiltration well design is as follows:
- Area of well cross section (Asr) = 2.25 m2
- The perimeter of the well cross section (P) = 6 m

- Soil Permeability Coefficient (k) = 0.015184 m/hour
- Rain Intensity (I) = 0.0115 m / hour
- Duration of rain (D) = 60 minutes = 1 hour
- Catchment area = 184 m (canteen roof)

Then the depth of the wells obtained in accordance with the data above is 0,889 = 1 metre.
The Infiltration wells has been built in the study area is a 2-meter-deep well, so that the recharge well discharge obtained is 3,192 m^3/hour. The study area needs 15 wells.

4. Conclusion

A research has been conducted to obtain the maximal runoff could recharge the groundwater in study area. Infiltration wells is an alternative method to recharge groundwater besides bioretention, infiltration trench, as a Low Impact Development (LID) to harvest the rainwater. The purpose of recharge the groundwater is to maintain water balance and to meet the basic needs of clean water for households, agricultural irrigation of the people expecially in dry season. The infiltration wells are also used for water conservation and to prevent land subsidience. According to the calculation the infiltration wells could saving 3,192 m^3/hour of rainwater in study area.

5. Acknowledgments

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