

PAPER • OPEN ACCESS

Optimization Of Recharge Well Functions In The Campus Complex Of Uny Yogyakarta

To cite this article: S. Purwantara 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **271** 012002

View the [article online](#) for updates and enhancements.

Optimization Of Recharge Well Functions In The Campus Complex Of Uny Yogyakarta

S. Purwantara

Departement of Geography Education, Faculty of Social Science
Universitas Negeri Yogyakarta, Jl. Colombo No.1 Yogyakarta, 55281, Indonesia

Email: suhadi_p@uny.ac.id

Abstract. The prevalent floods happened in Yogyakarta suburbs is not decreasing but growing every year. The same thing also happens in the campus complex of Yogyakarta State University (UNY) and its surroundings. Some parts of the campus and its surroundings having an area of 56,58 hectares are often flooded when rains occur with somewhat high intensity. This happens because the amount of run-off and drainage channels is imbalance. Also, many the recharge area spaces are diminishing since they have been converted into buildings. How large is the recharge area existing in the complex of UNY? How much is the volume of rainwater that is accommodated in this campus complex? How many recharge wells are needed?. This research aims at investigating the built-up areas and open spaces, rain water volume prediction, and the estimation of the optimal number of recharge wells needed. This research utilizes the rainfall data, built-up area data gathered using satellite imagery, infiltration data, permeability, and the number of recharge well data. The amount of discharge and the estimated volume of rainwater are calculated using a rational method $Q = C.I.A$. Based on the volume of rainwater, the method can be used to predict the number of recharge wells needed. To determine the depth of recharge wells, the DPU formula $H = D.I.A.t - D.K.As / As + D.K.P$ is employed. The results show that the recharge area is only 37,80%. This number is quite small since a lot of space of land that is supposed to be a strategic open space such as parking lot or garden has been converted into concrete and cement construction. The maximum of the rainfall volume at 50 mm / hour is around 28,290 m³. Therefore, based on the calculation, 3,519 units of artificial recharge wells are needed. In fact, the recharge wells built by the campus are only 128 units.

1. Introduction

Floods and droughts have become a daily topic discussed in various mass media every year. Floods usually become the topic or even headlines in regional and national newspapers during the rainy season, while drought becomes the subject of discussion during dry season. These topics do not decrease but always increase from year to year. The issue will spark if the affected areas are densely populated areas. The densely populated areas consist of urban or suburban areas. The urban areas which are often affected by the flood include Yogyakarta and its surroundings. Yogyakarta also experiences drought every year. Various news headlines include "Heavy Rain, Yogyakarta is Flooded" [1], "Wates street of Yogyakarta is flooded, Traffic Contagious reaches 5 km" [2], "Winongo river of Yogyakarta Overflows, The biggest Flood Since 1984" [3] reported on Liputan 6.com. Similarly, the news on drought is also existing in mass media such as news published by Balairung Press entitled "Yogyakarta experiences a deficit of



Water, Residents wells are dry" [4]. Another headline news is "The Rear of Hotel and Portrait of Drought Well in Yogyakarta Residence" [5] published on Acehkita.com. They are only a small part of news headlines about the floods and droughts in Yogyakarta.

The area close to the city of Yogyakarta lies a campus complex in the north, namely Yogyakarta State University (UNY). This area is affected by flood during the rainy season. The area of UNY complex is around 45 hectares. This campus is located in Caturtunggal village Depok District Sleman Regency. The floods which hit the campus complex allegedly occur due to villages around the campus, namely Karangmalang and Mrican. Moreover, drought also occurs due to the same thing. A number of wells in the campus has experienced a very significant decline from year to year. Is there any relation between the flood happening in the UNY campus complex and the expansion of the campus building? Does open space begin to decrease? How large is the infiltration area in UNY? How much is the volume of rainwater that is accommodated in this campus complex? How many artificial recharge wells are needed? To solve these problems, this research aims at investigating the built-up and non-built-up areas, rain water volume prediction, and prediction of optimal recharge wells needed.

Based on the background of the study, this research aims at investigating the rainfall, rainfall volume, and open spaces. Also, it intends to provide a model and suggests the number of artificial infiltrations that must be constructed in order that floods and droughts can be avoided.

2. Conceptual Framework

The rain water that falls on the earth's surface partially seeps into the soil becoming infiltration and later it percolates. The media for rainwater infiltration can be natural and artificial. Natural recharge media can be forest land, bare land, grassland, paddy fields, yard area, and so forth. Meanwhile, artificial recharge media consist of rainwater shallow recharge wells, deep water recharge wells, and artificial puddles such as reservoirs, and artificial basin. Some groundwater recharges are porous and very permeable, while others are so hard to pass water that infiltration runs very slowly.

Groundwater recharge is infiltration components which seep into the groundwater through the unsaturated zone such as river or lake [6]. It means that the recharge is natural. Meanwhile, non-natural recharge is called artificial recharge.

Based on the review of [7], artificial recharge is simply defined as the addition of groundwater resources performed by humans. The main purpose of building artificial recharge in many developing countries is to store water primarily for irrigation. Other objectives include preventing sea water intrusion in coastal areas, reducing run-off and erosion, and maintaining good quality of water.

Artificial recharge serve many functions such as sustaining groundwater as a source of life, inhibiting groundwater subsidence, and reducing land subsidence. Various methods of building artificial recharge include making trenches, basin, recharge wells, ditches, pools, and irrigation. An effective artificial infiltration development is building dam so that much water can seep into groundwater body [8].

3. Research Method

This research utilizes secondary data which include rainfall data, built-up area primary data gathered using satellite imagery, infiltration primary data, permeability data, and the data on recharge wells which have been built. Employing the rational method $Q = C.I.A$, the number of discharge and the estimated rain water volume is calculated. The volume of rainwater can be used to predict the number of recharge wells needed. To determine the depth of the recharge well, DPU formula $H = D.I.A_t - D.K.A_s / A_s + D.K.P$ [9] is employed.

4. Research Findings and Discussions

The research area is located on the suburb of the northern part of Yogyakarta city. The area of research spots is about 56.58 hectares. This very narrow area is 135 m above sea level. The soil is sandy which seems to be a brown latosol mixed with a regosol. The slope of the area is not too high, which is less than 10. Vegetation is dominated longan trees in many campus spots. Most of the open space grows

Manila grasses mostly in the garden and field, while around the building are mainly concrete cement or paving.

4.1. Open Spaces

The area of research spots includes the area of the campus complex plus some parts of villages nearby which is around 56.58 hectares. The area of open space based on the interpretation using satellite imagery is approximately 21.39 hectares. Open space, in this context, covers land on which grass is the only plant that grows or just an open ground. The rest is built-up areas which consist of buildings, asphalted road, cement yard or paving. The built-up areas estimated using Quickbird satellite images is approximately 35.19 hectares.

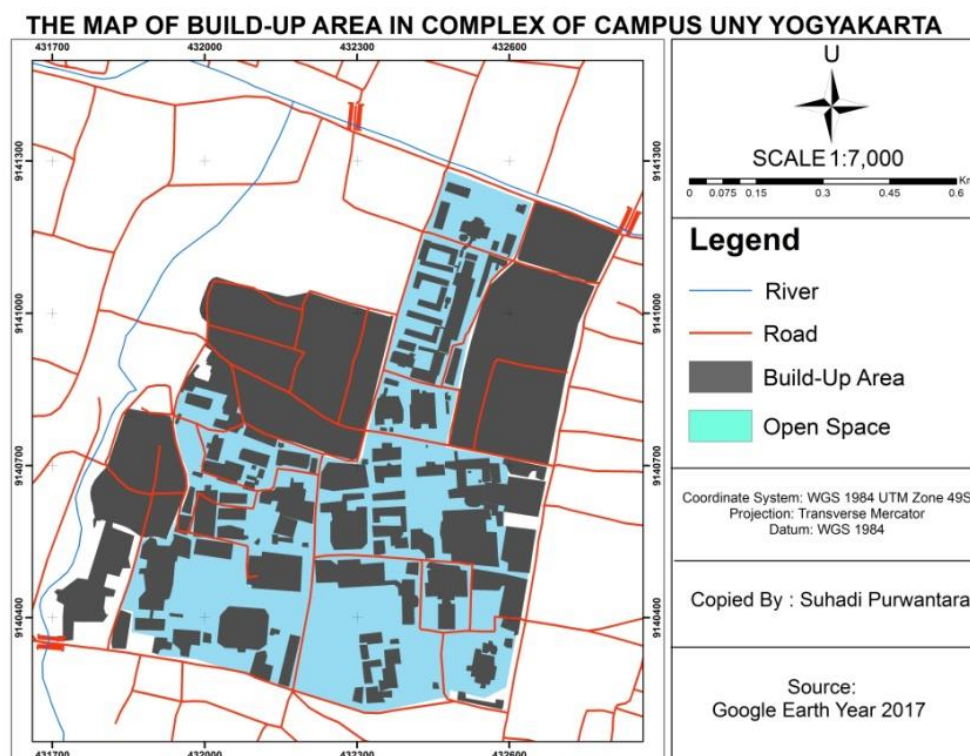


Figure 1. The Map of Build-up Area in Complex of Campus UNY Yogyakarta

4.2 Rain

Rainfall data is gathered from Colombo station which is located 150 meters at the eastern part of the campus. The rainfall data used in this research is the rainfall data from 2007 to 2016. The average rainfall is 1710 mm per year in which the highest rainfall average is 284 mm happened in February while the lowest is 13 mm occurred in August. The rainy season usually starts from November. The average rainfall is 195 mm in November, 261 mm in December, 269 mm in January, 202 mm in April, and 119 mm in May which is getting thinner. According to Koppen, the research area can be classified into Am rainfall. The maximum daily rainfall of single return period reaches 50 mm per hour. This means that daily rain happens every year at least 50 mm per hour. Therefore, if rain falls 50 mm / hour, the area that cannot absorb water will keep 5 m³ of rain water per 100 m² of built-up areas. In this case, 1.0 hectare of built-up areas must store 500 m³ of water. Thus, the 56.58 hectares of research area must keep 28,290 m³ of rain water when the rain having an intensity of 50 mm/hour.

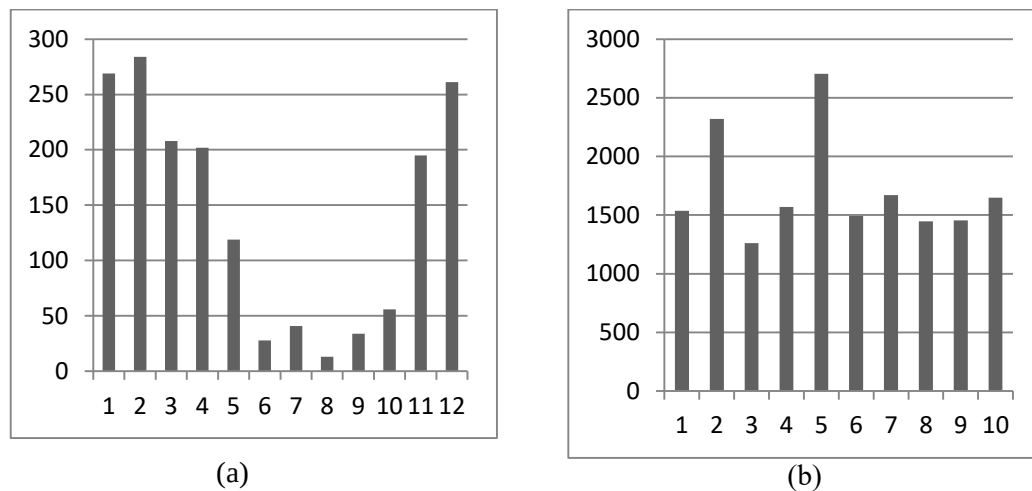


Figure 2. (a) The Diagram of Rainfall per month 2005 – 2014; (b) The Diagram of Rainfall per year 2005-2014

4.3 Water Drainage

The old strategy to overcome the abundance of rain water is to let rain water flow into the river through drainage channel. This is a short way but inappropriate. Building ditches spend a great cost, but it does not solve the problem. The problems in a location are solved but it may cause a new problem for another location in which the downstream river area gets flooding. To overcome this problem, rain water should be saved into the largest reservoir, i.e. in the soil. Soil is the best medium for rainwater storage. In the research area, there are many recharges wells but they are not sufficient.

4.5 Recharge Well

The depth of artificial recharge wells required to absorb rainwater at each location is varied, depending on several factors which include rainfall, land permeability, roof area or built up area, and well diameter. The type of soil in the research area is old regosol having permeability of $K = 11.56 \text{ cm / hr}$. For the depth of well having 80 cm in diameter, 6.22 meters deep is required to absorb all rainwater for a land or roof area of 100 m² calculated based on the formula of DPU. The built-up area in the research area is 35.19 hectares or 351,900 m². Therefore, the research areas require 3,519 recharge wells. Recently, there are 221 recharge wells in the complex of UNY. However, floods can still be reduced by utilizing drainage channels to flow water into the river.

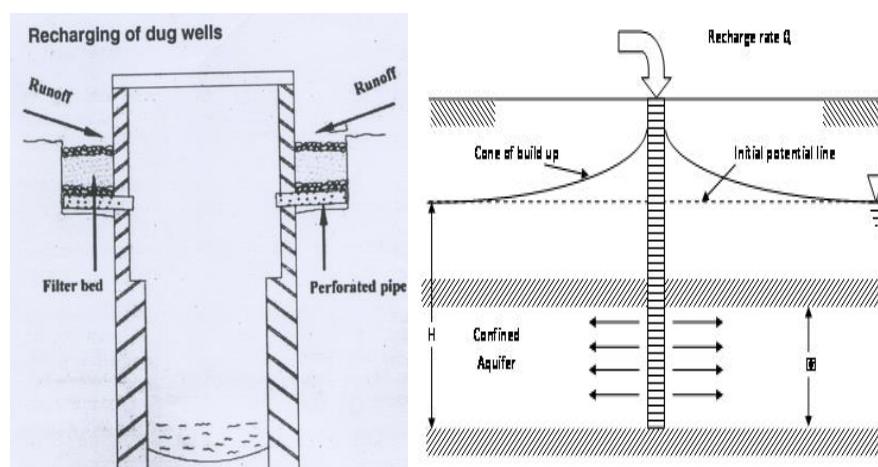


Figure 3. Types of recharges wells

5. Conclusion

The on going development is very encouraging since this indicates that the people's prosperity increases. The rapid development of campus infrastructure has reduced the open spaces (21.39 hectares). The 56.58 hectares of research area must keep 28,290 m³ of rain water when the rain having an intensity of 50 mm/hour. The insufficient recharge wells and the inappropriate construction of waterways are the major causes of flood occurred in campus complex. With regard to this, a good construction design including the development of green open spaces and artificial recharge is required. The research areas require 3,519 recharge wells. Recharge wells may become one of the alternatives to avoid flood from happening and prevent the shortage of ground water which is diminishing every year. UNY can be a model to deal with floods and to overcome the decrease of ground water by improving the number of recharge wells.

References

- [1] Nn, "Hujan Deras Yogya Banjir," *Liputan6*, 2017. [Daring]. Tersedia pada: Liputan 6.com. [Diakses: 24-Jan-2017].
- [2] Nn, "Jalan Wates Yogya Tergenang Banjir," *Liputan6*. [Daring]. Tersedia pada: Liputan 6.com.
- [3] Nn, "Kali Winongo Yogya Meluap," *Liputan6*. [Daring]. Tersedia pada: Liputan 6.com.
- [4] Nn, "Yogyakarta defisit Air Sumur Warga Kering," *Balairung Press*, 2016. [Daring]. Tersedia pada: Balairung Press .
- [5] Nn, "Belakang Hotel dan Potret Kekeringan Sumur Warga Yogya," *Acehkita*, 2015. [Daring]. Tersedia pada: Acehkita.com. [Diakses: 08-Feb-2015].
- [6] K. P. Seiler dan J. R. Gat, *Groundwater Recharge From Run-off, Infiltration and Percolation*. Dordrecht Netherlands: Springer, 2007.
- [7] I. Gale, I. Neumann, R. Calow, dan M. Moench, *The effectiveness of Artificial Recharge of groundwater: a review*. Nottingham: British Geological Survey, 2007.
- [8] Fetter, *Applied Hydrogeology*. New Jersey: Prentice Hall, 2001.
- [9] BSN, "Tata Cara Perencanaan Sumur Resapan Air Hujan Untuk Lahan Pekarangan," SNI No. 03-2453-2002. 2002, 2002.