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Implementation of bioretention system for environmental-based urban drainage planning

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Abstract. Drainage design patterns need improvements in an effort to find the root of the problems of flooding that often occur in big cities in Indonesia. The use of land that is not in accordance with applicable regulations makes drainage planning in a developing city will experience many difficulties. Rainwater management in particular is an effort to improve the existing drainage pattern. With the system, it temporarily absorbs rainwater into the ground with the application of bioretention. Drainage with the concept of environmentally sound makes it not just to drain water, but gives the optimum time for water to be able to absorb into the soil (Infiltration). Aiming at reducing the drainage load, filtering pollutants carried by rainwater into the soil, minimizing surface runoff and reducing annual runoff, the most important is groundwater recharge. Development of a bioretence system can be done in a Green Open Space that is adjusted to its designation, it can also be built on housing with easy calculations and can be applied at a cost that is not too expensive. The aim of this research is how a small artificial bioretention facility treating roof runoff from single family homes and nature bioretention overcome surface runoff from street and parking lot.

1. Introduction

Flooding is an event that is often experienced in Indonesia, especially when it enters the rainy season, considering that almost all cities in Indonesia experience floods. This event is repeated almost every year, but this problem has yet to be found a solution, and even tends to increase. The root of the problem of flooding in urban areas originates from the rapid population growth in each year above the national average, due to urbanization. Population growth that is not matched by the provision of adequate facilities and infrastructure makes the city burden even heavier which can end up in excessive use of city land by no longer following the standard rules that apply. For example, in every building that is built, it is necessary to leave a percentage of land for green open space. Law No. 26 of 2007 Article 17 concerning Green Open Space states that the proportion of forest area is at least 30% of the total watershed area intended for environmental sustainability. The purpose of this study is how to plan a bioretence system as one of the environmental-oriented drainage planning in open spaces in urban areas.

2. Literature Review

2.1. Urban Drainage

Drainage comes from the verb "to drain" which means drying or flowing water is the terminology



used to express systems related to handling the problem of excess water, both above and below the soil surface. The definition of urban drainage is not limited to excessive water disposal techniques but is more extensive regarding its relationship to aspects of life that are in urban areas [1]. The conventional drainage concept that has been adopted is drainage which is defined as an attempt to dispose of excess water in a place as quickly as possible to the river and immediately discharged into the sea. With this concept there will be accumulation of debits in the downstream and make low water conservation for the ecology upstream. Eco-Drainage concept or also called environmentally sound drainage can be interpreted as an effort to drain excess water into the river with the optimal time so as not to cause health problems and flood problems. All matters relating to excess water in the city area can certainly cause drainage problems in urban areas, so in planning and building water structures for drainage drainage, success depends on the ability of each planner. Thus, in the work process requires cooperation with several experts in other related fields [2], [3].

2.2. *Bioretention*

Bioretention is a system of quality and quantity control of surface flow using chemical, biological, and physical properties of plants, microbes, and soil to remove pollutants from rainwater runoff. A bioretention system is a landscaped depression that receives runoff from upgradient impervious surfaces, and consists of several layers of filter media, vegetation, an overflow weir, and an optional underdrain. Bioretention is a way to manage (by filtering and storing) rainwater runoff in the form of vegetated land with the composition of planting media in the form of soil and certain materials so as to form shallow water bags [1]. A bioretention is an engineered system to manage storm water runoff and consist of a soil with a clearly defined texture as a sandy loam with mixed in organic matter or other soil amendments. The soil is covered with a mixed vegetation cover. The system can be with or without a drainage pipe at the bottom, functioning as a groundwater recharge system or as a pure storm water treatment system with drainage at the bottom. Bioretention is also a part of Low Impact Development (LID), and is very intensive for limited land, for this underground recharge system must be considered. Bioretention integrates the function of pollution reduction and surface runoff due to filtering/cleaning of waste and sedimentation. The provision of compost and maintenance and replacement of plants is an effort to maintain and operate Bioretention that needs to be carried out. Bioretention areas are often also referred to as rain gardens and have some similarities to other Best Management Practices, such as vegetated buffers, grass swales, and infiltration trenches. Bioretention systems could be applied in housing close to home to catch runoff water from the roof of the house, city Center/Public area is placed close to buildings and along footpaths, along highways, on parking lots, close to transportation infrastructure, parks and recreation areas [4], [5], [6], [7], [8].

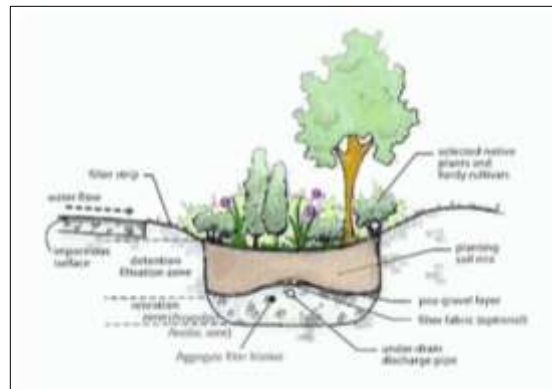


Figure 1. Residential bioretention

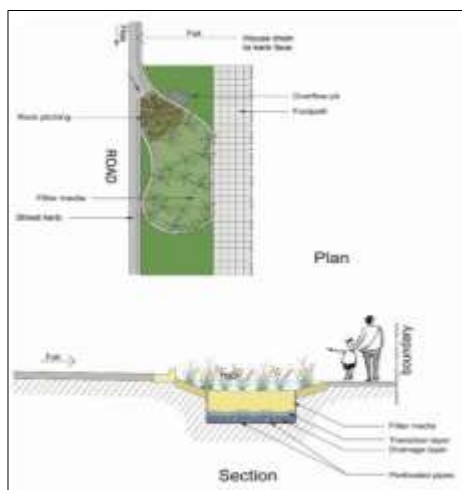


Figure 2. Public area bioretention applied to the pathway

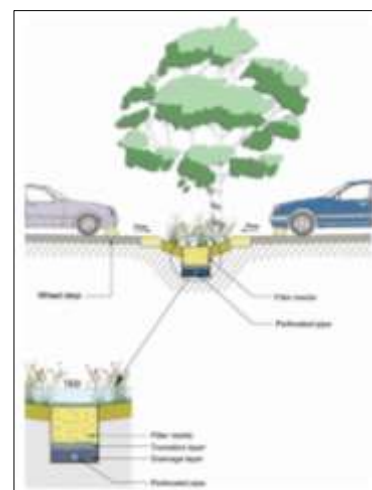


Figure 3. Public area bioretention Basin applied to the parking lot

3. Research Method

The research method is to analyze application of residential artificial and public bioretention. For nature bioretention location review is at Jagorawi Highway at kilometre 41. An arboretum is a place used to collect or collect plants or plants. Jagorawi highway arboretum is located on both sides of the toll road.



Figure 4. Public bioretention at Jagorawi highway

Arboretum location that is lower than the road will cause rainwater runoff from the entrance to the arboretum. Observations in the field indicate that rainwater entering the arboretum can be hydrologically retained because of its shape in the form of a basin. Thus, runoff water can be absorbed into the soil and utilized by vegetation above it. The basin in the arboretum has a depth of ± 2 m, so the arboretum meets the requirements of the bioretention system according to Scott (2009).



Figure 5. Acacia and teak vegetation



Figure 6. Grassland vegetation

4. Result and Discussion

4.1. Public Bioretention Planning

The planning of basins bioretention is knowing soil permeability of the location. Soil quality and permeability are important factors, which must be taken into consideration when identifying potential bioretention garden location. How to check soil permeability are (1) make a hole and filled with water, then observed how long the water can be infiltrated (2) if the water not infiltrated within 48 hours, then location can be moved or to be consider to make a deeper basin (3) if the water infiltrated within 24 hours it might be only need 6 inches deep for basins bioretention. The bioretention system requires land with low content weight. This is so that the surface water entering the arboretum will be absorbed by the soil quickly. Continuous rain will cause a large volume of surface flow, so the arboretum must be ready to accommodate and absorb water into the soil. If the storage capacity is less than the volume of surface water, floods will occur, and water will flow to the water body. Acacia land with a content weight of 1.03 g/cm^3 has met the physical properties of the bioretention system compared to other fields [9], [10].

4.2. Residential Bioretention

The artificial bioretention could be made from a water-tight plastic box. Media was filled to a height of 60 cm in the box, leaving 20 cm freeboard to allow for standing water in the box during runoff events. The vegetation used in the box was chosen based on the location and climate. Hot and drought resistant species that were chosen. Local vegetation landscape in the area were preferred as they have been proven to survive in the climate.

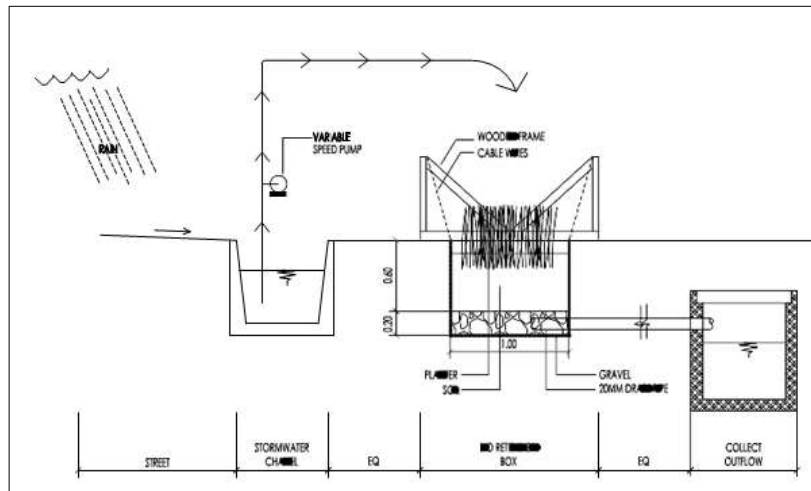


Figure 7. Residential artificial bioretention design

The process of artificial bioretention is storm water runoff will be accommodated by rainwater channels, which will then be pumped using variable speed pump to artificial bioretention planters. After experiencing the infiltration process, the water will enter and collected to outflow tank. In collect outflow tank, the rainwater has become clean from pollutants and chemicals. Furthermore, it will be used for household purposes such as toilet flushing, car washing and watering plants.

5. Conclusion

In a single-family residence with limited space, there will almost always be enough space to design an artificial bioretention to handle runoff. Sizing of artificial bioretention depend on the depth of the planter box and the percolation rates of the media, minimum percolation rate is 0.5"/hr. To examining how much water could be produced from the planter box depends on rainfall events in the area.

6. References

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