Groundwater Conservation with Hole Infiltration of Biopore Cube

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Abstract. Analysis of groundwater conservation with cube biopore infiltration holes using the value of soil permeability, the amount of rainfall, and the depth of the groundwater level. The groundwater conservation research method is carried out by making the cavity biopore infiltration holes to absorb the volume of rainwater and domestic waste water into the soil. Conservation is suitable for homes that have enough yard. The main reason is to use cube infiltration holes to accommodate large and small organic waste. Organic waste is trees, grass and domestic waste. For a small house yard, conservation of ground water enough with a cylindrical hole diameter of 10 cm. Benefits of biopore infiltration holes are reducing surface runoff, producing manure, fertilizing soil, reducing waste piles, and conserving ground water. The research objective was to analyze the cube biopore infiltration holes based on soil permeability, rainfall intensity, depth of groundwater level, and volume of organic waste. The results of the analysis can be obtained from the cube biopore infiltration holes which can absorb all the rainwater which can accommodate all organic waste. The results of permeability testing show that the average soil permeability is 0.00112 cm/s and the yield of maximum discharge runoff water in January is 97.57 cm3/second. The ground water level is two meters. While the volume of organic waste is one cubic per month. The result of the analysis showed that the area of cake absorption was 8.73 m2. When converted to a cube absorption field it takes approximately 8 meters wide by 0.5 meters and a depth of 0.5 meters. When divided into four cavity recharge holes LRB1 obtained area of 4 m2, LRB2 area of 2.7 m2, LRB3 area 2 m2, and LRB4 as reserve.

Keywords: Groundwater, Conservation, Cube LRB, Permeability, Rainfall, Organic Waste.

1. Introduction
The main problem of some parts of Indonesia is the water crisis during the dry season and flood in the rainy season. Does this crisis happen naturally or is it caused by human activity itself? Of course there are droughts and floods due to extreme weather. But there is also much environmental damage due to human activities resulting in drought and flooding. Some examples of human activities that can cause damage to the environment on land and in the ocean. Among them are excessive groundwater exploitation. Unplanned housing construction. Logging and burning forests. Sand mining in the sea.
Excessive use of chemicals and pesticides. Exploitation of marine resources. Use of motorized vehicles and others.

Makassar City residents still use a lot of ground water for their daily needs. As an illustration, especially in Mangala District, there are 62 drill wells. Of 62 drilled well data is taken at a distance of 50 meters [7]. If taken on a smaller space, more drilled wells will be found. In addition to drilling wells, the community also has a lot of digging wells. This shows that groundwater use in Makassar is still very massive.

Along with human growth and activity, the absorption of water into the soil becomes more difficult. Because human activity can cause a decrease in soil permeability [5]. Human activities by building infrastructure housing, roads, buildings and other facilities without taking into account the green open space resulted in increasingly narrow water absorption. The surface of the soil is getting denser so the pores of the soil get smaller. This causes the running water (run off) the greater. Another cause is the disposal of garbage in the flow of water bodies, so the water cannot flow smoothly that eventually lead to flooding.

To overcome the disruption of water absorption into the soil need technology. The technology needed is a simple technology that is easy for everyone to do. There are examples of simple technologies developed to cope with drought during the dry season and cope with flooding during the rainy season. Naturally keeping the forest is the solution, but since the forests are already bare deforested, it needs to be encouraged to replant trees for reforestation. In urban areas it is necessary to develop green open land and artificial lakes as recharge areas. In the blood of settlements developed technology of making hole biopori infiltration [3]. While deep groundwater exploitation through wellbore, restored by injection well [6].

In this research, cavity-shaped biopore infiltration holes are developed to absorb all the water in the soil surface. The water on the soil surface that is infiltration is rain water. The rain water covers the water that falls in the yard, and the water that falls from the roof of the house. In addition, water that needs to be infiltration is household waste water. As research material is taken case study of a house of resident in Antang unhas housing. The land area is 325 m2 and there is a house on it type 54.

2. Biopore Infiltration Holes (BIH)

Biopore is a continuous burrow macro pore that serves to accelerate the infiltration of water into the soil. The macro-shaped pores of this continuous shaft are formed by the activity of flora and fauna. The pores formed due to flora activity are decayed roots. While the pores formed by the soil fauna activity are worms, termites, and ants [2,3].

Biopore infiltration holes are holes that can be cylindrical or cube-shaped. The shape of the biopore infiltration hole depends on the available land. If the land is large enough, we are free to design a biopori infiltration hole according to the wishes of the owner. But if the land is narrow then simply made a cylindrical hole diameter of 10 cm. The depth of the biopore infiltration hole is not more than 100 cm from the soil surface. It should be noted that the depth of LRB should be adjusted to the depth of the groundwater level. The depth of the LRB is above groundwater depth.

The size of the biopore infiltration hole (BIH) depends on the amount of water discharge infiltration into the soil and the soil permeability value. If the water discharge is infused enough then the size of the BIH infiltration field is greater. Conversely, if the water is infiltrated slightly the area of BIH infiltration becomes smaller. What is more crucial is the soil permeability. If the soil permeability is large then the size of the LRB recharge field is smaller.

According to [4], for cylindrical holes, the size or number of biopore infiltration holes needed in certain areas of land is,

\[ N = \frac{I \times A}{P} \]  

Information:

- \( N \) = Total LRB
- \( I \) = Rain intensity (mm / h)
- \( A \) = Area of the impermeable area (m2)
- \( P \) = Water absorption per hole (liter / hour).
Water infiltration in the soil occurs vertically and horizontally. Vertical water infiltration rate is smaller than the horizontal water infiltration rate. For fine-grained soils the rate of water impregnation is horizontally 10 times larger than the rate of vertical infiltration. From this is the significance of making the rainfall hole (LR) into the soil. Storage of water in the soil and the rate of infiltration of water into the soil will increase further after the formation of biopori. Biopori is formed due to the activity of small animals in the soil and the roots of trees that have been weathered.

The size of the absorption plane of a cubic-shaped biopore infiltration with a certain depth (h) can be calculated from the water discharge to be infiltration. The water discharge that is infiltration is the amount of rainfall multiplied by the land surface area where the rainwater falls (L). In order to absorb all water on the surface, the extent of the LRB infiltration of the cube must be greater than or equal to the extent of water absorption in the soil permeability. In other words the rate of water absorption into the soil is equal to or greater than the surface water rate. Thus surface water from rainwater and household wastewater can be absorbed all into the ground. The calculation area of the cube LRB infiltration area is based on the highest rainfall in January so that there is no running water left throughout the year. The calculation of the LRB recharge area of the cube uses equation 2 as follows.

\[ A = \left( \frac{I \times L}{K} \right) \]

Information:
- \( A \) = cubic LRB infiltration area \((m^2)\)
- \( I \) = rainfall intensity \((m / day)\)
- \( L \) = land surface area \((m^2)\)
- \( K \) = soil permeability \((m/day)\)

3. Research Methods

This research is done by applying the biopore infiltration hole to settle rain water that falls in the yard and rain water that fall from the roof of the house. In addition, this biopori infiltration hole is also used to absorb household wastewater. Biopori infiltration holes are designed to absorb all of the water so there is no need to throw water into the ditch.

The location of this research was conducted in Unhas Antang in one of the houses. The location of this study is at coordinates (-5.1691446S, 119.4801432E). The study area is tilted westward with a slope of 10°. There are two dug wells near the research location in the west. The depth of the groundwater is measured from the two wells. The measurement of the depth of the well is three meters. The land area is 325 \( m^2 \). There is a house on it type 54 with size \((6 \times 9) \) meters. The area of the yard is 271 \( m^2 \). The sketch and design of a cubical biopori infiltration hole can be seen in Figure 1.
In Figure 1 we can see that four LRBs are LRB1, LRB2, LRB3, LRB4. The size of each LRB cube is calculated based on the highest rainfall. Why is that, because the volume of water falling on the ground reaches the maximum in the highest rainfall. If maximum rainfall has been recovered all the soil can automatically absorb all water for smaller rainfall. Therefore the desired LRB design is LRB that can absorb the maximum volume of rainwater that falls on the ground surface.

The data required in the LRB cube analysis is the permeability of the soil research area, and the rainfall data of the research area. In addition, data on groundwater depth and organic waste are required. The depth of the groundwater level becomes a benchmark of LRB depth. Because the depth of LRB should be above groundwater depth. To enable LRB in organic trash required. Organic waste used is waste from household waste and from plants and trees contained in the research area.

4. Results and Discussion
To know the depth of groundwater level in the research area using the existing dug wells around it. There are two dug wells near the research area in the west. The depth of the groundwater level is measured using a meter from the ground surface to the groundwater in the dug well. From the measurement results, it is known that the depth of groundwater in the study area is three meters. This data is taken from two wells close to the research site in July 2018. From the groundwater depth data, it can be made LRB depth more than one meter.

The long cube shaped LRB design aims to accommodate all forms of organic waste that exist. There is a large amount of organic waste collected in LRB and small ones. Large rubbish like tree trunks, tree stems, tree branches. Small-sized rubbish is leaves, grasses, household organic waste.

The research area covering an area of 325 m² contains many trees. Among them are four mango trees, two rambutan trees, and one durian tree. There are also plants such as moringa, srikaya, papaya, lombok, pariah, cereals, taro, galangal, turmeric etc. There are also many types of grasses. Garbage from these herbs and organic waste from household waste is used to fill LRB cubes. Volume of organic waste from household waste, trees, from plants not less than one cubic per month. This organic waste becomes food for small animals and some experience decay.

This organic waste quickly decomposes in LRB cubes because it is always moist so there are many biantang-animals such as termites, ants, earthworms etc. These animals develop quickly and make

![Figure 1. Sketch of Research Area LRB cube](image-url)
more holes in the ground. The holes formed as soil pores can store and absorb more water in the soil. The remains of organic waste will break down into compost that fertilizes the soil.

LRB maintenance needs to be done regularly. The trick is to lift organic waste that has broken down into compost to the surface of the soil. Then spread to surrounding plants as fertilizer. Maintenance is carried out every six months. So the function of the Cube LRB is to fertilize the soil and overcome runaway water.

4.1. Soil permeability

To know the size of soil permeability in the research area, soil permeability test is done directly in the field (in-situ). The test was conducted at the beginning of July 2018. In July still often rain in the study area so that the soil conditions are still wet when testing. Soil permeability testing method is to make a cylindrical absorption hole with a diameter of 10 cm with a depth of 20 to 120 cm. The volume of water inserted into the cylindrical hole varies from 2 to 3.5 liters. Each hole is filled with a certain volume of water to be infiltration in the soil. Then calculated the time of impregnation with stopwatch. Permeability is calculated by equation 3.

\[ K = \frac{V}{A \cdot t} \]  

Information:
- \( K \) = permeability of soil
- \( V \) = volume of infiltration water (cm\(^3\))
- \( A \) = Area of Cylindrical LSR recharge area (cm\(^2\))
- \( t \) = infiltration time (s)

The results of direct permeability testing in the field can be seen in Table 1.

| Parameter   | LSR1 | LSR2 | LSR3 | LSR4 | LSR5 | Average |
|-------------|------|------|------|------|------|---------|
| Depth (cm)  | 20   | 25   | 30   | 65   | 120  | 52      |
| Volume(cm\(^3\)) | 1000 | 1500 | 2500 | 1000 | 1000 | 1400    |
| Time (s)    | 1080 | 1320 | 2820 | 4980 | 7200 | 3480    |
| Debit(cm\(^3\)/s) | 0.9259 | 1.1363 | 0.8865 | 0.2008 | 0.1388 | 0.4023 |
| Permeability(cm/s) | 0.0019 | 0.0023 | 0.00082 | 0.00042 | 0.00014 | 0.00112 |

Table 1. Results Permeability Test of Research Area

The test results show that the mean permeability in the research area is 0.00112 cm / s. The soil's ability to absorb rainwater in the research area on average is 0.4023 cm\(^3\) / sec. If there are one hundred cylindrical absorption holes then it can be infused with rainwater of 0.4023 liters / sec.

The absorption of water into the soil in the study area varies with depth. The results of soil permeability testing show that the deeper the water hole seeps into the soil. The result of soil permeability test to depth can be seen in Figure 2.
4.2 Rainfall
Rainfall data used in this study is the rainfall data of Makassar City obtained from BMKG region VI Sulawesi. Rainfall data used is the last 12 years rainfall data is rainfall data year 2000 to 2011. Average annual rainfall in the city of Makassar in the last twelve years is 3060.04 mm / year, while the average monthly rainfall is 255,03 mm / month. Average rainfall per day in the last 12 years is 0.69864 mm / day while the average rainfall per second is 0.000000698 mm / s.

The highest rainfall occurred in January averaging 711 mm and the lowest in August 17.41 mm in the period of 12 year. High monthly rainfall in Makassar City on average within 12 years from 2000 to 2011 can be seen in Figure 3.

In the analysis of LRB manufacture is used maximum rainfall that is in January. Because LRB optimization is based on maximum rainfall. If the maximum rainfall in January 711 mm then the average rainfall per day in January is 23 mm/day. This means that the rainwater infiltration in the soil per day in the study area of 325 m² is 7,475 m³ or 86 cm³/sec so that no surface water runoff occurs. Table 1 shows the average soil permeability of 0.00112 cm/sec and the rain water infiltration in January 86 cm³/second then the minimum area of rainwater infiltration is 77060 cm² or 7,706 m².

Another water source infiltration into the soil is household waste water. The results of a survey conducted by the Directorate of Drinking Water Development, Directorate General of Human Settlements in 2006 showed that every Indonesian consumes an average water of 144 liters per day. Use of clean water in Makassar City an average of 190 liters / person / day [1]. If the water usage per person per day is 200 liters / day then it takes 1000 liters of water or one cubic / day. If converted to
cm$^3$/sec then obtained 11.57 cm$^3$/sec. For household wastewater, the required area of impregnation is 10330 cm$^2$ or 1.033 m$^2$.

The maximum flow of running water is the rain water discharge plus the discharge of household waste water that is 97.57 cm$^3$/second. From the data of soil permeability and the running water debit can be obtained the extent of LRB recharge area of cube using equation (2). The result of this calculation shows that the total area of infiltration of LRB cube running water is 8.73 m$^2$. When converted to LRB cube then it takes approximately 8 meters wide by 0.5 meters and a depth of 0.5 meters. So based on the data permeability and rainfall data can be determined the size of the four areas of LRB recharge cube as in Figure 1 above. The size of the four LRB recharge areas is LRB1 4 m$^2$, LRB2 2.7 m$^2$, LRB3 2 m$^2$, LRB4 as reserve.

5. Conclusions
The results of soil permeability testing of the study area showed that the average soil permeability was 0.00112 cm/s. The volume of water infiltration from rainfall and domestic waste is 97.57, cm$^3$/sec. To absorb the water is required area of water absorption in LRB cube is 8.73 m$^2$. When converted to LRB cube size it takes approximately 8 meters wide by 0.5 meters and a depth of 0.5 meters.

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