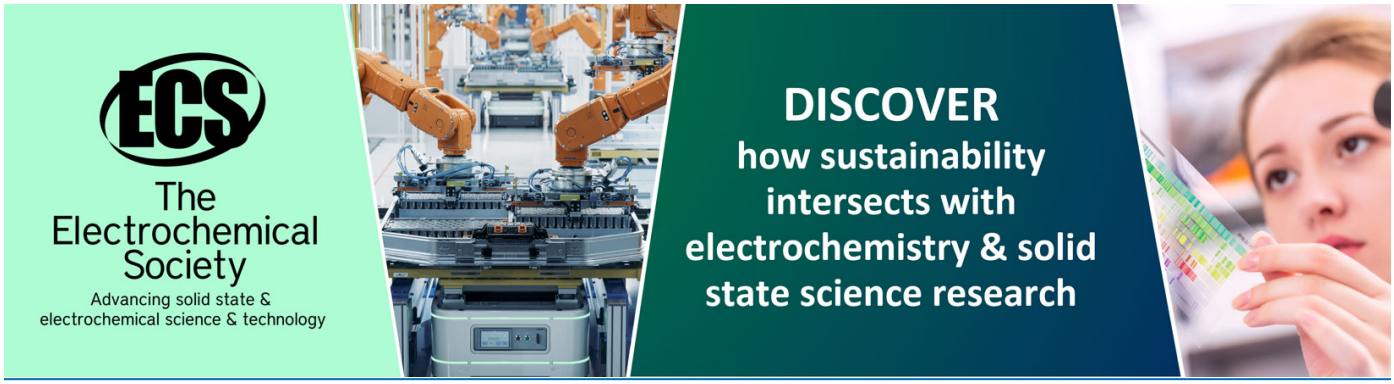
# The Study of Area Infiltration Rate by Using Biopori Holes as an Effort to Reduce Water Level and Groundwater Conservation





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# The Study of Area Infiltration Rate by Using Biopori Holes as an Effort to Reduce Water Level and Groundwater Conservation

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**Abstract.** The expansion of land development for settlement and other infrastructure has impact for lessen of green open space that serves to absorb rainwater. Accordingly to that, there is a need of effort to increase the absorbtion rate of rainwater into the ground; one of the methods is using biopori holes. The area that uses as a sample to observe the infiltration rate using biopori holes is Kopelma Darussalam, Banda Aceh. The aim of this study is to measure the infiltration rate before and after the application of biopori holes, find out the amount of holes that required, discover the differences of ground water level every 2, 5, and 10 years return period and find out the amount of water that absorbed to ground water. The data which uses to calculate the water level is the annual maximum daily rainfall, land area under forest cover and texture, and infiltration rate. Meanwhile, the data which uses in order to calculate the volume of water infiltrated into the soil in each month is monthly rainfall data, land area which classified by the cover and texture and infiltration rate. Inundation height at annual maximum rainfalll plan for 2, 5, and 10 years return period with using 100, 160 and 400 holes for each 100 $m^2$ is lower from 9.01% to 77.43% compared to not using biopori holes. In addition, the amount of water that infiltrated after using biopori holes is increasing up to 4120 $m^3$ for each month.

## 1. Introduction

The ongoing development of life requires a transformation of land-use that continues to increase. The expansion of land development for settlement and other infrastructure has impact for lessen of green open space that serves to absorb rainwater. These conditions has resulted intoinundation affected by rain become higher and the amount of rainwater that infiltrated reduce [1-2].

Due to the growing water demand and the main source of water comes from rainfall; efforts are required to effectively absorbp rainwater into the ground. Some technologies that increase water infiltration into the soil such as infiltration basin, infiltration trench, and french drain have long been introduced to society. However, the water absorption technology is not yet wide spread applicability for various reasons. Among others is the needed of a relatively large place, a relatively long time, and the cost is not economical. Thus, a further technology is still needs to be developed to be more appropriate, maintained at more economical cost, and environmentally friendly. One of the method is using biopori holes [3].

The aim of this study are to measure the infiltration rate before and after the application of biopori holes, determine differences for every annual maximum rainfall plan for 2, 5 and 10 years return period. Other than that, to know the amount of water that infiltrated into the soil. Biopori hole is cylindrical holes made vertically into the ground with a diameter of 10 cm and about 80-100 cm depth or in the case of shallow groundwater, not exceed the depth of groundwater level. The space between the biopori holes ranged between 50 cm to 100 cm. Holes filled with organic waste. Surface run off will go into the hole and seep into all directions around the hole through biopori [3].

Kopelma Darussalam is the center of academicals activity in Banda Aceh. Besides, the population growth in this area is increasing year by year. That is why to know the infiltration rate with and without using biopori holes, so that the differences of infiltration rate in both conditions can be measured [2]. Before doing field measurement for using or not using biopori holes condition, first to do this is to analysis the geospatial information for the area so that the area to apply biopori holes can be determined for each variation of soil textures. The soil textures for Kopelma Darussalam area according to soil textures map is divided in two types which is sand and silt. Whereas the land coverage that investigated is grass-covered, weed-covered and uncovered soil. After each type of land condition has classified, and then the field measurement for each land condition can be processed [3].

Infiltration is the entry process of the water from the surface in to the ground. Inside the soil water flow in the lateral direction known as interflow, flowing to the lakes and rivers springs, or vertically, known as percolation, flowing to the groundwater [4]. The calculations is done based on the amount of rainfall statistical formula as follows $R_T = R_{bar} + K. S_d$ [2, 5].

Calculate the volume of rain flow (direct runoff) that is Volume = Direct flow x Time. In this case, volume is expressed in cubic meters, direct flowing $m^3$/sec and the time in seconds. Furthermore, the flow depth is calculated, that is the total volume divided by the area of watershed, depth (m) = Volume ($m^3$)/Area ($m^2$) [4]. In estimating flow caused by heavy rains, evaporation and evapotranspiration that occurs within a short time periodic small and can be ignored, so that the formula becomes, flow = (presipitation-infiltration). The Geographic Information System (GIS) is a series of systems that utilize digital technology to perform spatial analysis[2].

## 2. Experimental apparatus and procedure

The tools used for this study includes drill biopori; steel ruler 20.0 cm and 30.0 cm; gauge; modified pipes with a diameter of ± 10 cm height, 25 cm for size measurements without biopori hole sand , 100.0 cm for the measurement biopori holes; hollow cans with ±15.5 cm diameter and 16.0 cm high; stopwatch; and stationery. Material that used in this study is composition of the fertilizer plant with a mixture of 1:1:1 (soil: rice husk: cow dung) with the fertilizer plan is using as the biopori filler and sufficient water.

The maps that used in this study is satellite image for Kopelma Darussalam from 2011, which sourced from Regional Development Agency Banda Aceh; Administration Map; Soil Texture Map for Kopelma Darussalam; annual maximum rainfall plan from BMKG Blang Bintang, Montly Rainfall Data from BMKG Blang Bintang, Aceh Besar. Spatial analysis of the study area is done by using the Geographical Information System. Input data including data from satellite imagery. Restrictions on land units are doing through the interpretation of satellite imagery. Interpretation of satellite image classification focused on the preparation stage to restrict land units that have the same physical characteristics.

For the implementation of infiltration measurements using modified pipes and hollow cans instead of ring infiltrometer. The first step is clearing the land-area of study; and prepare the tool at the location of measurement; the hollow can is pressed into the soil surfaces into ±5cm depth; modified pipes measuring 25.0 cm high and 10.0 cm in diameter is pressed in to the soil surface in to ±5cm depth; the remain high above the surface is 20.0 cm; pipe already laid ±5cm into the soil surface, vertically inside the pipe is placed a 20.0 cm steel ruler and water is poured into the pipe until full. Once the water is full, the stopwatch is started and every 2 minute interval water degradation seen in the ruler is noted; when the water runs out, but the decrease in water level has not showing the constant infiltration rate, the water can be added with observe or record the position of the clock in the delivery of addition water into

the pipe. Experiments' performed in three types of land cover which is uncovered, grass-covered and weed-covered, on sand and silt soil texture.

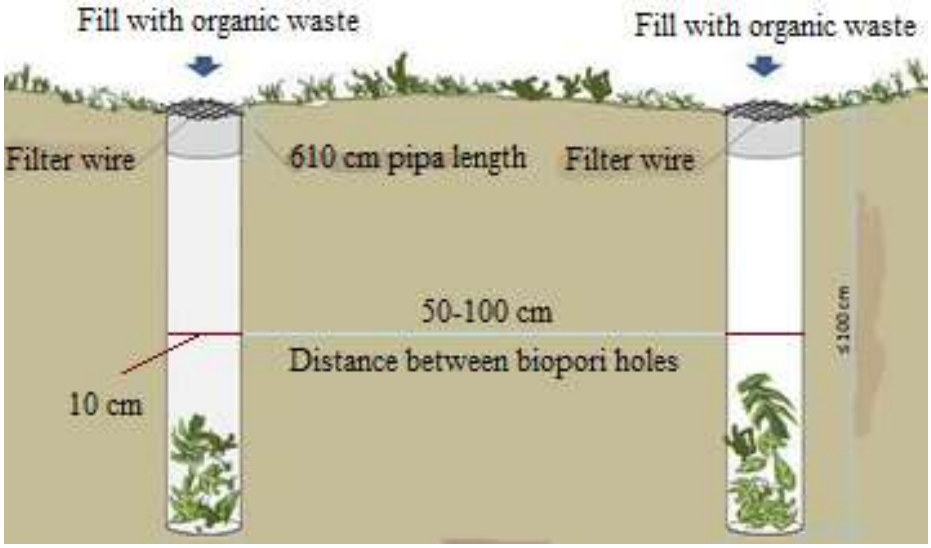


**Figure 1.** Biopori holes

First step is determine the land-area of study and prepare the tools on the location of measurement; create cylindrical holes using a drill biopori vertically in to the ground with a diameter of ±10.0 cm; and ±70.0 cm depth or lower if ground water level is shallow; press the modified pipes measuring 100 cm in height and diameter ±10.0 cm in to the existing hole. The height of the pipe left above the surface is 30.0 cm; fill the hole with fertilizer plants until its level with soil surfacee; affix a 30.0 cm ruler whose given double-sided tape to the inside of the pipe vertically. Water is poured into the pipe until full; once full of water, stopwatch is turned on and each time interval 30 sec the degradation of water level visible in the liner noted; when the water runs out, but the decrease of water level has not demonstrated a constant infiltration rate, more water can be added when observing or recording the position of the clock at the delivery of addition water into the pipe.

Rainfall data were obtained from a rainfall station daily rainfall data. Rainfall data were obtained at 53 years. Rainfall data that does not follow a normal distribution and lognormal, then expected to follow the Gumbel distribution. This estimate proved by Kolmogorov-Smirnov test.

To calculate the inundation level in the region of Kopelma Darussalam, the area is divided into several parts, where the parts are separated based on soil texture and land cover. In calculating the volume and inundation level using biopori holes, the biopori holes are divided into 3 different patterns. For the distance between holes is 50.0 cm the holes per 100.0 $m^2$ is 400 unit, distance between holes 75.0 cm the holes per 100.0 $m^2$ is 160 unit and distance between holes 100.0 cm then the holes per 100.0 $m^2$ is 100 unit.

Step calculations to determine the inundation level is recounted annual maximum rainfall plan for 2, 5, and 10 years return period; calculate the rate of infiltration without using biopori holes (uncovered, grass-covered and weed covered soil) with two types of soil texture; calculate the area of each land cover with two types of soil texture. In this case, to facilitate the calculation,each soil texture is divided into several sections or segments of land cover (egs and withgrass-covered, and so on); types of land cover and soil texture that has already grouped, calculated by finding the difference between the total area with rainfall and the rate of infiltration of the area, with return period of 2, 5, 10 years; then the volume of inundationon the uncovered, grass-covered, and weed-covered soil summed together with the volume

of inundation from the rain that fell on top of the building. So the indundation pool of total volume obtained for each segment after the total volume obtained calculate the water level for each segment by dividing the volume of a inundation with total area of each segment. Do this until the volume and level of inundation for all of the area is calculated in various return period of rainfall.

Step calculations to determine the inundation level is recounted annual maximum rainfall plan for 2, 5, and 10 years return period; calculate the rate of infiltration after the aplication of biopori holes (uncovered, grass-covered and weed covered soil) with two types of soil texture and infiltration rate without biopori holes. First calculate the area of the land that using biopori hole (uncovered, grass-covered and weed covered soil) with two ground textures. Then calculated according to the distributions segment. First, for 80 biopori holes every 100.0 $m^2$, count the numbers of holes that will fill these lands according to existing land area in the segment. After the number of holes on the land is acquired, it will be known how much land in the segment that uses biopori holes in various types of land cover and soil texture. And the land that does not use biopori holes calculated by subtracting the extent of land that has been given biopori holes; at the calculation of the volume of the inundation with biopori holes, the type of land cover and soil texture that already grouped, calculated by finding the difference between the total area with rainfall and the rate of infiltration of the area, with return period of 2, 5, 10 years. Then the volume of inundationon the uncovered, grass-covered, and weed-covered soil that not use and using biopori holes summed together with the volume of inundation from the rain that fell on top of the building. So the pool of total volume obtained for each segment. Later, the total volumes obtained and calculate the water level for each segment by dividing the volume of a inundation with total area of each segment. Do this until the volume and level of inundation for all of the area is calculated in various return period of rainfall. Then, the water level for the whole of the land has been acquired by repeated periods of 2, 5, 10 years.

The steps taken in calculating the volume of water that goes into the ground (infiltration) with and without biopori holes are as follows, calculate monthly rainfall lR90; calculate the infiltration rate for each soil texture and variety of land cover; classify land area before using the biopori holes based on soil texture and land cover; classify land area after the aplication of biopori holes based on soil texture and land cover; area that using biopori holes calculated based on the distance between holes which ranged between 50.0 cm to 100.0 cm; to determine the volume of water that enters the soil before using biopori holes. Every month is calculated area of the land that has been classified earlier with each infiltration rate or monthly rainfall, then calculate the overall volume in a region Kopelma Darussalam, Banda Aceh; to determine the volume of water that enters the soil after use biopori holes (with the number of biopori holes variated per 100.0 $m^2$ with a distance between holes 50.0 cm-100.0 cm), then in each month is calculated area of land that has been classified as partially before the infiltration rate of each individual or monthly precipitation, including land which using the biopori holes. Instead of that, calculate the overall volume in the region Kopelma Darussalam, Banda Aceh and calculation of the volume of water that enters the soil before and after use biopori holes put in the chart for every month.

## 3. Result and Discussion

Rate of infiltration area without and by using biopori holes. Infiltration rate measurements that performed on Kopelma region Darussalam, Banda Aceh shows that the infiltration rate for sandy soil texture is faster than the silt-textured soil, with a variety of land cover. Land that is not covered absorbs water more slowly than land which has a cover such as grass and weed. In addition, by using biopori hole the ability of soil to absorb water is much faster than not using biopori. This is because the hole that has been filled biopori fertilizer plant has more cavities that allow water to be rapidly absorbed into the ground in lessen time. This result can be shown in table 1, 2, 3 and 4 as follows;

**Table 1:** Rate of infiltration at the various land cover and soil.

| Variation of Land Cover | Infiltration rate (mm/min) |
|---|---|

| | Sand | Soil |
|---|---|---|
| Ground without cover | 0.07 | 0.025 |
| Grass | 0.09 | 0.033 |
| Weeds | 0.100 | 0.042 |
| Biopori holes | 8.000 | 1.000 |

**Table 2:** The water level at return period of 2, 5 and 10 years.

| Return period (years) | Rainfall (mm) | Biopori holes (mm) | | | |
|---|---|---|---|---|---|
| | | 0 | 100 | 160 | 400 |
| 2 | 114.86 | 83.11 | 67.03 | 57.37 | 18.76 |
| 5 | 172.34 | 140.60 | 124.51 | 108.25 | 76.24 |
| 10 | 210.40 | 178.66 | 162.57 | 152.92 | 117.31 |

**Table 3:** Water volume per month at variety number of biopori holes.

| Variation in the number of biopori holes | The volume of water entering the soil per month | | | | | |
|---|---|---|---|---|---|---|
| | January | February | March | April | May | June |
| 0 | 58253 | 53737 | 58221 | 58253 | 55667 | 17769 |
| 100 | 59122 | 53878 | 58483 | 58738 | 58613 | 17835 |
| 160 | 59643 | 53963 | 58640 | 59029 | 58830 | 17851 |
| 400 | 61729 | 54301 | 59267 | 60194 | 59695 | 17879 |

**Table 4:** Water volume per month at variated number of biopori holes

| Variation in the number of biopori holes | The volume of water entering the soil per month | | | | | |
|---|---|---|---|---|---|---|
| | July | August | September | October | November | December |
| 0 | 13384 | 54012 | 58037 | 35313 | 58253 | 58253 |
| 100 | 13363 | 54158 | 58259 | 35456 | 59283 | 58987 |
| 160 | 13351 | 54246 | 58393 | 35459 | 59901 | 59428 |
| 400 | 13302 | 54597 | 58928 | 35467 | 62373 | 61191 |

## 4. Conclusion

Infiltration rate without biopori holes: Uncovered soil with sand textured is 0.07 mm/min and silt textured is 0.025 mm/min. Grass-covered soil with sand textured is 0.09mm/min and silt textured is 0.033mm/min. Weed-covered with sand-textured is 0.10 mm/min and silt textured is 0.0416 mm/min. Infiltration rate using biopori holes for sand-textured soils is 8.0 mm/min and silt-textured is 1 mm/min. Inundation height at annual maximum rainfall plan for 2, 5, and 10 years return period with using 100, 160 and 400 holes per 100.0 $m^2$ is lower from 9.01% to 77.43% compared to not using biopori holes. In addition, the amount of water that infiltrated after using biopori holes is increasing up to 4120 $m^3$ for each month, compared to not using biopori holes.

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