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EDITOR IN CHIEF
Prof. Dr. Ir. Enri Damanhuri

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Green Technology towards Sustainable Environment

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PREFACE

Green Technology that provides the basic needs of society in sustainable environment is essential for the survival, health and well-being of a society in developing countries. The engineers, scientists, policy makers, academics, environmental consultants, environmental contractors, industrial practitioners, businessmen, politicians, NGOs are at the epicenter in seeking means to enhance human life through modernization of technology and infrastructure. The current rate of urbanization, industrialization and environment mismanagement rise environmental issues. The problems are further aggravated with environmental degradation such as soil erosion, depletion of water resources, climate changes, and others. In order to seek answers for these multifaceted challenges, proper planning, implementation and verification exercises are required, via an integrated, multidisciplinary and holistic approach especially in the area of green infrastructure and green cities, development of eco-industry, environmental health and risk assessment, air quality, advanced technology, natural resources and mitigation of climate change. This international conference shall become a momentum for development of sustainable environment through green technology.

The 5th Environmental Technology and Management Conference (ETMC) was held on 23-24th November 2015, at *Sasana Budaya Ganesha, Institut Teknologi Bandung* (ITB). The ITB is located in Bandung, West Java. Bandung is the center of Sundanese culture and volcanoes surrounds city which make Bandung to be a delightful place to host this conference. More than 300 scientific participants (researcher, students, government officers and industries) had many fruitful discussions and exchange ideas that contribute to the success of the conference. Participants of the conference are coming from US, Australia, Nederland, Japan, Malaysia, Singapore and Indonesia, made the conference truly worthwhile globally. There are 4 speakers in plenary sessions covering different areas, and all the keynote speakers are well known and competent speakers; They are Ir. Mochamad Basoeki Hadimoeljono, M.Sc., Ph.D (Ministry of Public Works and Housing, Republic of Indonesia), Prof. Dr. AJM Smits (Director of Institute for Science, Innovation & Society, Radboud University Nijmegen), Albert Simanjuntak (President Director of Chevron Pacific Indonesia) and Ir. Edwan Kardena, PhD (Environmental Engineering, Institut Teknologi Bandung). There were also 5 parallel sessions with eight invited speakers : Prof. Satoshi Okabe; Prof. Ir. Mindriany Syafila, MS; Prof. Ir. Iwan Kridasantausa Hadihardaja, MSc, PhD; Prof. Dr. Takeshi Fujiwara; Rene van Berkel, PhD; Prof. dr. A.M.J. Ragas; Dr. Budi Haryanto, SKM, MKM, MSc; Dr. rer.nat Armi Susandi,MT.

This volume of proceedings from the conference provides an opportunity for readers to engage with a selection of refereed papers that were presented during the conference. These proceedings divided into 6 sections of 110 abstracts as oral presentation and 23 abstracts as poster session with such topics as follows: Air Quality & Climate Change, Green Cities & Infrastructures, Eco-Industries, Appropriate & Advanced Environmental Technology, Natural Resource Management, and Environmental Health and Risk Assessment. Selected papers will be republished in the special issues of Journal of Technological and Engineering Sciences.

Generous support for the conference was provided by Chevron Pacific Indonesia, JICA, BNI, Vale, Sari Husada, Indocement, Holcim, Sabuga and Faculty of Civil and Environmental Engineering, ITB. The funds were sizeable, timely, and greatly appreciated, and allowed us to support a significant number of young scientists (students) and delegates from developing countries.

Finally, the 5th ETMC was a very successful conference. The plenary lectures, parallels session and special reports bridged the gap between the different fields of green technology, making it possible for non-experts in a given area to gain insight into new areas. Also, included among the speakers were several young scientists and students, who brought new perspectives to their fields. Given the rapid advancement of science in all areas that covered by ETMC, we expect that this ETMC was as stimulating as the previous one, as indicated by the papers contributions presented in this proceeding volume.

Bandung, 24 November 2015

Ir Agus Jatnika Effendi, PhD

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THE EFFECTIVITY OF BIOPORE INFILTRATION HOLE APPLICATION IN INCREASING WATER INFILTRATION RATE IN SOIL

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Abstract:*Biopore infiltration hole (BIH) is a technology which can improve the soil quality and structure and increase the infiltration rate of the soil. The raised discussion about this infrastructure is the effectiveness of this BIH if it applied in the different soil type especially in loam soil that known having a small hydraulic conductivity. Therefore, the objective of this study is to determine in which kind of soil this BIH will perform its function more effectively.This study was carried out in three BIH with 10 cm of diameter and a depth about 60 cm at three different kind of soils (clay loam, silty loam, and loam soil). The dimension of LRB that applied was adapted from the BIH that was commonly applicate in Bandung area, and the effectivity of each BIH was examined by determined the amount of water that can be infiltrated to each BIH at the time of test.The result of this study portray that at the beginning of the test was relatively high and decrease following exponential curve to constant point. The amount of water that could be infiltrated into a week old BIH are 16.26 liter for BIH in clay loam soil, 9.965 liter for BIH in silty loam soil, and 24.087 liter for BIH in loam soil. The amount of water that can be infiltrated in each BIH increase along the time goes, except for BIH in loam soil that fall on some capacity deterioration after the fourth week.At the fourth week, the amount of water that could be infiltrated into BIH A increased 84 % to 29.953 l. for BIH B the volume increased reach 569% to 66,57 l while the capacity of BIH C which meet the deterioration is 39.874 l or still increased 65% from the first week. From this data, we can simplify that in this study, the most effective application of BIH is in silty loam soil. From this fact, we can conclude that the effectiveness of BIH that represented by the amount of water that infiltrated is vary according to the soil structure, that's way we have to give another consideration to BIH application especially in its application at the loamy soil.*

Keywords:*Biopore infiltration hole; infiltration*

1. Introduction

The massive development nowadays, sometimes not meet with the effort to maintain the environmental quality. That's make we often encountered with some problem such as soil structure damage that disrupt the process of water infiltration and increase the amount of surface run off. Finally, the amount of these problems will accumulate and become a larger situation like flooding in the rainy season and drought in the dry season.

Several attempts have been made to improve these conditions. For example, soil remediation and green drainage. Water conservation can be done by making some infiltration wells/trench. The infiltration wells or trench was made with the aim to increase the infiltration area and collect the rainwater before it become surface runoff. Another method that can be done is soil remediation. Olson et all (2012), proving that the replacement of the existing soil with some

layer of compost can improve the soil structure as well as increase the rate of water infiltration to the soil.

Raoet all (1977) conducting research on similar structure but with different filler materials. This structure called vertical mulch. In his study, Rao recorded higher moisture content in the soil around the mulch. The favorable effect of mulch extended to 1.5 m on either side of mulch row.

Brata combines the principle of remediation and water conservation then introduce Biopore Infiltration Hole (BIH). Basically, BIH is a small hole that dug in the ground and filled by organic waste. This organic waste will turn out as food for soil organism and become a trigger to stimulate the organism to build biopores around the BIH (Brata,2008) and be able to store the excess rainwater and increase the rate of water infiltration on the ground.

Lately, the use of BIH received many positive responses from the public. Even, nowadays making a BIH become a trend and by some local government, usually associated with green infrastructure. But in the field, the implementation of BIH seems just following the trend and didn't give some considering to the local condition especially to the soil condition, is it suitable for BIH implementation or not. Therefore, this study was conducted to examining the infiltration rate increasing through BIH implementation in different type of soil. And then it can be conclude whether this BIH effective to applied in all type of soil or only in some specific soil type.

2. Materials and Methods

Infiltration is the process of water entering the soil through the ground surface. This process separate rain water into two fractions that is surface run off and groundwater flow. The amount of water that infiltrated to the soil are influenced by various factors such as soil physical condition, ground condition also influenced to by rain intensity and duration. The amount of water that infiltrated to the soil can be represented using infiltration rate that is the height of water that can be infiltrated to the soil in a unit time.

To investigate the water infiltration rate in each kind of soil, this study was conducted by making 3 separated pit holes with ±50 cm depth in different type of soil (clay loam, silty loam and loam). Each pit filled with 500 gr leaf litter. To strengthening the BIH, the surface of the BIH was reinforce by 4" PVC pipe to 15 cm depth. As the controls, we measured the initial infiltration rate of the soil before we make the Biopore Infiltration Hole at it.

Infiltration rate measurements performed with a single ring infiltrometer by install a transparent measuring tube around the BIH. The height of the tube is 20 cm and then filled with water until 10 or 11 cm above the ground. The infiltration rate measured by calculated the decline of the water level in tube with Equation 1 (Triadmodjo, 2008). The scheme of the Biopore infiltration hole can be seen in **Error! Reference source not found.**.

$$f_t = \frac{\Delta h}{t} \qquad \textbf{(Eq.1)}$$

With f_t = infiltration rate
Δh = water surface declining
t = time for water to decline

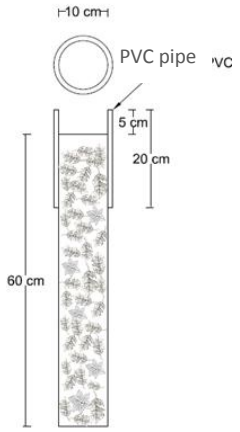

Figure 1.Biopore Infiltration Hole Scheme

The infiltration rate test was conducted for 5 weeks because from some previous study (Sibarani, 2009 and Juliandari, 2011) it's known that the infiltration rate increasing would began at the third and the fourth week. The infiltration capacity then calculated by estimating the area below the infiltration curve. The area was estimated by integrating Horton equation so the area below the infiltration curve can be estimated by Equation 3 (Triadmojo, 2008).

$$F(t) = \int_0^t f_c + (f_0 - f_c)e^{-kt}$$

$$F(t) = f_c t + \frac{1}{k}(f_0 - f_c)(1 - e^{-kt}) \qquad \textbf{(Eq.2)}$$

With f_t = Infiltration rate at t
f_0 = Initial infiltration rate or maximum infiltration rate
f_c = minimum infiltration rate or saturated infiltration rate
k = a constant that indicate the rate of infiltration capacity reduction

To calculate the volume of water that infiltrated to the soil during the test we use the **Equation 4**

$$V_{total} = V_1 + V_2 \qquad \textbf{(Eq.3)}$$

$$V_1 = F_{total} \times L_{LRB}$$

$$V_2 = Q_{in} \times t_{fill}$$

With F = BIH capacity
L_{LRB} = BIH surface area
Q_{in} = water discharge
T_{fill} = time to filled the BIH until the water level reach the measurement level.

The differences in infiltration volume at the first ten minute after first pouring then used to compare the effectiveness of each LRB that being tested.

3. Results and Discussion

3.1 Infiltration Test

The infiltration test was conducted in a field scale at three different location at TeknikLingkungan ITB Building courtyard by adjusting the dimension of the BIH with the field condition that can be seen in Before the BIH implemented, the infiltration rate of water in the soil was measured by single ring infiltrometer. From the test, the initial infiltration rate

in the soil was 0.0015 cm/s for silty loam, 0.0036 cm/s for clay loam, and 0.0040 cm/s for loam soil, as can be seen in **Error! Reference source not found.**.From all three kinds of soil tested, clay loam soil has a grain size that smallest than the other. Silty loam soil has the bigger and loam soil has biggest grain size than the other. Because of differences in the grain size of the soil infiltration rate of the soil clay loam will be lower than the other three types of soil while in loamy soil infiltration rate will be the highest than the other.

Table 1.Testing condition of each BIH. At this paper we will call the BIH in first location as BIH A, the BIH in second location as BIH B, and the BIH in the third location as BIH C.

Before the BIH implemented, the infiltration rate of water in the soil was measured by single ring infiltrometer. From the test, the initial infiltration rate in the soil was 0.0015 cm/s for silty loam, 0.0036 cm/s for clay loam, and 0.0040 cm/s for loam soil, as can be seen in **Error! Reference source not found.**.From all three kinds of soil tested, clay loam soil has a grain size that smallest than the other. Silty loam soil has the bigger and loam soil has biggest grain size than the other. Because of differences in the grain size of the soil infiltration rate of the soil clay loam will be lower than the other three types of soil while in loamy soil infiltration rate will be the highest than the other.

Table 1.Testing condition of each BIH

Spesification	BIH A	BIH B	BIH C
Diameter	10 cm	10 cm	10 cm
Depth	50 cm	55 cm	59 cm
PVC reinforcement length	15 cm	14 cm	15 cm
Filler	500 gr leaf litter	500 gr leaf litter	500 gr leaf litter
Field condition	There is a rock below the BIH	There are tree root that become a barrier under the BIH	The base part of the BIH free from any barrier.
Soil type	Clay loam	Silty loam	Loam

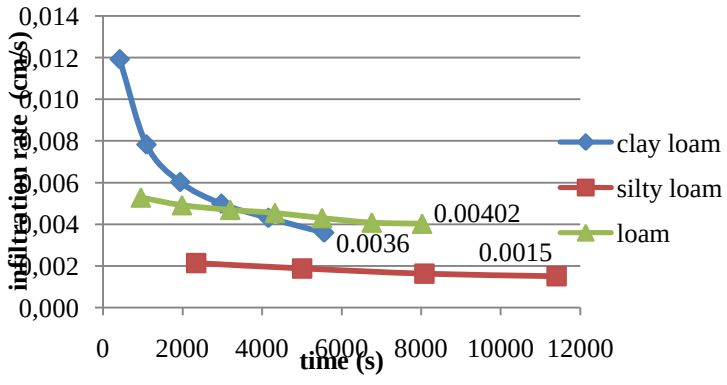

Figure 2. Infiltration Rate in The Ground Without BIH

The results that obtained in this study have some different with the concept, we can see at the **Error! Reference source not found.** that infiltration rate in silty loam soil lower than water infiltration rate in clay loam soil. But according to Abidin et all research in Maria and Lestiana (2014), water infiltration rate in JalanSurapatiwich has clay loam soil type is 0.00367 identic with the result of this study. So the part that must be considered is the value of infiltration in the silty loam soil. The small value of saturated infiltration rate yang rendah may be because there is a thin layer of clay in the soil surface that affect the process of water

infiltration into the soil.

Table 2. Comparison of Saturated Infiltration Rate in Some Test

Location	Soil Type	F_{sat}(cm/s)	Source
TL ITB courtyard (A)	Clay loam	0,0036	
TL ITB courtyard (B)	Silty loam	0,0015	
TL ITB courtyard (C.)	loam	0,0040	
Cisitu lama	Clay loam	0,0082	Maria danLestiana (2014)
Surapati	Clay loam	0,0036	
Cigadung	clay	0,001	Hutasoit (1998)

Infiltration rate changes of each BIH can be seen in **Error! Reference source not found.**. In each diagram we can see that in each test, by the time going, the infiltration rate will decrease along an exponential curve. This rate will decrease until its reach a constant number that called saturated infiltration rate. In the tests that were conducted, it only needs 1-4 minutes to make the BIH full (it's according to the discharge) and 10 until 20 minutes to reaches the saturated infiltration rate. From this fact, we can conclude that the time that needs to reach the saturated infiltration rate is too short if it compare with the duration of the rain, so we can conclude that BIH only suitable in a short duration of rainfall because in long duration of the rain that BIH will become saturated, and the BIH can't perform its functions effectively. The other things that can be seen in **Error! Reference source not found.** are there are increasing in infiltration rate, in connection with the age of the Biopore Infiltration Hole. As example at the first week, the infiltrated water volume of BIH A only about 16.262 liter. But in the fifth week the infiltrated capacity increased 84.45% to 29.995 liters.

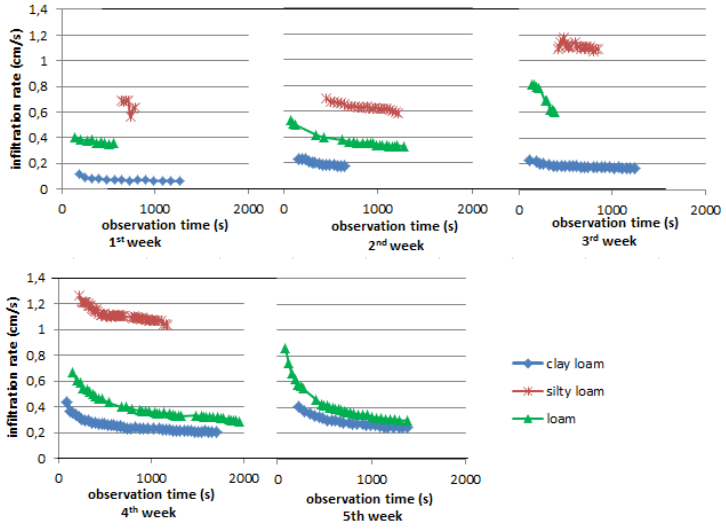

Figure 4 Infiltration Rates at LRB's

Table 2.Comparison of infiltrated water volume changes before and after BIH application.

	LRB A (*clay loam*)	LRB B (*silty loam*)	LRB C (*loam*)
Without BIH	0,788 liter	0,126 liter	0,372 liter
1 week old BIH	16,26 liter	9,96 liter	24,087 liter
4 week old BIH	29,95 liter	53,91 liter	39,87 liter

The infiltration capacity that recorded every week not always increased as the previous pattern. The volume that can be infiltrated at the fifth week in BIH C is 39.196 liters lower than the previous week which reaches 39.874 liters. However, the infiltration capacity in this BIH increased 62.27% at the fifth week.

The most significant increases occur in BIH B or in silty loam soil. In this soil, the infiltration rate after BIH application increase 500 times from before application of BIH. These increases can be occurred because of the presence of some additional spaces in soil (such as the BIH itself and the biopore which form by the soil organism) that will increase the volume of the stored water.

3.2 The Effect of Decomposition to Infiltration Capacity

Naturally, organic waste inside the BIH will decomposed, the decomposition identified by the reducing of waste volume in BIH (Hartono,2012dan Brata,2008). Decreasing volume of waste in BIH caused by the activity of soil organism that decompose the organic matter in waste. In this study, it is known there is a relationship between changes in infiltration rate to changes in the volume of waste contained in biopore infiltration hole as can be seen **Error! Reference source not found.**.From the chart, it can be seen that the slowest decomposition rate occur in clay loam soil (BIH A). Consistent with its infiltration capacity increasing that comparatively low if it compared with the other soil type which just 1.23%. On the contrary, the decomposition rate of the organic waste in LRB B (silty soil), have the highest rate. At the same time, the infiltration capacity of the BIH B increased rapidly until it reached 452% if it compared with the infiltration capacity at the first week.

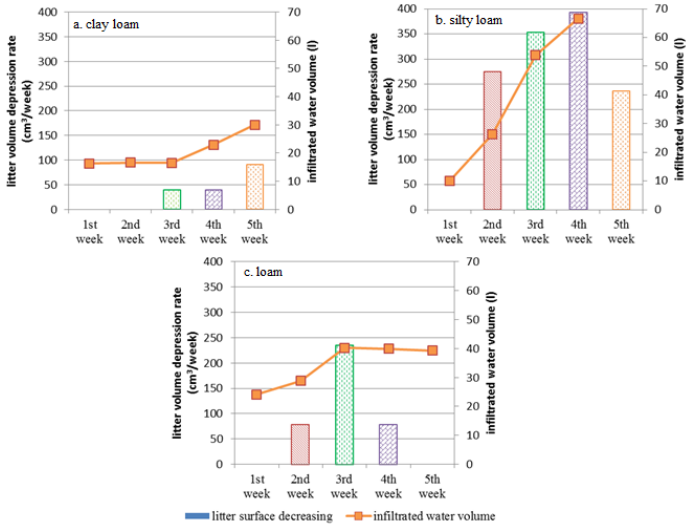

Figure 5 The Comparison Between The Volume of Infiltrated Water and Waste Volume Depreciation at BIH

Brata (2008), wrote that the infiltration rate increasing or the increase of amount of water that can be infiltrated in to the BIH caused by the forming of biopore formation due to soil organism activity around the BIH. The test result showed that there are differences in water infiltration volume in each biopore infiltration hole. In the first week, which soil organism activity not expected increase to much at the time. The infiltration capacity differences on each BIH could be caused by the differences in soil type and the differences of absorption are in each BIH that caused by the dimensions difference or by blocking material like rock or root.

In the following weeks, the volume of infiltrated water began to increase (Error! Reference source not found.). This volume increases caused by the increasing of soil organism activity around the BIH that form a biopori network that will facilitate the water to flow into the soil around the LRB.

4. Conclusions

The effectivity of BIH on increasing the infiltration capacity influenced by the type of the soil, physical condition of the BIH and the activity of the soil organism around the biopore infiltration hole. In generals, the type of soil determines the amount of water that can be infiltrated at the initial conditions. While the physical condition of the BIH and activity of the soil organisms determine the change of the water infiltration capacity. The BIH categorized being effective if there are significant capacity change between before the application, and after BIH application. In this study, silty loam soil suitable to BIH application because application of BIH in this type of soil tend to be effective that prove by the increasing of the infiltration volume that reach 528 times from before BIH application.

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