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Analysis of Microbial Activity on Electrolite Conductivity & Infiltration Rate in Recovery Aluvial Soil Using Biosoildam Technology for Paddy Field

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Abstract

This research was conducted on alluvial soils, especially for paddy fields, aimed at restoring soil health and fertility due to the use of chemical fertilizers and pesticides. Through the rate of microbial activity which is controlled by the biohole, periodic investigations of changes in soil acidity, infiltration and electrolyte conductivity levels around the center of the biohole are the centers of microbial distribution.
As a comparison, observations were made using biohole which was only filled with water without microbes. Furthermore, these two conditions, namely biohole with microbes and biohole without microbes, were compared to changes in soil parameters: soil acidity, infirtration rate and electrolyte conductivity levels.
The research was carried out on January to March 2018 at area of Paddy Field in Nganjuk Districts. The research was use double ring infiltrometer to measure soil infiltration with three replication on each distance from Biohole and use electrolit conductivity meter (EC) to measure soil fertility by salt ion consentration and soil acidity. The measurement was done in every five minute and observtian periode every fifteen days along forty five days. The result of research show that the highest of infiltration rate, infiltration capacity , fertility & acidity was happened on soil with involve Biofertilizer MA-11, ie 28-55 cm/hour, 223 – 859 uS/cm, PH = 6- 6,5. While the lowest of infiltration rate, infiltration capacity , fertility & acidity was happened on soil without involve Alfaafa Microba MA-11, ie 27- 39 cm/hour, 223 – 344 uS/cm , PH 5 – 6

Keywords: *alluvial, biohole, infiltration, biosoildam, land use, Alfaafa Microba, fertility, acidity.*

1. INTRODUCTION

The current decline in carrying land capacity continues to expand. One of the main contributing factors is the decrease in the soil fertility, health and absorption (infiltration rate), triggered by excessive use of inorganic fertilizers (pesticides) **(Nugroho Widiasmadi, 2019)**. To restore the land's capacity quickly and measurably and to restore soil productivity as well, infiltration is not enough. Biological agents are needed to support soil and water conservation. However, so far, there has not been any periodical and continuous/real-time measurement of the monitoring & assessment system of agricultural cultivation. Thus, accurate information on a soil parameter in achieving a harvest target is needed.

Infiltration is the process of water flowing into the soil which generally comes from rainfall, while the infiltration rate is the amount of water that enters the soil per unit time. This process is a very important part of the hydrological cycle which can affect the amount of water that is on the surface of the soil. Water on the surface soil will enter the soil and then flow into the river **(Sunjoto, S., 2011)**. Not all surface water flows into the soil, but some portion of the water remains in topsoil to be further evaporated back into the atmosphere through the soil surface or soil evaporation **(Suripin, 20013)**.

Infiltration capacity is the ability of the soil to absorb large amounts of water into the ground and influenced by the microorganism activities in the soil **(Nugroho Widiasmadi, 2020).** The large infiltration capacity can reduce surface runoff. The reduced soil pores, generally caused by soil compacting, can cause a decreased infiltration. This condition is also affected by the soil contamination **(Nugroho Widiasmadi, 2020)** due to excessive use of chemical fertilizers and pesticides which hardens the soil as well.

Biosoildam is a Biodam technology that involves microbial activity in increasing the measured and controlled inflation rate. Biological activities through the role of microbes as agents of biomass decomposition and soil conservation become important information for soil conservation efforts in supporting healthy food security.

Increased soil friability by involving microbial activities (*Bioinfiltrosoil*) can be used as the development of the science of Civil Hidro Engineering as Eco-Civil Engineering. So that engineering is able to provide value to the carrying capacity of land productivity through soil and water conservation **(Nugroho Widiasmadi, 2019)**

2. METHODOLOGY

The study was conducted on alluvial land which for decades has been the source of livelihood for the community of Mojorembun Village, Rejoso District, Nganjuk Regency. Land management lacks soil and water conservation. People use chemical fertilizers & pesticides excessively which harden the soil texture, acidify the soil and decrease the yields. Hardened agricultural land also triggers floods, since the soil's ability to absorb decreases. This research that took place from January to March 2018, intends to restore the carrying capacity of the land.

Tools and materials used in research are : Biohole as Biosoildam Injector, microbial decomposer Alfafaa MA-11, red onion straw as microbial nest, Abney level, measuring tape, Double Ring Infiltrometer, stirring rod, Erlemeyer, ruler, Stop watch / watch, bucket plastic, tally sheet, measuring cup , scales, hydrometers and water **(Douglas, MG 2018)**.

2.1. Determining plot and sensor points

To determine plots and sensors, this study uses purposive sampling at various distances: 0.5; 1,0; 1,5 meter from the centre of Biohole with a diameter of 1 meter as the central radial distribution of the biological agent Microbe Alfaafa MA-11 through the water injection process. Infiltration rate and radial biological agent distribution can be controlled measurement sensors with parameters: EC/salt ion (macronutrients), pH, the infiltration rate with a Double Ring Infiltrometer on the variable distance from the centre of the Biohole are manually measured. Next, soil samples are also taken to analyze their characteristics, such as soil texture, organic material content and bulk density **(Douglas, M.G.2018)**.

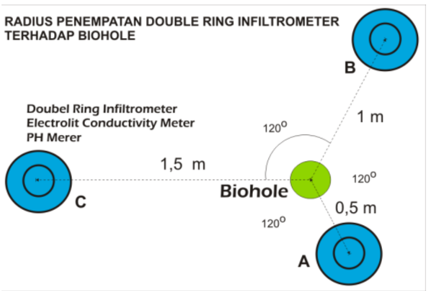

Figure 2. Double Ring Infiltrometer setting

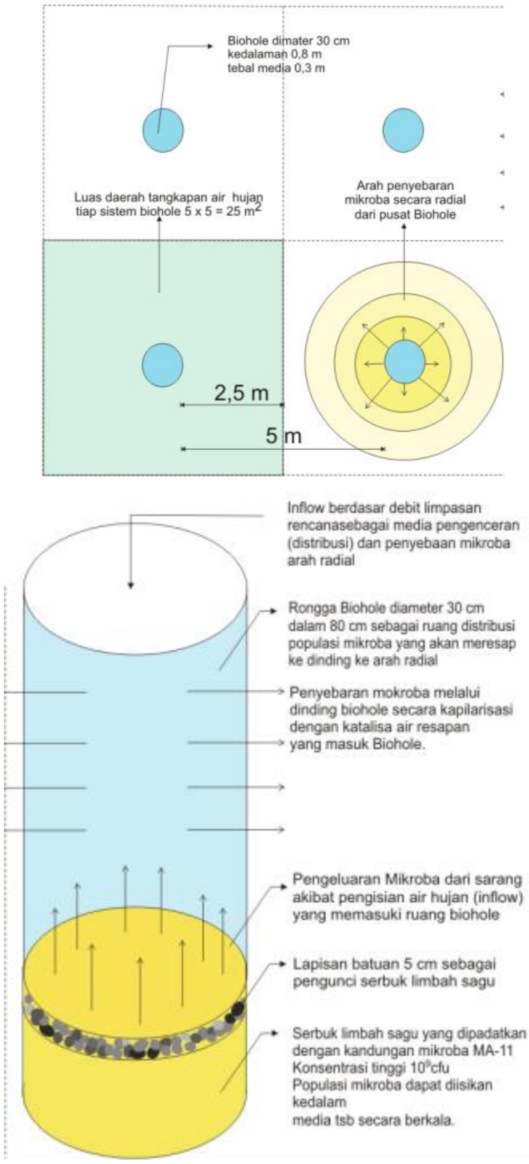

Figure 3. Distribution biohole & Biohole Structure

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Figure 3A. Biohole Process

Figure 3A. Instalation of Doubel Ring Infitrometer

2.2. Data Processing

2.2.1. Catalytic Discharge

Biosoildam innovation uses runoff discharge as a media for biological agents distribution through the inlet/inflow (Biohole) as a centre for the microbial populations distribution with water. The runoff discharge calculation as a basis for the Inflow Biosoildam formula requires the following stages:

1. conducting a rainfall analysis,
2. calculating the catchment area, and
3. analyzing the soil/rock layers.

Biosoildam structure can be made with holes in the soil layer without or using water pipes/reinforced concrete pipes (RCP) with perforated layer that will let microbes to spread radially. We can calculate the discharge entering Biohole as a function of the catchment characteristic with a rational formula:

$$Q = 0{,}278 \; CIA \quad (1)$$

where C is the runoff coefficient value, I is the precipitation and A is the area **(Sunjoto, S. 2018)**. Based on this formula, the Table presents the results of runoff discharge.

2.2.2. Infiltration

The spread of microbes as a biomass decomposing agent can be controlled through the calculation of the infiltration rate at several point radii from Biohole as the centre of the spread of microbes. by using the Horton method . Horton observed that infiltration starts from a standard value fo and exponentially decreases to a constant condition fc. One of the earliest infiltration equations developed by Horton is:

$$f(t) = f_c + (f_o - f_c)e^{-kt} \quad (2)$$

where :

k is a constant reduction to the dimension [T - 1] or a constant decreasing infiltration rate.

fo is an infiltration rate capacity at the beginning of the measurement.

fc is a constant infiltration capacity that depends on the soil type.

The fo and fc parameters are obtained from the field measurement using a double-ring infiltrometer. The fo and fc parameters are the functions of soil type and cover. Sandy or gravel soils have high values, while bare clay soils have

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little value, and for grassy land surfaces, the value increases **(Sutanto. 2012)**.

The infiltration calculation data from the measurement results in the first 15 minutes, the second 15 minutes, the third 15 minutes and the fourth 15 minutes at each distance from the centre of Biohole are converted in units of cm/hour with the following formula:

Infiltration rate = (ΔH/t x 60) (3)

where:

ΔH = height decrease (cm) within a certain time interval,

T = the time interval required by water in ΔH to enter the ground (minutes) **(Huang, Z, and L Shan.2011).** This observation takes place every 3 days for one month.

2.2.3. Microbial Population

This analysis uses MA-11 biological agents that have been tested by the Microbiology Laboratorium of Gadjah Mada University based on Ministerial Regulation standards: No 70/Permentan/SR.140/10 2011, includes:

Table 2.1: Microbes Analysis

No	Population Analysis	Result	No	Population Analysis	Result
1	Total of Micobes	18,48 x 10^8cfu	8	Ure-Amonium-Nitrat Decomposer	Positive
2	Selulotik Micobes	1,39 x 10^8cfu	9	Patogenity for plants	Negative
3	Proteolitik Micobes	1,32 x 10^8cfu	10	Contaminant E-Coly & Salmonella	Negative
4	Amilolitik Micobes	7,72 x 10^8cfu	11	Hg	2,71 ppb
5	N Fixtation Micobes	2,2 x 10^8cfu	12	Cd	<0,01 mg/l
6	Phosfat Micobes	1,44 x 10^8cfu	13	Pb	<0,01 mg/l
7	Acidity	3,89	14	As	<0,01 ppm

(resource : Nugroho Widiasmadi, 2019)

Its application in Biosoildam is concentrating the microbes into "population media", as a source of soil conditioner for increasing infiltration rates and restoring natural fertility **(Nugroho Widiasmadi, 2020)**.

2.2.4. Soil Fertilizer & Soil Acidity

Microbial activity as a contributor to soil nutrition from the biomass decomposition results can be controlled through the salinity level of the nutrient solution expressed through conductivity as well as other parameters as analogue inputs. Conductivity can be measured using EC, Electroconductivity or Electrical (or Electro) Conductivity (EC) is the nutrients density in solution. The more concentrated the solution is, the greater the delivery of electric current from the cation (+) and anion (-) to the anode and cathode of the EC meter. Thus, it results in the higher EC. The measurement unit of EC is mS/cm (millisiemens) (**John M Lafle, PhD, Junilang Tian, Professor ChiHua Huang, PhD,2011)**.

Indications of microbial activity on fertility can be controlled through acidity. The number of nutrients contained in the soil is an indicator of the level of soil fertility due to the activity of biological agents in decomposing biomass. Important factors that influence the absorption of nutrients (EC) by plant roots are the degrees of soil acidity (soil pH), temperature (T) and humidity (M). Soil Acidity level (pH) greatly influences the plant's growth rate and development **(Nugroho Widiasmadi, 2020)**.

3. RESULTS AND DISCUSSION

3.1. Design Rainfall and Frequency Duration Intensity (FDI)

The design rainfall intensity was determined using rainfall data from Nganjuk Station in 2010-2017. Statistical analysis was performed to determine the distribution type used, which in this study was the Log Person III's. Distribution checking on whether rain opportunities can be accepted or not is calculated using the Chi Square test and the Kolmogorov Smirnov test. Next, the design rainfall intensity is calculated using the mononobe formula.

3.2. Design Discharge

The design discharge as a MA-11 microbial catalyst uses the rainfall intensity for 1 hour since it is estimated that the most predominant rainfall duration in the area studied is 1 hour. The runoff coefficient for various surface flow coefficients is 0.70 - 0.95 **(Suripin 2013)**, while in this study we use the smallest flow coefficient value, which is 0.70.

The design discharge has various catchment areas, between 9 m2 to 110 m2 with a proportional relationship. The larger the plot, the greater the plan discharge generated as a biohole inflow. The depth of Biohole in the study area in the 25-year return period ranges from 0.80 m to 1.50 m. The absorption volume will determine the maximum capacity of water contained in Biohole. The greater the volume of Biohole is, the greater the water container is.

3.3. Biohole Design

Biohole walls use natural walls with a 0,3-diameter and a 0.8-depth or the storage area of 36 m2. Organic material (solid pressed paddy straw waste) is used as a place for microbial populations/microbial sources. The top is coated with a 5 cm thick rock which acts as an energy-breaking medium. Thus, when filled with organic material water, it remains stable to maintain the radial spread of microbes.

The Biohole volume capacity for that dimension is 0.0565 m3, with a catchment of 36 m2 and the 25 year-discharge = 0.0000841 m3/sec and will be fully filled in about 10 to 15 minutes. This figure considers natural resources in the form of rainfall intensity of the study area which adjusted to the spread of microbes. Therefore, the water-emptying phase and the microbial population formulation phase can take place optimally.

3.4. Soil Coating Effect on Biohole

Geomorphology of agricultural land and its surroundings is in the form of alluvial plains. Alluvial soil in this area is a soil type that resulted from the silt deposition usually carried by rivers. This soil is most often found in the downstream or low areas. The soil colour ranges from brown to grey. This land is fertile and suitable for agriculture, either for rice, crops, or tobacco. This soil is soft and easy to work on. This soil type is widely distributed in the Nganjuk plains area.

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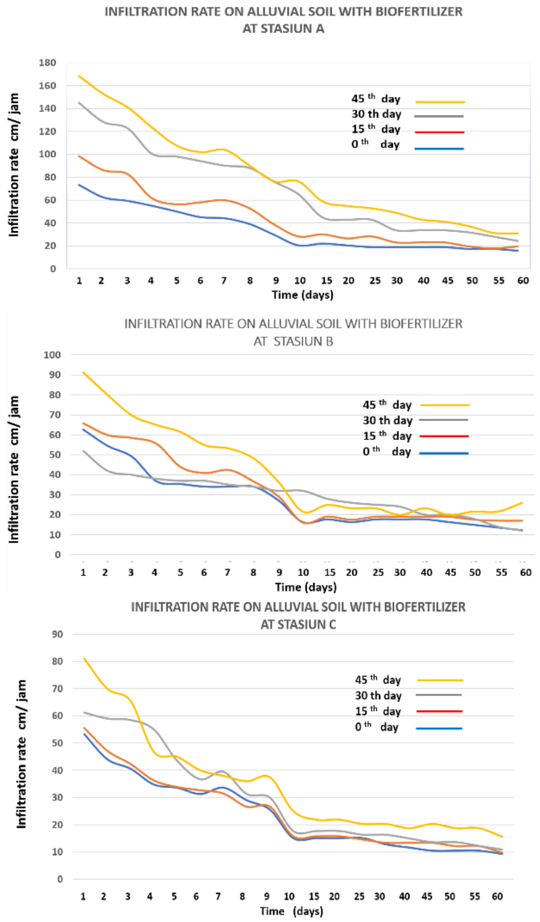

Figure 4. Graph Infiltration rate with Biofertilizer

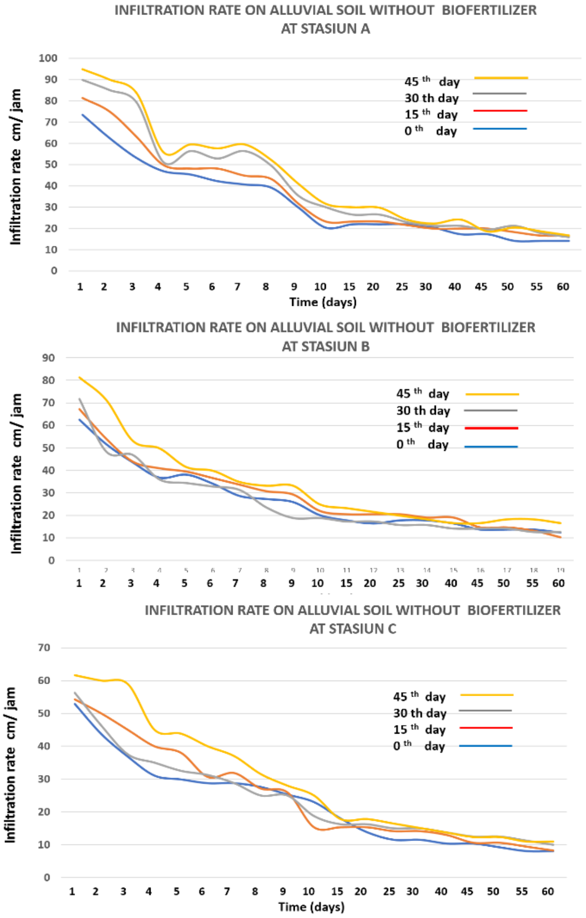

Figure 5. Graph Infiltration rate with Biofertilizer

Technically at the beginning of the spread the infiltration rate is still relatively small because it only relies on capillary power, but in the following period the microbial activity that has spread can increase the cavity (poruosity), so that the infiltration rate in this advanced period is also greater in Alluvial soils. In addition, the ability of microbes to break down (decomposing) organic material biomass is able to increase nutrient content in the soil and neutralize soil acidity, along with the increasing infiltration rate.

The above-mentioned soil parameters can be controlled towards the infiltration rate, where the infiltration rate graph shows a constant value at the level of 20 to 40 cm/h reached after 30 days with the value ranging from 600 to 700 uS/cm. The biological agent activities in alluvial soils with infiltration levels will be optimal on the 30th day.

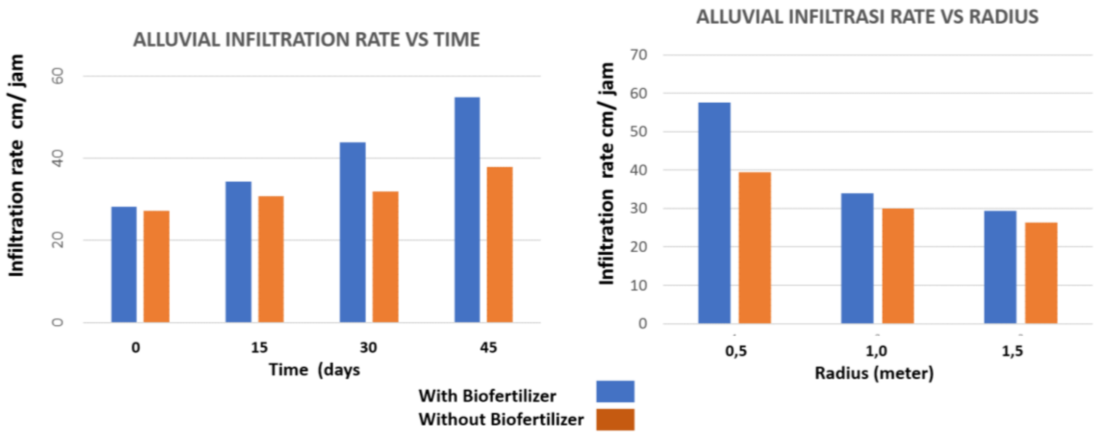

Figure 6 - Infilration Rate vs Time

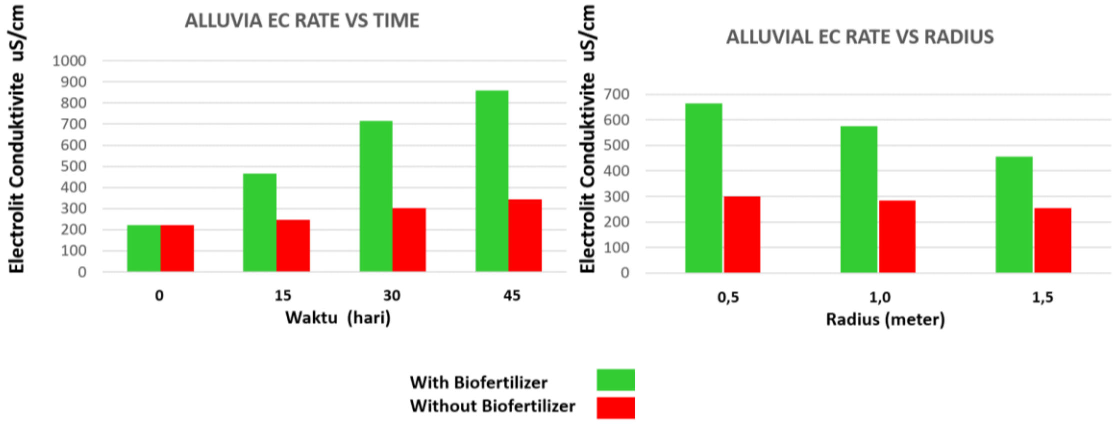

Figure 7 - EC Rate vs Time & EC Rate vs Radius

The above-mentioned soil parameters can be controlled towards the infiltration rate, where the infiltration rate graph shows a constant value at the level of 20 to 40 cm/h reached after 30 days with the value ranging from 600 to 700 uS/cm. The biological agent activities in alluvial soils with infiltration levels will be optimal on the 30th day.

4.CONCLUSION

a. Microbial distribution in this case that is the alluvial soil layer is quite effective at a maximum radius of 2 meters with a distance between Bioholes of 5 meters and even the spread of the microbes can be even further.

b. The use of microbes in the infiltration well system or the biosoildam method as a biological agent is very effective, especially to increase the productivity of barren land into fertile land in a measurable manner, so that it does not merely include water.

c. Biosoildam method still needs to be tested for various lands with various rock soil formations so that the relationship between the soil permeability level and the concentration value of microbial population involved for a fertility target of an area to be a productive land is acquired.

d. Biosoildam can be called "Active Infiltration System" since it involves microbial activities that can be useful for:
   i. Expanding soil porosity that increases oxygen content as a source of soil health.
   ii. Increasing macro and micro soil nutrient content of the biomass elements that the

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microbes break down in the distribution zones from the biohole centre.

iii. Repairing saturated soils that have long been contaminated with chemical fertilizers and pesticides by the microbial degradation.

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