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SOIL IMPROVEMENT WITH AGROCONSERVATION SYSTEM USING BIOSOILDAM TECHNOLOGY

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Abstract

This analysis aims to improve the soil infiltration rate on Humus agroland by involving biofertilizer MA-11 on the Biosoildam. As control is, original soil without microbial activity triggered. The research was carried out from October to December 2022 at the shallot agroland in Ngawi Districts. The research used a double-ring infiltrometer to measure soil infiltration with three replications at each distance from Biohole. It used an electrolyte conductivity meter (EC) to measure soil fertility by salt ion concentration and soil acidity. The measurement was done every five minutes, and the observation period was every fifteen days to forty-five days. The research results show that the highest infiltration rate, infiltration capacity, fertility & acidity happened on soil with involvement in Biofertilizer MA-11. The infiltration rate shows a constant value of 80 to 120 cm/hour, achieved after the 30th day. Meanwhile, the EC value in stable conditions is achieved on the 30th day, between 950 and 1200 uS / cm, so that the activity of biological agents on humus soil with infiltration levels will be optimal on the 30th day.

Keywords: infiltration, biosoildam, land use, humus,Alfaafa Microba, fertility, acidity

INTRODUCTION

The current decline in carrying land capacity continues to expand (environmental degradation). One of the main contributing factors is the decrease in soil fertility, health, and absorption (infiltration rate), triggered by excessive use of inorganic fertilizers (pesticides) (Nugroho Widiasmadi, 2019). More than infiltration is needed to restore the land's capacity quickly and measurably and to restore soil productivity. Biological agents (biofertilizer) are needed to support soil and water conservation. However, there has yet to be 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 of time. This process is a significant part of the hydrological cycle, affecting the water on the soil's surface. 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. However, some water remains in the topsoil to be further evaporated back into the atmosphere through the soil surface or evaporation (Suripin, 2003).

Infiltration capacity is the ability of the soil to absorb large amounts of water into the ground and is influenced by the microorganism activities in the soil (Nugroho Widiasmadi, 2019). 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 soil contamination (Nugroho Widiasmadi, 2020) due to the excessive use of chemical fertilizers

The Seybold Report
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and pesticides, which also hardens the soil. Smart-Biosoildam is a Biodam technology development involving microbial activity to increase the measured and controlled inflation rate. Biological activities through the role of microbes as agents of biomass decomposition and soil conservation become essential information for soil conservation efforts in supporting healthy food security (Nugroho Widiasmadi Dr. 2020). Such development has used a microcontroller to effectively monitor the activities of the said agents through the electrolyte conductivity parameter as an analogue input of EC sensors embedded in the soil and further converted to digital information by the microcontroller (Nugroho Widiasmadi, 2021a).

To control the activities of biological agents, other variables are needed, such as information on pH, humidity (M) and soil temperature (T) obtained from pH sensors, T sensors, and M sensors. These sensors are connected to a microcontroller which can be accessed through a pin that functions as a GPIO (General Port Input Output) in the ESP8266 Module to provide the additional capability of a WIFI-enabled microcontroller to send all analogue responses to digital in real-time, every second, minute, hour, day and monthly. Furthermore, we can display this data in infographics and numeric tables to be stored and processed in the WEB (Sigit Wasisto, 2018).

METHODOLOGY

The study was conducted on humus land, which has been the livelihood source for the community of Legundi Village Karangjati District Ngawi Regency for decades. Land management needs 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 absorption ability decreases. This research, which took place from January – July 2021, intends to restore the land's carrying capacity.

Tools and materials used in research are Microcontroler Arduino UNO, Wifi ESP8266, Soil parameter sensor: Temperature (T) DS18B20, humidity (M) V1.2, Electrolit Conductivity (EC) G14 PE, Acidity pH) Tipe SEN0161-V2, LCD module HD44780 controller, Biohole as Injector fotr Biosoildam, Biofertilizer Mikrobia Alfafaa MA-11, red union straw as microbia nest, Abney level, Double Ring Infiltrometer, Erlenmeyer, rules, Stopwatch, plastic bucket, tally sheet, measurement glass, micro scale, hydrometer dan water (Douglas, M.G. 1988).

Determining plot and sensor points

To determine plots and sensors, this study uses purposive sampling at various distances: 1.5; 2; 3 metre from the center 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 (Nugroho Widiasmadi, 2020). Infiltration rate and radial biological agent distribution can be controlled in real-time through measurement sensors with parameters: EC/salt ion (macronutrients), pH, humidity and soil temperature. And as a periodical control, the infiltration rate with a Double Ring Infiltrometer on the variable distance from the center 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.1994).

ISSN 1533-9211
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Figure 1: Double Ring Infiltrometer & Sensors

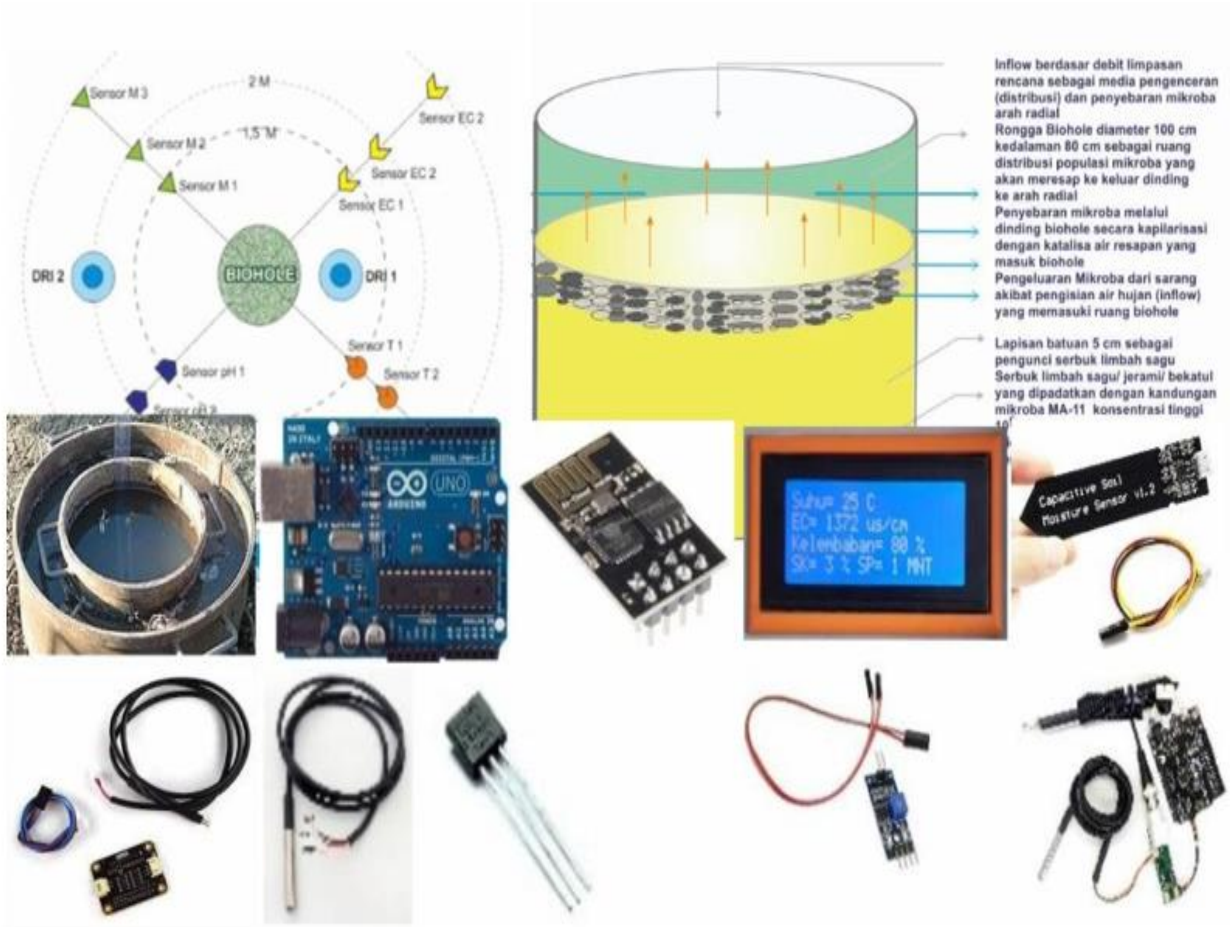

Figure 2: Distribution Sensor Position & Biohole Structure

DATA PROCESSING

Catalytic Discharge

Smartbiosoildam innovation uses runoff discharge as a media for biological agents' distribution through the inlet/inflow (Biohole) as a centre for the microbial population's distribution with water (Nugroho Widiasmadi Dr. 2021b). 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

The Seybold REPORT
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radially (Nugroho Widiasmadi, 2020). We can calculate the discharge entering Biohole as a function of the catchment characteristic with a rational formula:

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

Where C is the runoff coefficient value, I is the precipitation and A is the area (Sunjoto, S. 1988). Based on this formula, the Table presents the results of runoff discharge.

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 (1933, 1939). 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:

$$f(t) = fc + (fo - fc)\ e^{-kt} \qquad (2)$$

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 little value, and for grassy land surfaces, the value increases (Sutanto. 1992).

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:

$$\text{Infiltration rate} = (\Delta H/t \times 60) \qquad (3)$$

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.1997). This observation takes place every 3 days for one month.

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:

The Seybold Report
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Table 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

(Nugroho Widiasmadi, 2019)

ts 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).

Microcontroller against Nutrient Content, Acidity, Temperature & Soil Moisture

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 (Nugroho Widiasmadi Dr. 2022a). 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 (Boardman, C. R. and Skrove, J.W., 1966).

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, Electro conductivity 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, 2000).

This study uses an Arduino Uno microcontroller which has 14 digital pins, of which there are 6 pins used as Pulse Width Modulation or PWM outputs, namely the pins D.3, D.5, D.6, D.9, D.10, D.11, and 6 analogue input pins for these soil parameter elements, namely EC, T, pH, M. Analog input on Arduino Uno uses C language and for programming uses a compatible software for all types of Arduino (Samuel Greengard 2017). Arduino Uno microcontroller can facilitate communication between Arduino Uno with computers including smartphones. This microcontroller provides USART (Universal Synchronous and Asynchronous Serial Receiver and Transmitter) facilities located at the D.0 (Rx) pin and theD.1 (Tx) pin (Nugroho Widiasmadi Dr. 2022b).

This research uses the ESP8266 data transmission system with the firmware and the AT Command set that can be programmed with Arduino. The ESP8266 module is an on- chip

The Seybold Report
ISSN 1533-9211
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system that can be connected to a WIFI network. Besides, several pins function as GPIO (General Port Input Output) to access these ground parameter sensors that are connected to Arduino, so that the system can connect to Wifi (Klaus Schwab, 2018). Thus, we can process analogue inputs of various soil parameters into digital information and process them via the web.

RESULTS AND DISCUSSION

Rainfall Design and Frequency Duration Intensity (FDI)

The rainfall design intensity was determined using rainfall data from Ngawi in 2009-2018 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.

Discharge Plan

The discharge plan 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 2003), while in this study we use the smallest flow coefficient value, which is 0.70.

The discharge plan 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.

Biohole Design

Biohole walls use natural walls with a 1.0-diameter and a 0.8-depth or the storage area of 36 m2. Organic material (solid pressed red onion 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 (Nugroho Widiasmadi, 2019).

The Biohole volume capacity for that dimension is 0.157 m3, with a catchment of 36 m2 and the 25 year-discharge

= 0.0000841 m3/sec and will be fully filled in about 15 to 20 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.

The Seybold REPORT

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Soil Coating Effect on Biohole

Geomorphology of agricultural land and its surroundings is humus plains. Humus is a very fertile soil formed from weathered leaves and tree trunks in dense tropical rain forests. Humus is known as the remains of plants and animals that have been overhauled by organisms in the soil, is in a stable state, blackish brown in color. Chemically, humus is defined as a macromolecular organic complex that contains many substances such as phenols, carboxylic acids, and aliphatic hydroxides. This soil is widely distributed around the Java forest area of the Ngawi plain.

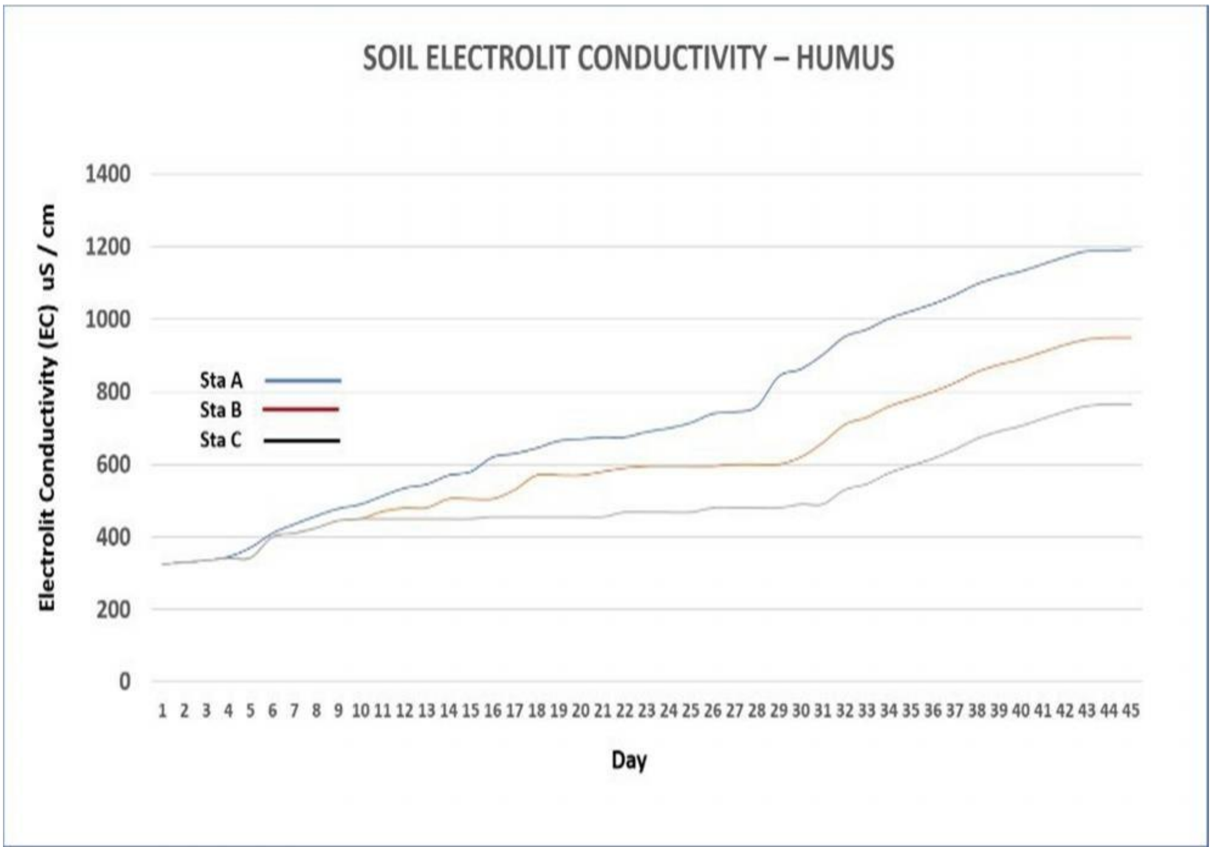

Figure 3: Graphic EC Humus

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Figure 4: Graphyc of Soil: Acidity, Moisture & Themperature

Figure 5: Infilrasi Rate

Microbial activity can be seen in the EC graph above at stations A, B and C. The EC graph pattern of the three Humus ground stations immediately increased significantly. Then on days 20 to 30 it tends to be flat and after that the EC chart pattern rises again significantly and reaches sluggishness on day 45.

For Station A, the EC value starts in the range of 350 uS / cm, the graph continues to increase until 27 days to 750 uS / cm on the 28th day, rising even more sharply until the figure of 1200 uS / cm on the 42nd day and then tends to be stable. The change in soil acidity with a pH value is moderate from an acidic condition of 5.5 to normal 6.5 on day 25 and continues until it is constant to

7.0 on the 35th day. The soil moisture value also changes from 35% to 45% and after 35 days tends to constant at ground temperature 20 to 25 ° C.

For Station B, the EC value starts in the range of 350 uS / cm, the graph continues to increase

The Seybold Report
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until 18 days to 580 uS / cm on the 19th day it moves flat (stable) until the 30th day then on the 32nd day to the 42nd day, then it increases even more sharply until the number 950 uS / cm on day 42 and then moving stably. The change in soil acidity with a pH value is moderate from an acidic condition of 5.5 to normal 6.0 on day 25 and continues until it is constant to 6.5 days 35. Soil moisture values also change from 32% to 42% and after 35 days tend to constant at ground temperature 22 s / d 26 ° C.

For Station C, the EC value starts in the range of 350 uS / cm, the graph continues to increase until 18 days to 480 uS / cm on the 19th day it moves flat (stable) until the 30th day, then on the 32nd day to the 42nd day it increases even more sharply until 780 uS / cm on day 42 and then moving steadily. The change in soil acidity with a pH value is moderate from an acidic condition of 5.5 to normal 5.8 on day 25 and continues until it is constant to

6.0 on day 35. Soil moisture values also change from 31% to 40% and after day 35 tends to be constant at ground temperatures of 23 to 27 ° C.

The soil parameters mentioned above can be controlled against the level of the infiltration rate, where the infiltration rate graph shows a constant value at a level of 80 to 120 cm / hour which is reached after the 30th day. While the EC value in stable conditions is achieved on day 30 with a value between 950 - 1200 uS / cm. So that the activity of biological agents on humus soil with an infiltration rate will be optimal on the 30th day.

CONCLUSION

a) The activity of biological agents on humus soil will be seen significantly on days 20 to 35 with an increase in the EC value up to 400%.

b) Changes in soil pH values from acidic to neutral conditions in humus soils are achieved between 30 to 35 days after the start of biological agent activity.

c) Increasing the EC value is related to the soil pH level, the higher the EC, the soil tends to be at a neutral pH level with a soil pH value between 5.5 to 7.0.

d) Microbial activity can increase the infiltration rate and conversely the infiltration rate can also affect the speed of spread of microbial activity where this relationship can be seen at the EC level 780 to 1200 uS / cm which will form soil porosity with an infiltration rate of 80 to 120 cm / hour.

e) Due to the porous nature and full of nutrients (rich in biomass content) in humus soil, the EC value and soil acidity level tend to increase rapidly after being triggered by microbial activity sourced from Biohole in both vertical and horizontal types

f) The Biosoildam method can be more effective in utilizing humus soil as a filler for marginal soil / land such as sandy soil and clay so that it needs to be tested for various variables such as:

- Analysis of the filler / media filler with humus soil for clay and sandy etc.
- Comparison analysis of the of main & filler media with various number of

comparisons.

- Analysis of the distribution of nutrients with a pressure drip irrigation system (drib irrigation pressure).
- Analysis of the distance formation and size type of biohole

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