ANALYSIS OF THE EFFECT OF BIOFERTILIZER AGENT ACTIVITY ON SOIL ELECROLIT CONDUCTIVITY & ACIDITY IN REAL TIME WITH THE SMART BIOSOILDAM METHOD

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Abstract

*The objective of this analysis improvement of soil infiltration rate on Grumosol agroland with involve biofertilizer MA-11 on the Biosoildam . A*s a control is original soil without microbial activity triggered. *The research was carried out on January to Juni 2020 at area of shallot agroland in Blora 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.*
The infiltration rate shows a constant value at a level of 40 to 90 cm / hour which is achieved after the 30th day. Meanwhile, the EC value in stable conditions is achieved on the 35th day with a value between 650 - 700 uS / cm. So that the activity of biological agents on gromosol soils with an optimal infiltration rate on the 33rd day.

Key Word: *infiltration, biosoildam, land use, gromosol, Alfaafa Microba, fertility, acidity*

1. INTRODUCTION

The current decline in carrying land capacity continues to expand (*environement degradation*) . 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 (biofertilizer) 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, 2003).

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, 2005). 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, 2010) due to excessive use of chemical fertilizers and pesticides which hardens the soil as well.

Smart-Biosoildam is a Biodam technology development 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. 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, 2020).

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, 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 so as 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)

2. METHODOLOGY

The study was conducted on alluvial land which for decades has been the source of livelihood for the community of Purworejo Village Blora District Blora District. 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 Januari – Juni 2020, intends to restore the carrying capacity of the land.

Tools and materials used in research are: Mikrokontroler 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,* Erlemeyer, penggaris, *Stop watch* , plastic bucket , *tally sheet,* measuremet glass, micro scale , hydrometer dan water (*Douglas, M.G. 1988).*

2.1. 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. 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).

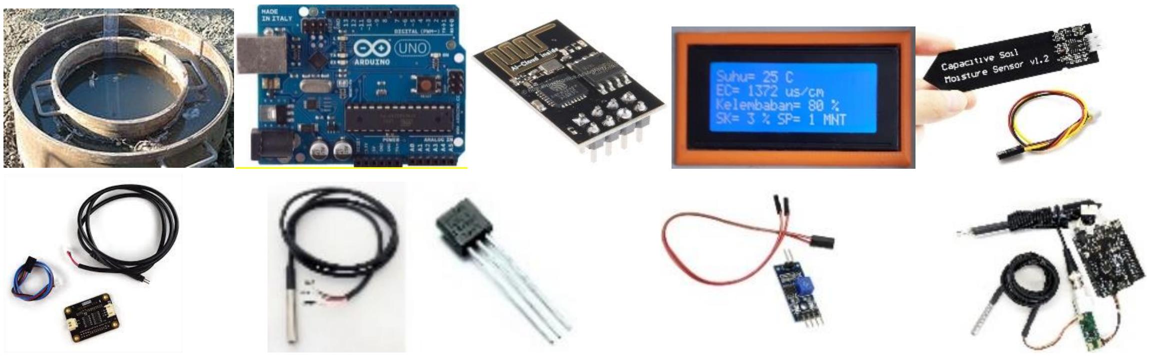

Figure 1: Double Ring Infiltrometer & Sensors

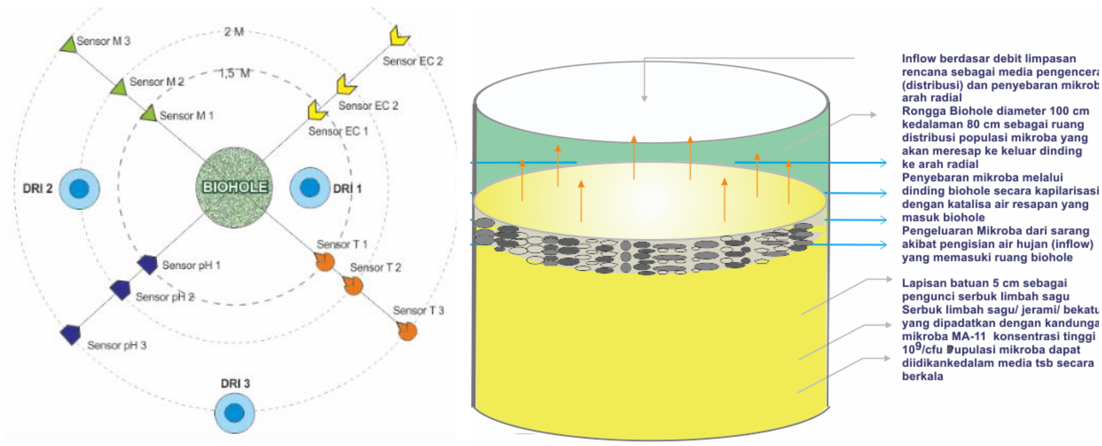

Figure 2. Distributiom Sensor Position & Biohole Structure

2.2. Data Processing

2.2.1. 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 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. 1988). 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 (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:

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

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:

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.1997). 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	$18,48 \times 10^8$cfu	8	Ure-Amonium-Nitrat Decomposer	Positive
2	Selulotik Micobes	$1,39 \times 10^8$cfu	9	Patogenity for plants	Negative
3	Proteolitik Micobes	$1,32 \times 10^8$cfu	10	Contaminant E-Coly & Salmonella	Negative
4	Amilolitik Micobes	$7,72 \times 10^8$cfu	11	Hg	2,71 ppb
5	N Fixtation Micobes	$2,2 \times 10^8$cfu	12	Cd	<0,01 mg/l
6	Phosfat Micobes	$1,44 \times 10^8$cfu	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.

2.2.4. 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. 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, 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,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 the D.1 (Tx) pin.

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 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.

3. RESULTS AND DISCUSSION

3.1. Rainfall Design and Frequency Duration Intensity (FDI)

The rainfall design intensity was determined using rainfall data from Blora Station in 2013-2017 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. 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.

3.3. Biohole DesVDign

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 padi 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.

3.4. Soil Coating Effect on Biohole

The geomorphology of agricultural land and its surroundings is the Grumosol plain. Grumusol soil is soil formed from limestone and volcanic tuffa source rock which is generally alkaline so that there is no organic activity in it. This is what makes this soil very poor in nutrients and inorganic. The nature of lime itself is that it can absorb all the nutrients in the soil so that high lime levels can be toxic to plants.

Grumusol soil still carries the characteristics and facts of its source rock. Weathering that occurs only changes the physical and textural textures such as Ca and Mg which were previously tightly bound to the parent rock to become looser which can be relied on by external factors such as weather, climate, water and others. Sometimes grumusol soil occurs with lime concretions with soft lime elements and continues to develop into a thick and hard layer. This land is popular in the Plains of Blora.

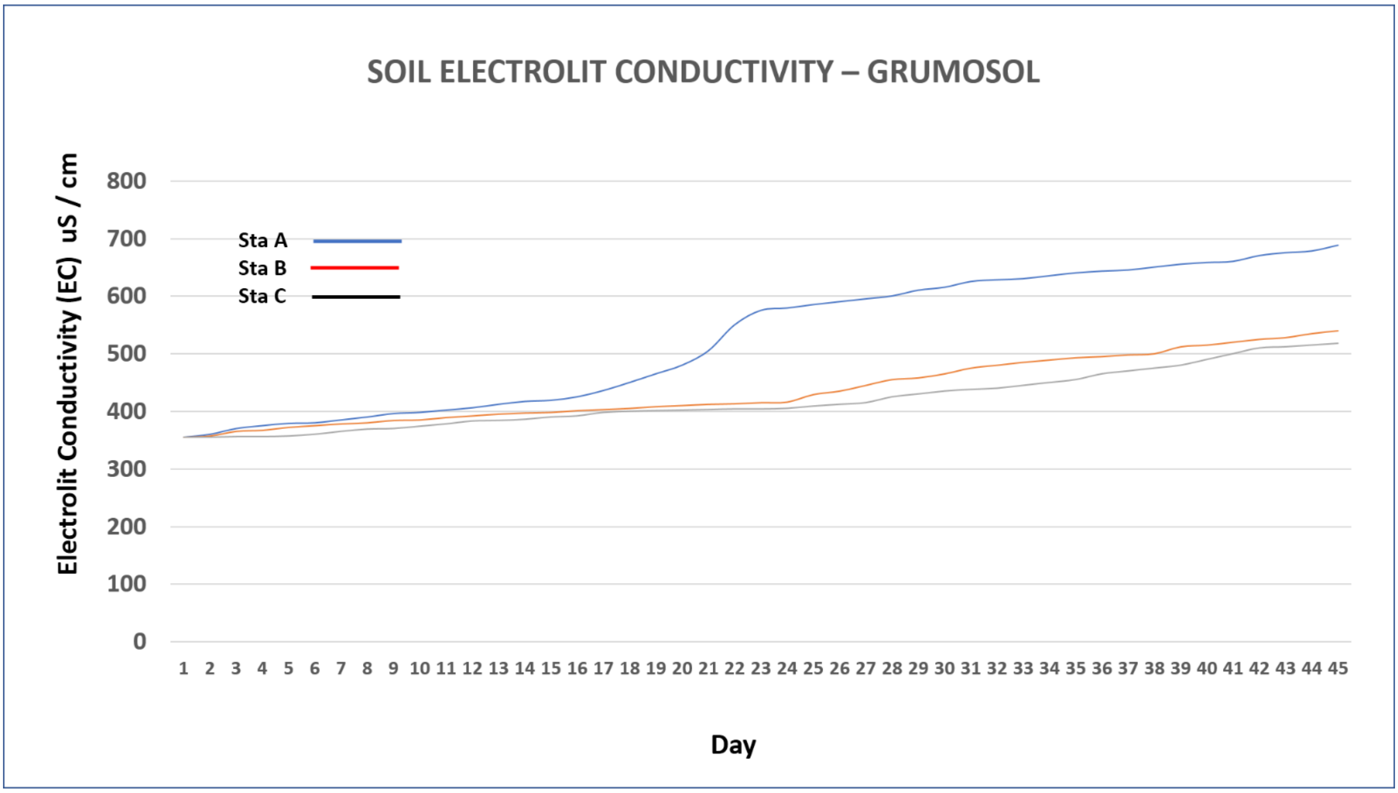

Figure 3: Graphic EC Aluvial

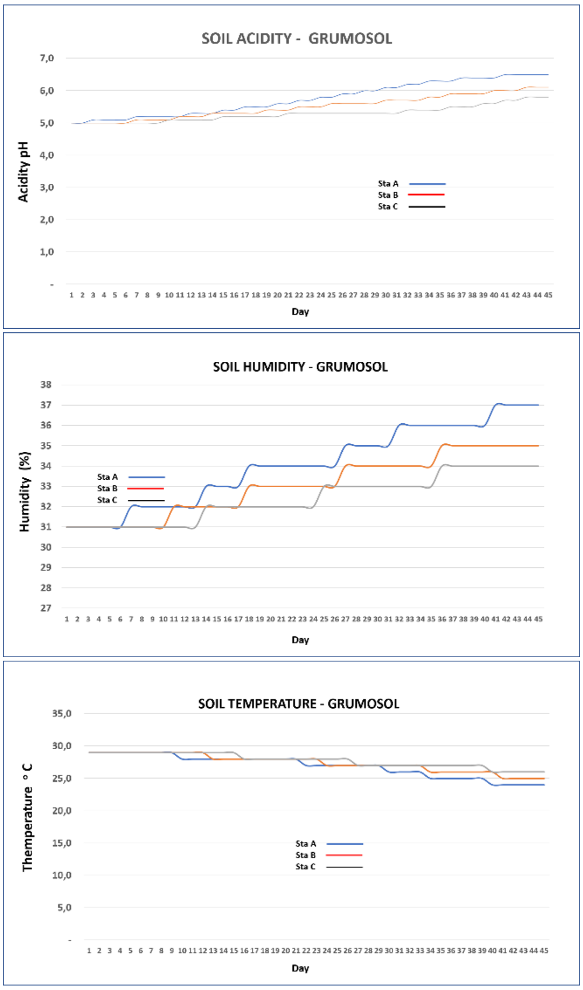

Figure 4: Graphyc of Soil : Acidity, Moisture & Themperature

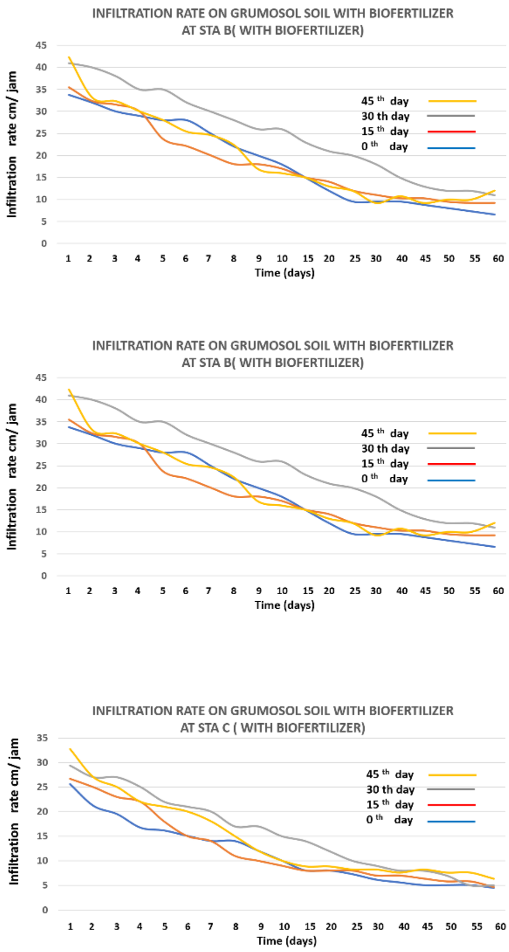

Figure 5: Infilrasi Rate

Microbial activity can be seen in the EC graph above at stations A, B and C. The EC graph pattern of the three Gromosol ground stations at the beginning tends to slope and in the middle, namely on the 20th day the graph tends to rise sharply for 5 to 7 days and then moving gently again until it finally reaches a stable value on day 45.

For Station A, the EC value starts in the range of 350 uS / cm, the graph increases but with a gentle slope of up to 20 days to a value of 425 uS / cm then for 5 days it increases sharply on day 24 reaching a value of 580 uS / cm and then the graph goes up again but with a gentle slope reaching a value of 700 uS / cm on the 45th day. The change in soil acidity with a pH value is moderate from acidic conditions 5.0 to normal 6.0 on day 30 and continues to be constant to the number 6.5 on the 35th day. Soil moisture values also changed from 31% to 33% and after 35 days tended to be constant at a soil temperature of 24 s / d 28 ° C.

For Station B, the EC value also starts in the range of 350 uS / cm, the graph increases but with a gentle slope of up to 28 days to a value of 400 uS / cm then for 13 days it increases slightly on the 38th day reaching a value of 500 uS / cm and then the graph returns increasing but with a gentle slope reaching a value of 525 uS / cm on the 45th day. The change in soil acidity with a pH value is moderate from an acidic condition of 5.0 to normal 5.5 on the 30th day and keeps increasing until it is constant to 6.0 on the next day. 35. Soil moisture values also changed from 31% to 35% and after 35 days tended to be constant at soil temperatures of 23 to 29 ° C.

For Station C, the EC value also starts in the range of 350 uS / cm, the graph increases but with a gentle slope of up to 28 days to a value of 380 uS / cm then for 13 days it increases slightly on the 38th day reaching a value of 480 uS / cm and then the graph returns. increasing but with a gentle slope reaching a value of 510 uS / cm on the 45th day. The change in soil acidity with a pH value is moderate from acidic conditions 5.0 to normal 5.3 on the 30th day and keeps increasing until it is constant to 5.8 on the next day. 38. Soil moisture values also changed from 30% to 34% and after 35 days tended to be constant at soil temperatures of 24 to 30 ° 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 40 to 90 cm / hour which is reached after the 30th day.While the EC value in stable conditions is reached on day 35 with a value between 650 - 700 uS / cm. So that the activity of biological agents on gromosol soils with an optimal infiltration rate on the 33rd day..

4. CONCLUSION

a) The activity of biological agents on gromosol soil will be significant on day 28 to 38 with an increase in the EC value up to 200%.
b) Changes in soil pH values from acidic to neutral conditions in gromosol soils are achieved between days 33 to 38 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 5.0 to 6.0.
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 400 to 700 uS / cm which will form soil porosity with an infiltration rate of 40 to 90 cm / hour .
e) Grumusol soil is soil formed from limestone and volcanic tuffa main rock which is generally alkaline so that there is no organic activity in it. This is what makes this soil very poor in nutrients but porous and easy to bind organic elements, making it easy to increase its nutrients
f) The Biosoildam method to be more effective and optimal in the Grumosol area still needs to be tested for various variables such as:
   - Analysis of the distribution of nutrients with a pressure drip irrigation system (drib irrigation pressure).
   - Analysis of the distribution of biohole with a vertical / horizontal type so that the radial spread of microbes can sweep a stretch of peatland into productive soil.

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