

# ANALYSIS OF THE RELATIONSHIP BETWEEN EFFECT OF BIOFERTILIZER AGENT ACTIVITY ON SOIL ELECTROLIT CONDUCTIVITY & ACIDITY USING REAL TIME DATA OF THE SMART BIOSOILDAM

Nugroho Widiasmadi

Faculty of Engineering, Wahid Hasyim University, Menoreh Tengah X/22, Sampangan, Semarang 50236, Indonesia,  
Email: nugrohowidiasmadi@unwahas.ac.id

## Abstract

The objective of this analysis improvement of soil infiltration rate on Humus agroland with involve biofertilizer MA-11 on the Biosoildam . As a control is original soil without microbial activity triggered. The research was carried out on January to July 2019 at area of shallot agroland in Ngawi 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 concentration and soil acidity. The measurement was done in every five minute and observian 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 80 to 120 cm / hour which is achieved after the 30th day. Meanwhile, the EC value in stable conditions is achieved on the 30th day with a value between 950 - 1200 uS / cm. So that the activity of biological agents on humus soil with infiltration levels will be optimal on the 30th day.

**Keyword:** infiltration, biosoildam, land use, humus, Alfaafa Microba, fertility, acidity

## 1. INTRODUCTION

The current decline in carrying land capacity continues to expand (environment 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, 2019). The large infiltration capacity can reduce surface runoff. The reduced soil pores, generally caused by soil compacting, can cause a decreased

## Analysis Of The Relationship Between Effect Of Biofertilizer Agent Activity On Soil Electrolit Conductivity & Acidity Using Real Time Data Of The Smart Biosoildam

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.

**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 Legundi Village Karangjati District Ngawi 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 – July 2018, intends to restore the carrying capacity of the land.

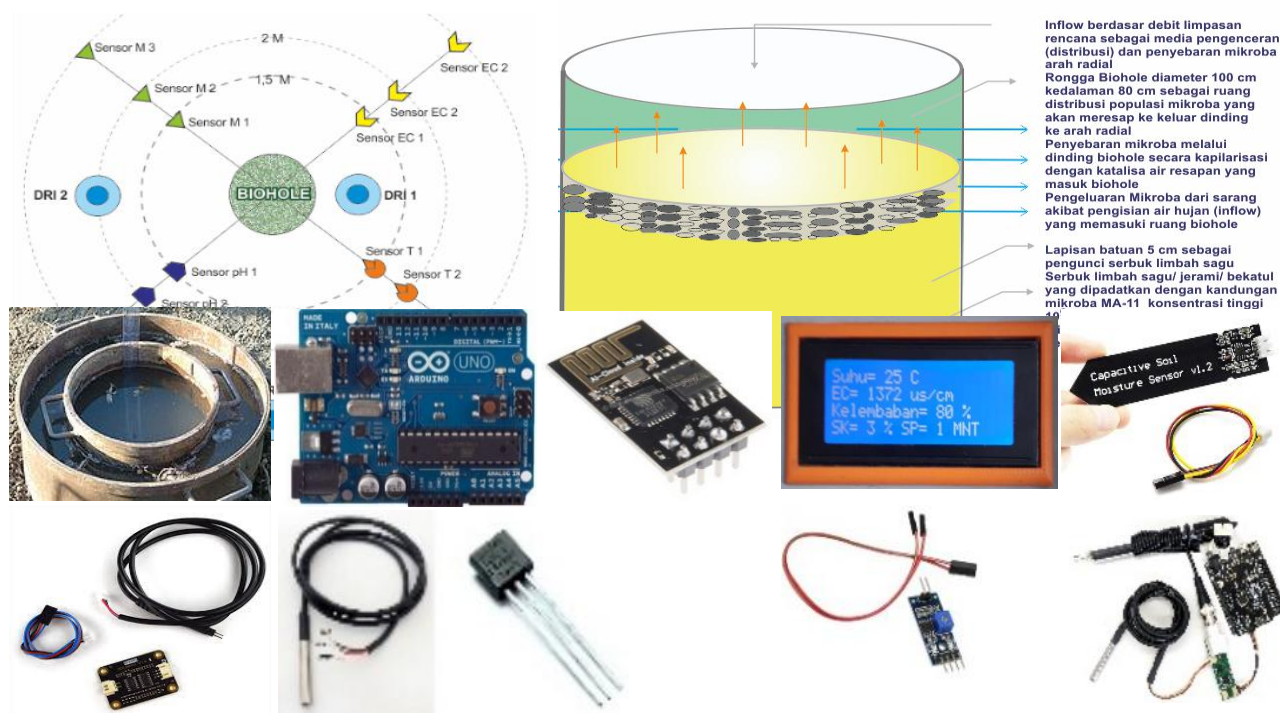
Tools and materials used in research are: Microcontroller Arduino UNO, Wifi ESP8266, Soil parameter sensor : Temperature (T) DS18B20, humidity (M) V1.2, Electrolit Conductivity (EC) G14 PE, Acidity pH) Tipe SEN0161-V2 , LCD module HD44780 controller, Biohole as Injector for Biosoildam, Biofertilizer Mikrobia Alfafaa MA-11, red union

straw as microbia nest , Abney level, , Double Ring Infiltrometer, Erlenmeyer, rules, Stop watch , plastic bucket , tally sheet, measurement 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 (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).

**Figure 1. Double Ring Infiltrometer & Sensors**  
**Figure 2. Distribiomm Sensor Position & Biohole Structure**



# Analysis Of The Relationship Between Effect Of Biofertilizer Agent Activity On Soil Electrolit Conductivity & Acidity Using Real Time Data Of The Smart Biosoildam

## 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 population's 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 (Nugroho Widiastadi, 2020). 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  $f_0$  and exponentially decreases to a constant condition  $f_c$ . One of the earliest

infiltration equations developed by Horton is:

$$f(t) = f_c + (f_0 - f_c)e^{-kt} \quad (2)$$

where :

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

$f_0$  is an infiltration rate capacity at the beginning of the measurement.

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

The  $f_0$  and  $f_c$  parameters are obtained from the field measurement using a double-ring infiltrometer. The  $f_0$  and  $f_c$  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:

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

where:  $\Delta H$  = height decrease (cm) within a certain time interval, T = the time interval required by water in  $\Delta H$  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 x 10 <sup>8</sup> cfu	8	Ure-Amonium-Nitrat Decomposer	Positive
2	Selulolitik Micobes	1,39 x 10 <sup>8</sup> cfu	9	Patogenity for plants	Negative
3	Proteolitik Micobes	1,32 x 10 <sup>8</sup> cfu	10	Contaminant E-Coly & Salmonella	Negative
4	Amilolitik Micobes	7,72 x 10 <sup>8</sup> cfu	11	Hg	2,71 ppb
5	N Fixtation Micobes	2,2 x 10 <sup>8</sup> cfu	12	Cd	<0,01 mg/l
6	Phosfat Micobes	1,44 x 10 <sup>8</sup> cfu	13	Pb	<0,01 mg/l
7	Acidity	3,89	14	As	<0,01 ppm

(Nugroho Widiastadi, 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 Widiastadi, 2020).

### 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.

## Analysis Of The Relationship Between Effect Of Biofertilizer Agent Activity On Soil Electrolit Conductivity & Acidity Using Real Time Data Of The Smart Biosoildam

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 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.

#### 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 m<sup>2</sup> to 110 m<sup>2</sup> 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.

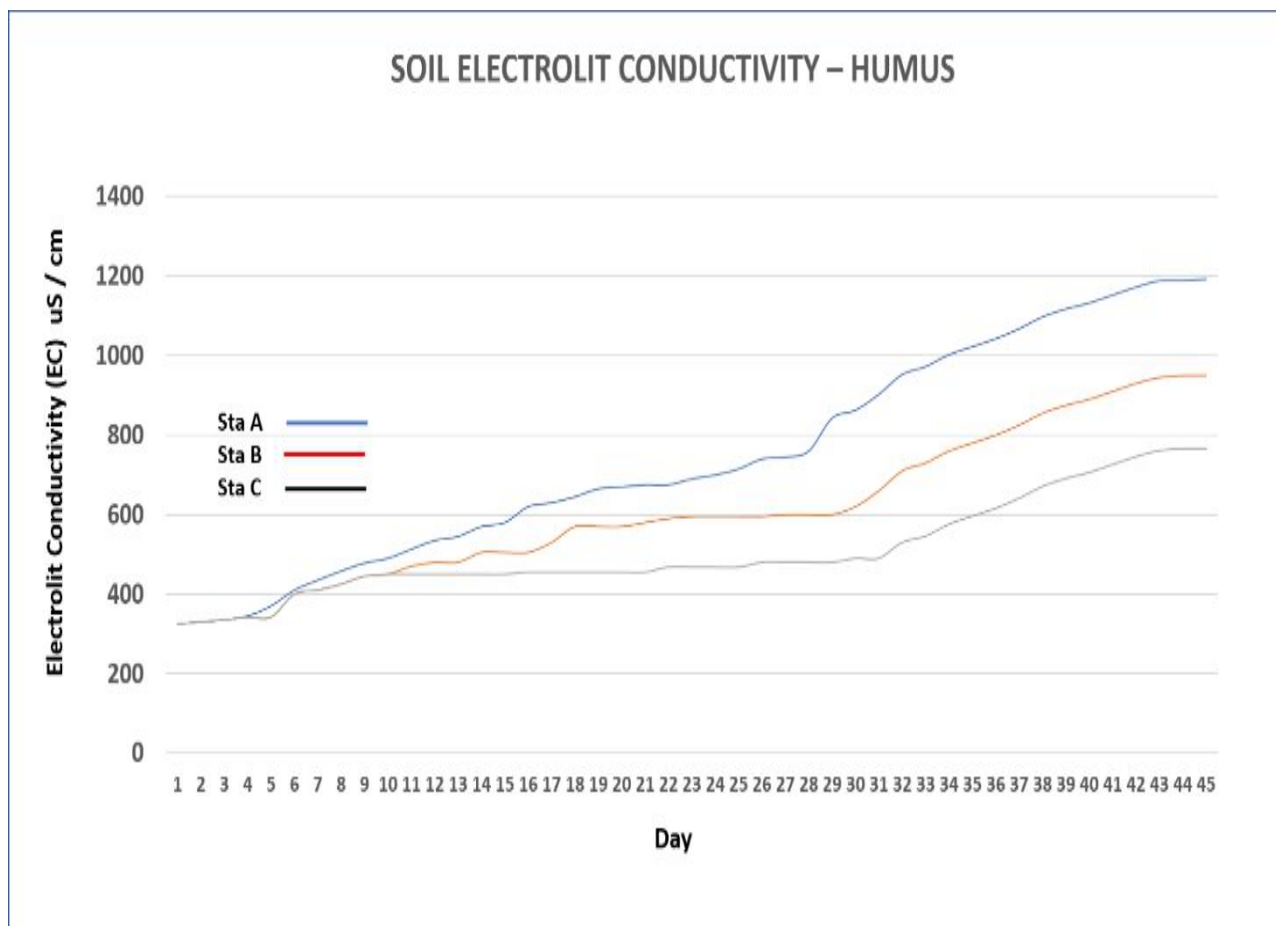
#### 3.3. Biohole Design

Biohole walls use natural walls with a 1.0-diameter and a 0.8-depth or the storage area of 36 m<sup>2</sup>. 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 m<sup>3</sup>, with a catchment of 36 m<sup>2</sup> and the 25 year-discharge = 0.0000841 m<sup>3</sup>/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

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.



# Analysis Of The Relationship Between Effect Of Biofertilizer Agent Activity On Soil Electrolit Conductivity & Acidity Using Real Time Data Of The Smart Biosoildam

Figure 3. Graphic EC Aluvial

Figure 4. Graphyc of Soil : Acidity, Moisture & Temperature  
INFILTRATION RATE ON HUMUS SOIL WITH BIOFERTILIZER  
AT STA A ( WITH BIOFERTILIZER)  
SOIL ACIDITY - HUMUS

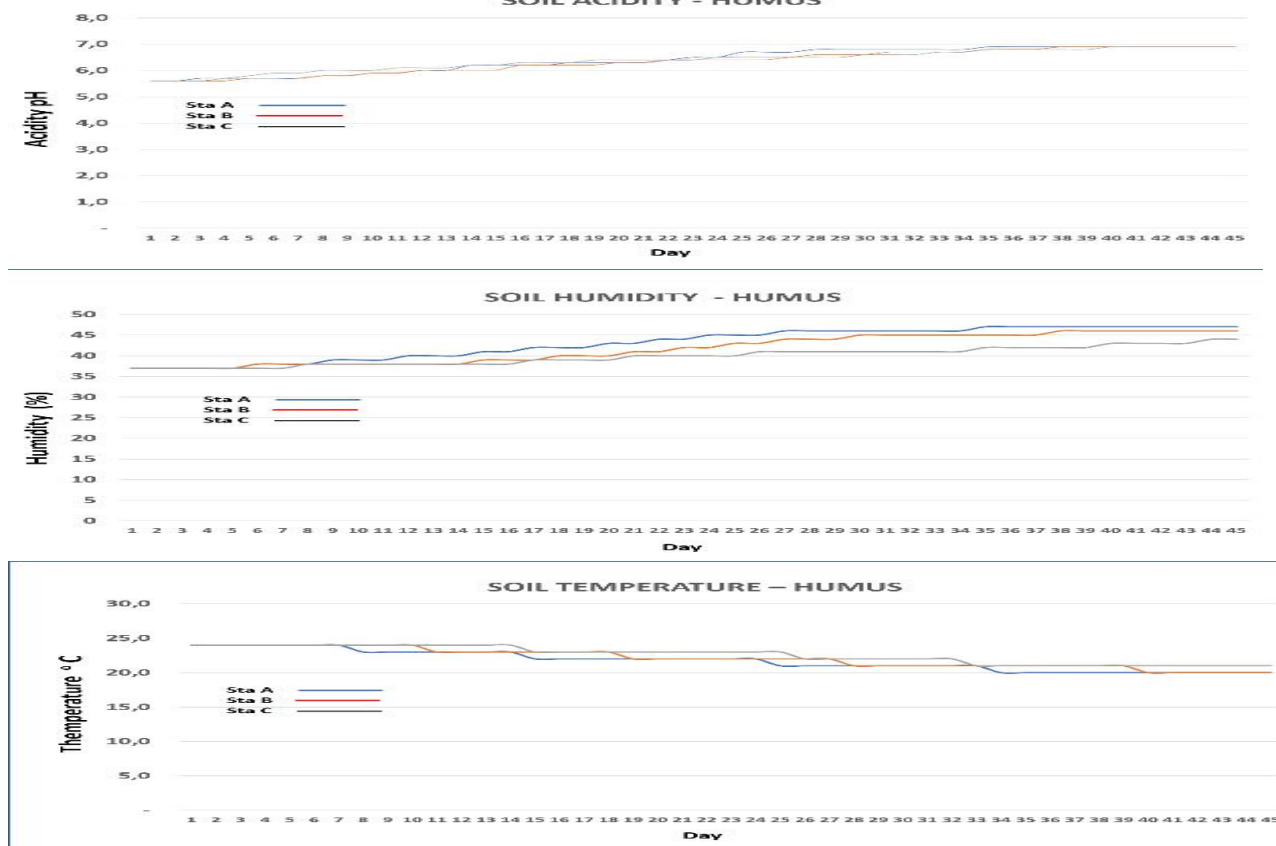


Figure 5. Infiltrasi Rate

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 of 23 to 27 °C.

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

## 4. CONCLUSION

- 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%.
- 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.
- 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.
- 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

## *Analysis Of The Relationship Between Effect Of Biofertilizer Agent Activity On Soil Electrolit Conductivity & Acidity Using Real Time Data Of The Smart Biosoidam*

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 Biosoidam 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

### REFERENCES

1. Douglas, M.G. 1988. Integrating Conservation into Farming System : The Malawi Experience, in W.C Moldenhauer and N.W. Hudson (Eds), Conservation Farming on Steep land . Soil dan Water Conservtion Society and World Association of Soil and Water Conservction , Ankeny, IOWA. Pp 215-227.
2. Boardman , C. R. and Skrove. J.W. , 1966 Distribution and fracture permeability of a granitic rock mass following a contained nuclear explosion. Journal Pteroleum Technologi v. 15 no 5 .p. 619-623
3. Childs, E.C. 1969, In Introduction to the Physical basis of soil water phenomena . New York, John Wiley and Sons . Inc. 493 p.
4. Douglas, M.G.1994 Suistanable Use of Agriculture soil A Rvwview of t he Prerequisitesfor Success od Failure. Development and Environment Reports No : 11 Groub for Development & Environtment , Institute for Geography , Universitu of Berne, Switzerland.
5. John M Laffen, Ph.D, Junilang Tian , Professor Chi-Hua Huang, PhD,2000. Soil Erosion & Dryland Farming: Library
6. [6] Huang, Z, and L Shan.1997 Action of Rainwater use on soil and water conservation and suistanable development of Agriculkture . Bulletin of soil and Watr Conserv,17(1):45-48.
7. Kramer , P.J. 1983 Water Relations of Plants . Academic Press New York.
8. Shan. L. 1994 Water use efficiency of plant and agricultural water use ini semi-arid area. Plant Physiol.Comm. 30(1):61-66.
9. Tao Y, 1997. Studies on the optimized pattern for integrated and sustainable agricultural developmenet in dray land farming area of eastern Shanxi and Western Henan Provinces. Chinese Agricultural Meteorolgy.18(3):11-13.
10. Sunjoto, S. 1988. Optimasi Sumur Resapan Air Hujan Sebagai Salah Satu Usaha Pencegahan Instrusi Air Laut. Yogyakarta : Fakultas Teknik Universitas Gadjah Mada
11. Sunjoto, S. 2011. Teknik Drainase Pro-Air. Yogyakarta : Fakultas Teknik UGM
12. Suripin. 2003. Sistem Drainase Perkotaan Yang Berkelanjutan. Yogyakarta : Penerbit Andi
13. Sutanto. 1992. Desain Sumur Peresapan Air Hujan. Laporan Penelitian. Yogyakarta : Fakultas Geografi Universitas Gadjah Mada
14. Nugroho Widiasmadi Dr, 2019. Peningkatan Laju Infiltrasi & Kesuburan Lahan Dengan Metode Biosoidam Pada Lapisan Tanah Keras & Tandas : Prosiding SNST ke-10 Tahun 2019 Fakultas Teknik Universitas Wahid Hasyim.
15. Nugroho Widiasmadi Dr, 2020. Soil Improvement & Conservation Based in Biosoidam Integrated Smart Ecofarming Technology (Applied in Java Alluvial Land & Arid Region in East Indonesia): International Journal of Inovative Science and Research Technology (IJRST), Volume 5| Issue 9| September 2020
16. Nugroho Widiasmadi Dr, 2020. Analysis of Soil Fertlity and Acidity in Real Time Using Smart Biosoidam to Improe Agricultural Land : International Journal of Research and Analytical Reviews (IJRAR), Volume 7 | Issue 3 | September 2020 Page no 194-200
17. Nugroho Widiasmadi Dr, 2020. Analisa of the Effect of Biofertilizer Agent Activity on Soil Electrolit Conductivity & Acidity in The Real Time With The Smart Biosoidam :Journal of Mechanical & Civil Engineering (IJRDO), ISSN : 2456-1479 Vol-6, October 2020.
18. Nugroho Widiasmadi Dr, 2020. Analisa Elektrolit Konduktifitas & Keasaman Tanah Secara Real Time menggunakan Smart Biosoidam : Prosiding National Conference of Industry, Engineering, and Technology (NCIET), ISSN : 2746-0975 Vol 1, November 2020.
19. Sigit Wasisto, 2018. Aplikasi Internet of Things (IoT) dengan Arduino & Android : Penerbit Deepublish Yogyakarta
20. Sigit Wasisto, 2018. Aplikasi Internet of Things (IoT) dengan Arduino & Android : Penerbit Deepublish Yogyakarta
21. Samuel Greengard, 2017. "The Internet of Things" covers how IoT works in our current world, as well as the impact it will have in the long run on society. , Amazone
22. Klaus Schwab, 2018. "The Fourth Industrial Revolution", Amazone