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Soil Improvement & Conservation Based on Biosoildam Integrated Smart Ecofarming Technology (Applied in Java Alluvial Land & Arid Region in East Indonesia)

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Abstract:- Biosoildam a technology that combines agricultural and environmental activities (water & soil conservation) based on IOT. This analysis aims to improve alluvial agricultural lands by analyzing the relationship between microbial activity on acidity and the infiltration rate for alluvial lands that widely spread on the north coast of Java with Biosoildam Technology. Microbial activity as a biological agent / biofertilizer of slurry biomass decomposition taken from the livestock center and soil conditioning will affect soil electrolyte conductivity (EC). Other variables use the humidity and soil temperature parameters to control the relationship. Integrated Ecofarming where harvest straw for feed and livestock waste for fertilizer in micobial decomposting process is a cost-effective method that can improve soil quickly and measurably. The research took place from January to July 2018 on the red onion farms in Nganjuk Regency.

The tools used include Double Ring Infiltrometer for measuring the infiltration rate at three radial distances from the centre of the microbial hole (biohole), microcontroller & wifi, electrolyte conductivity sensor as the soil fertility indication, pH meter for measuring soil acidity, and humidity and soil temperature sensors. The real-time information on soil paramaters is obtained through analogue inputs from EC, pH, humidity and temperature sensors, converted into digital information data by a microcontroller which later sent via wifi. Sensors are spreadly placed with radius A= 1,5 m ;B= 2 m ; C= 3m.

Average Result : infiltration rate =40cm/h EC=1100 M=45 % T=25°C pH=6,5.

Keywords:- *Integrated Smartecofaring, Infiltration Rate , Biofertilizer, Biosoildam, Alluvial Land , Biohole, Soil Decomposer, Fertility , Acidity, Humidity.*

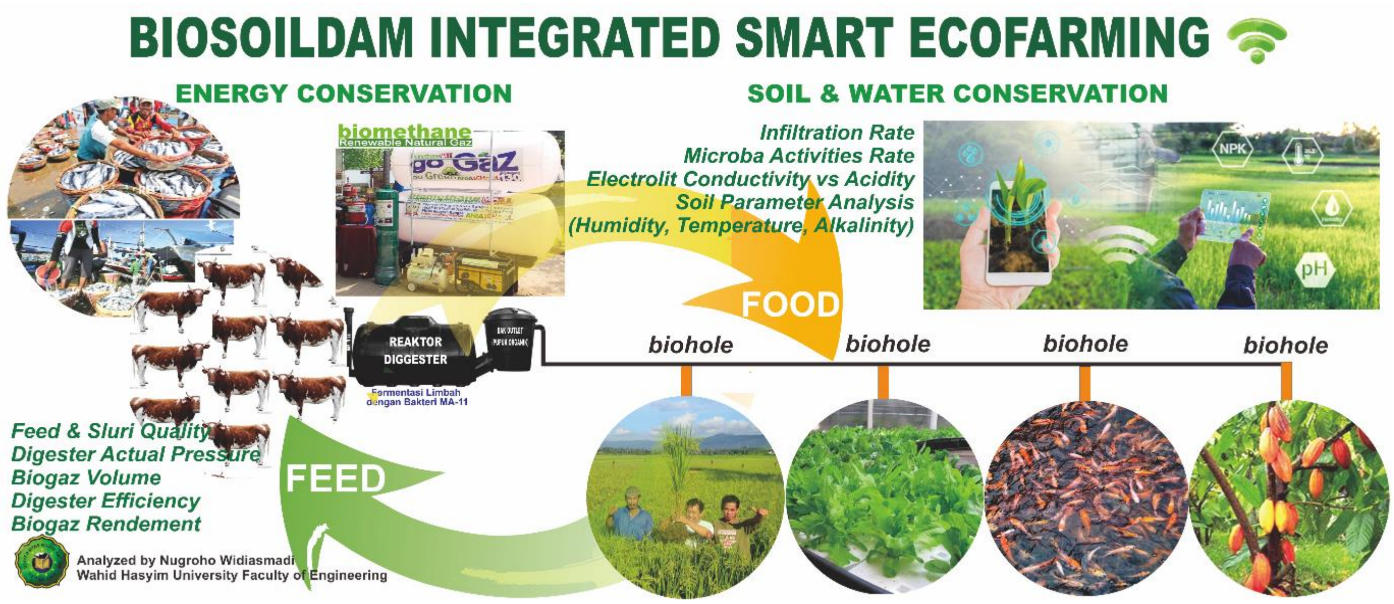

Fig 1:- Biosoildam Integrated Smart Ecofarming

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I. 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, 2010). 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.

Biosoildam is a Biodam technology development that involves microbial activity in increasing the measured in the digester or in the on soil for controlled infiltration rate. Biological activities through the role of microbes as agents of biomass decomposition like slurry taken from livestock centre 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.

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)

➢ *Biosoildam Standard*

- Controlling the quality of waste (pre decomposting process) on conventional farms and using Digester technology (minimum 2000 uS / cm)
- Controlling the quality of fertilizers (past decomposting process) that are ready to be given to plants (at least 4000 uS / cm)
- Controlling microbial population in the soil (at least 100 million / gram soil)
- Controlling soil fertility during the vegetative period (1000 uS / cm)
- Controlling Soil Fertility at Generative Period (1000 uS / cm)

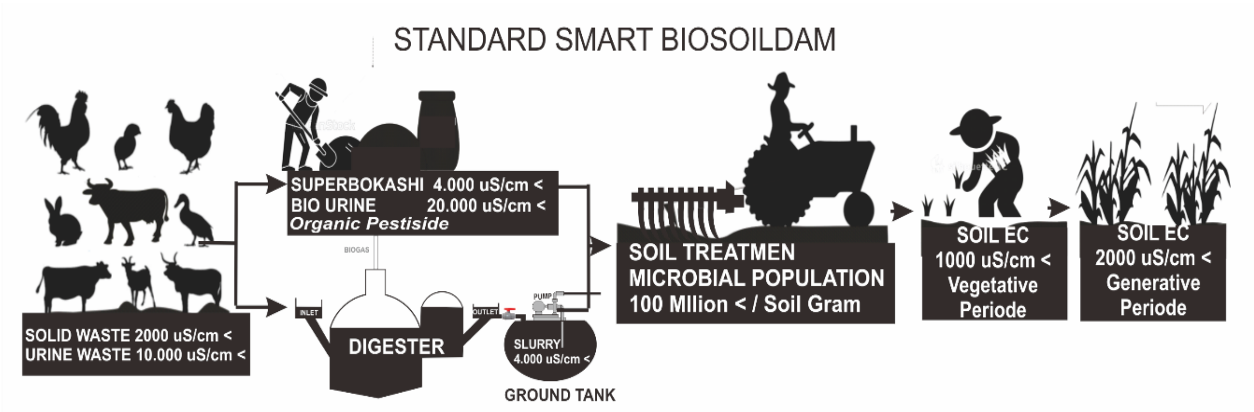

Fig 2:- Standard Smart Biosoildam

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II. METHODOLOGY

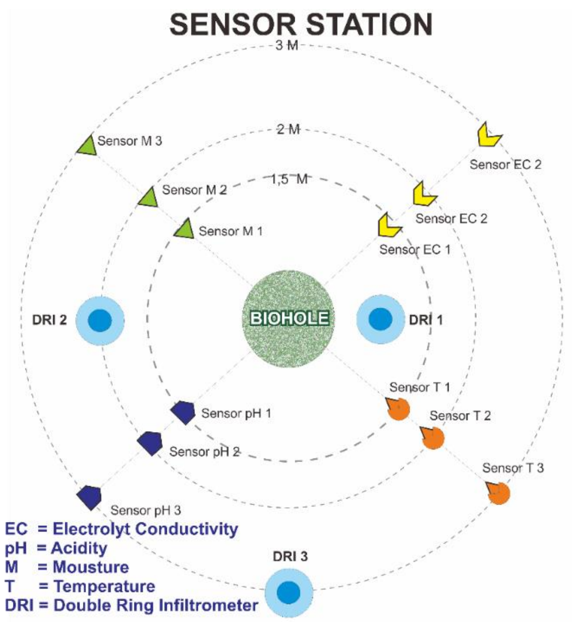
The study was conducted on alluvial land which for decades has been the source of livelihood for the community of Mojorembun Village, Rejoso District, Nganjuk Regency. Land management lacks soil and water conservation. Farmers use chemical (unorganic) fertilizers & pesticides excessively which harden the soil texture, acidify the soil and decrease the yields. Hardened agricultural land also becaming increasing for surface run off and than triggers floods, since the soil's ability to infiltration rate decreases. This research that took place from January to July 2018, 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).*

➢ *Determining plot and sensor points*

To determine plots and sensors, this study uses purposive sampling at various distances: 1.5; 2; 3 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 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 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.1994).

Fig 3:- Double Ring Infiltrometer & Sensors



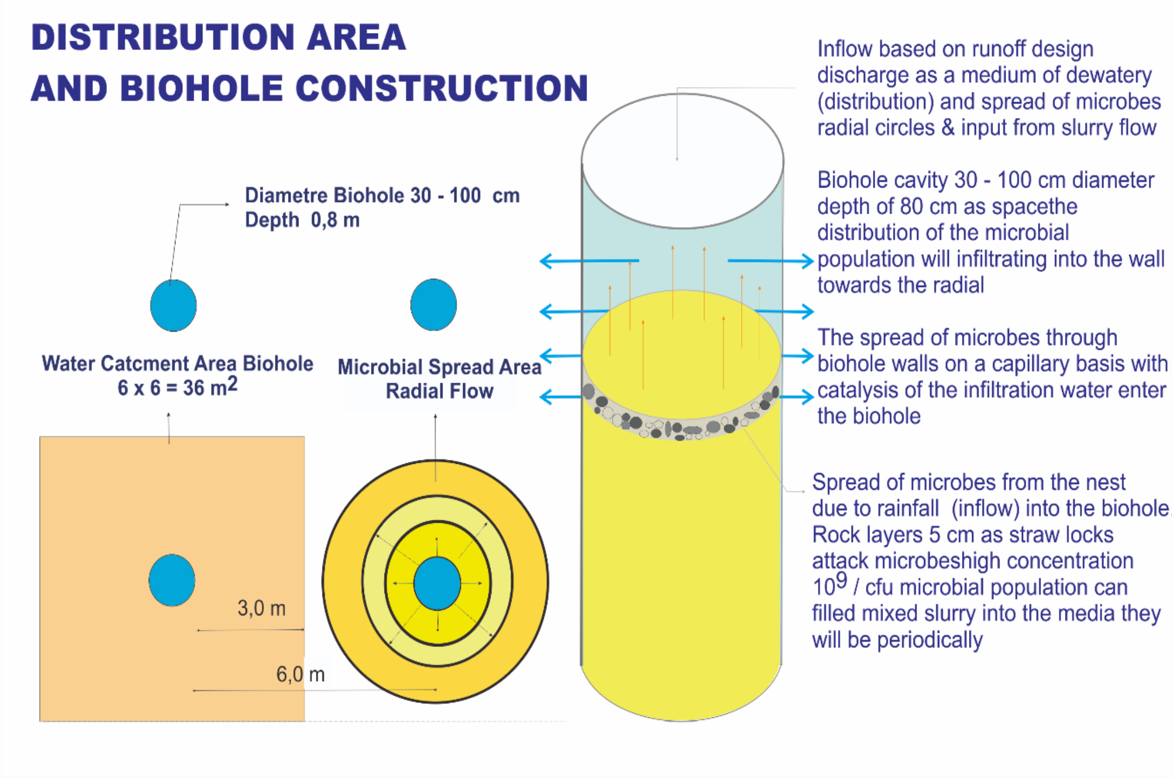


Fig 4:- Sensor Station & Biohole Structure

- *Data Processing*
- *Design Discharge*

Smartbiosoildam innovation uses runoff discharge as a media for biological agents distribution through the inlet/inflow (Vertical 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:

- ✓ conducting a rainfall analysis,
- ✓ calculating the catchment area, and
- ✓ 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.

- *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:

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

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 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.

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Microbial dispersal activity is influenced by interflow spread out biohole due to infiltration rate. Interflow which is the surface water flow in the top soil can be displayed by calculating the Finite Volume, method for representing and evaluating partial differential equations in the form of algebraic equations, volume integrals of interflow in a partial differential equation that contain a divergence term are converted to surface integrals in top soil, using the divergence theorem. In this topic, the finite volume method for calculation interflow is not discussed. We only use the calculation results to see the pattern of interflow distribution due to infiltration.

- *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:

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

Table 1
(sources: 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. This Micoba MA-11 is very effective and quickly improves the quality of slurry and bioemethane.

The Indonesian government has built MA-11 Microbial Production Small Laboratories in 35 District with the aim that farmers can produce Fertilizer, Feed and Energy to carry out The Integrated Ecofarming Program with Biosoildam Technology.

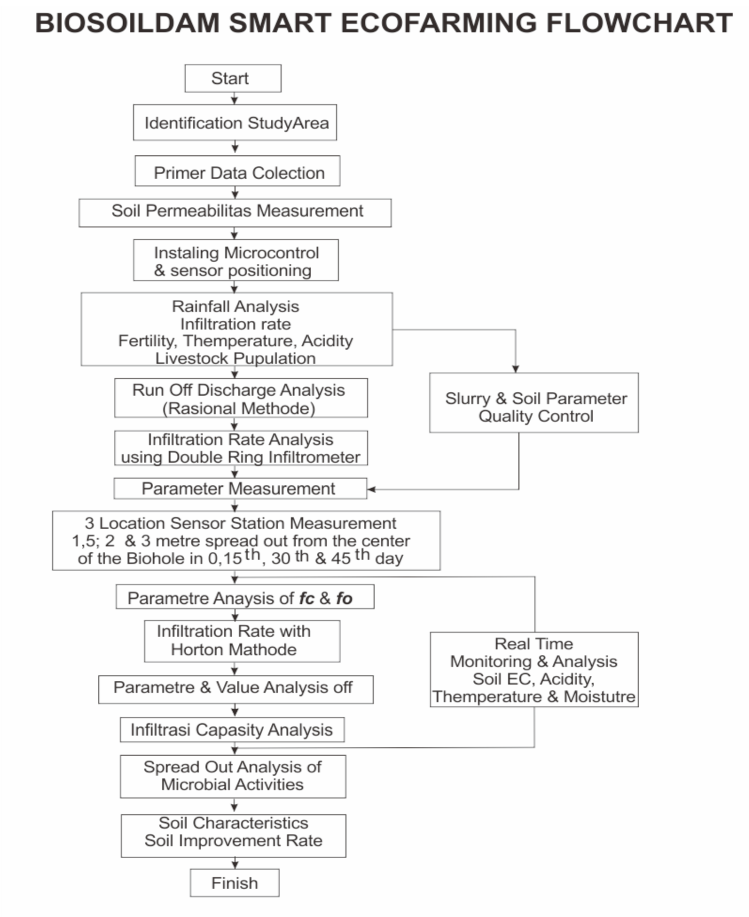

Fig 5

- *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.

III. RESULTS AND DISCUSSION

- *Rainfall Design and Frequency Duration Intensity (FDI)*

The rainfall design 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.

- *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*

There are two forms of biohole, horizontal & vertical type, we will discuss this material with the vertical biohole type. vBiohole walls use natural walls with a 1.0-diameter and a 0.8-depth or the storage area of 36 m2. Organic material (slurry combined with solid pressed red onion straw waste) is used as a place for microbial populations/microbial sources. The top is installed pipe from ground tank to slurry flow from digester. 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 0.157 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.

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➢ *Soil Coating Effect on Biohole*

Geomorphology of agricultural land and its surroundings is in the form of alluvial lands. Alluvial material 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.

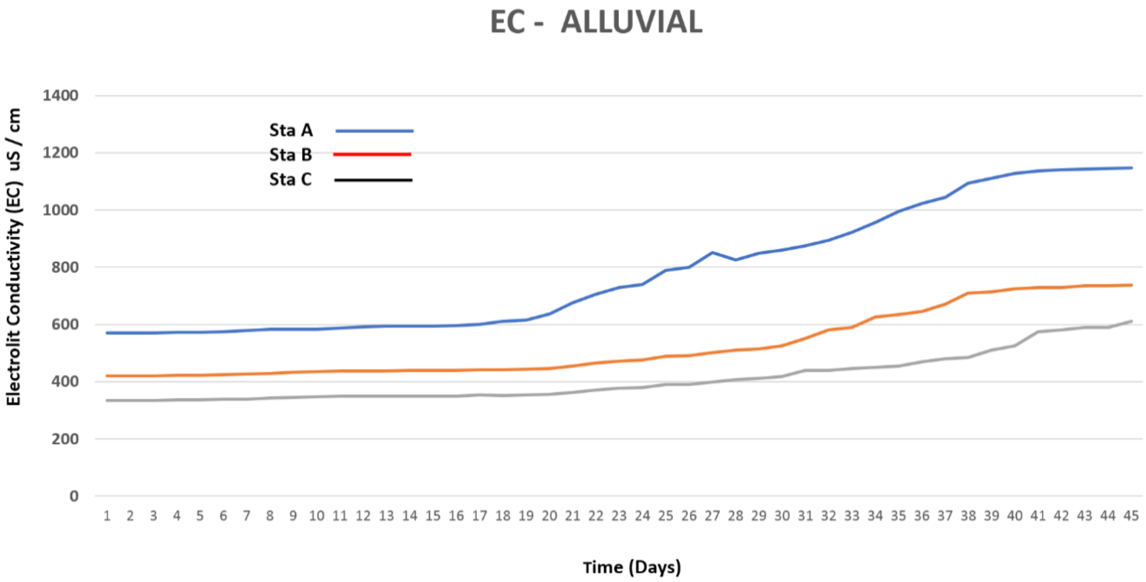
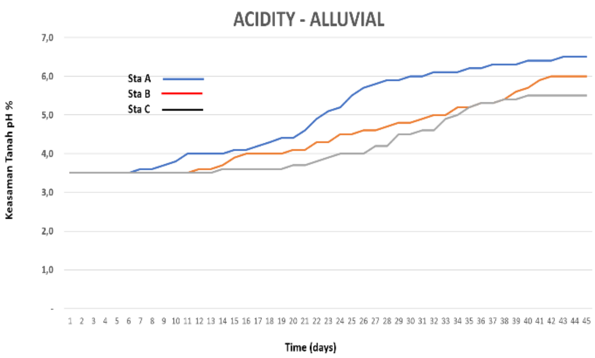
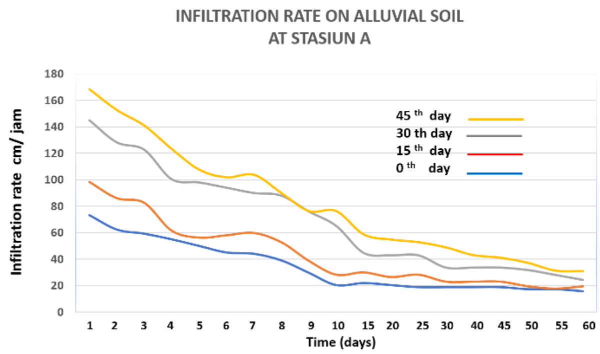
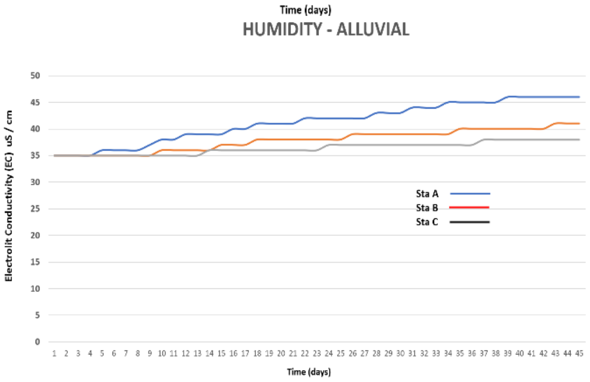
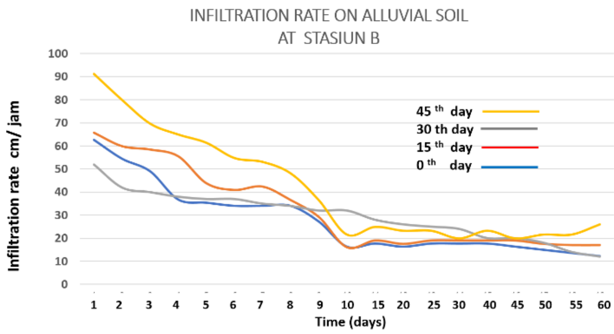


Fig 6:- Graphic of EC Alluvial









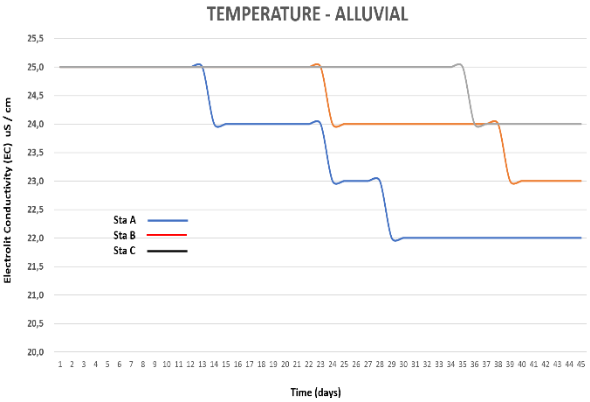


Fig 7:- Graphic of Acidity , Humidity & Themperature

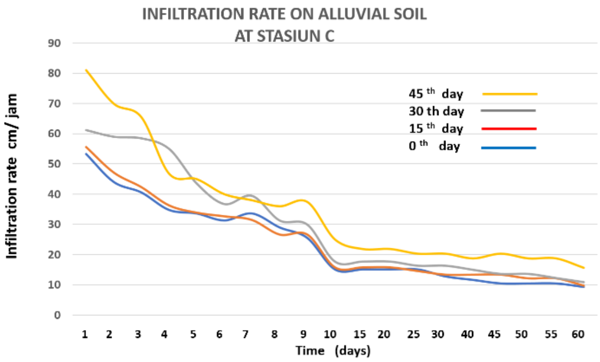


Fig 8:- Graphic of Infiltration Rate

The EC graph shows the microbial activities at stations A, B and C. The EC graphs of the three stations at the beginning shows a quite gentle activity. EC values at Station A start in the range of 600 uS/cm. The chart slopes significantly for up to 18 days later. It starts to rise to 1100 uS/cm and then slopes starting at the 38th day with a fairly rapid change in pH values, from acidic conditions 3.5 to normal 6.0 or 6.5 on the 25th day, the average humidity level is 40 to 45% at the soil temperature 22 to 25 °C.

The EC value at Station B starts with around 400 uS/cm. The graph slopes up to 23 days then significantly begin to rise to 700 uS/cm. It starts to slope on the 40th day with a relative slow-change in pH values from the acidic condition 3.5 to normal 5.5 or 6 on the 40th day, the average humidity level is 37 to 40% at the soil temperature 23 to 25 °C.

As for Station C, the EC value starts with 350 uS/cm. The graph slopes up to 25 days then significantly starts to rise to 600 uS/cm. It starts to slop on the 42nd day with a relative slow-change in pH values, from the acidic condition 3.5 to normal 5.0 or 5.5 on the 42nd day, the average humidity level is 35 to 38% at the soil temperature 24 to 25 °C.

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.

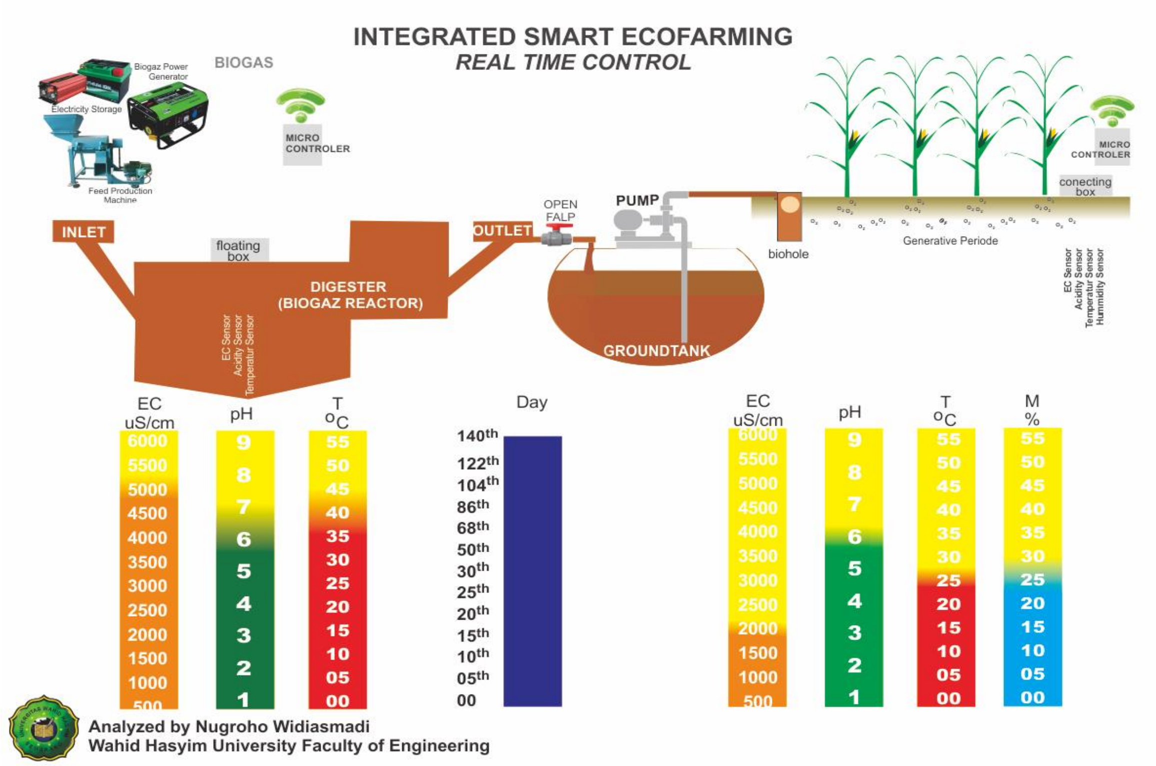


Fig 9:- Simulation of Real Time Data for Fertilizer & Soil Paraeter

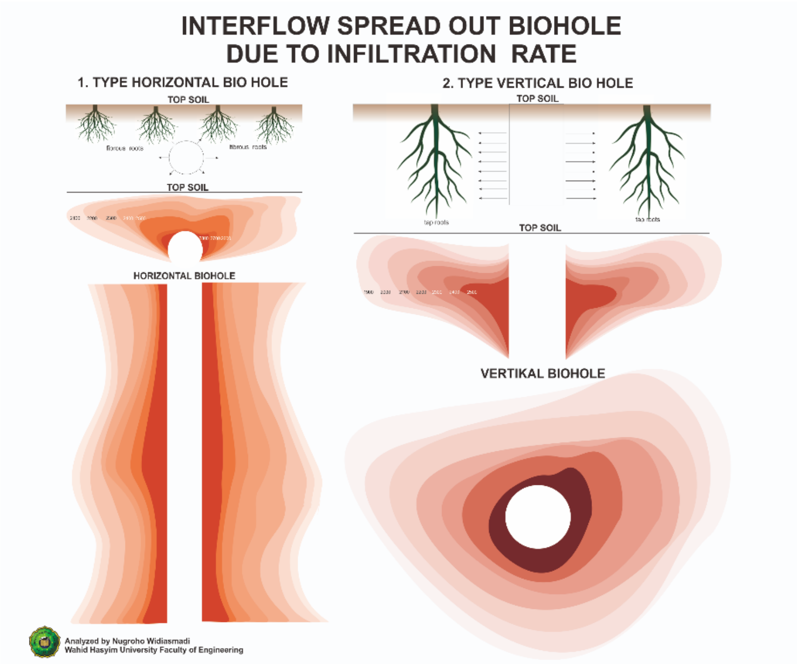


Fig 10:- Interflow Spread Out

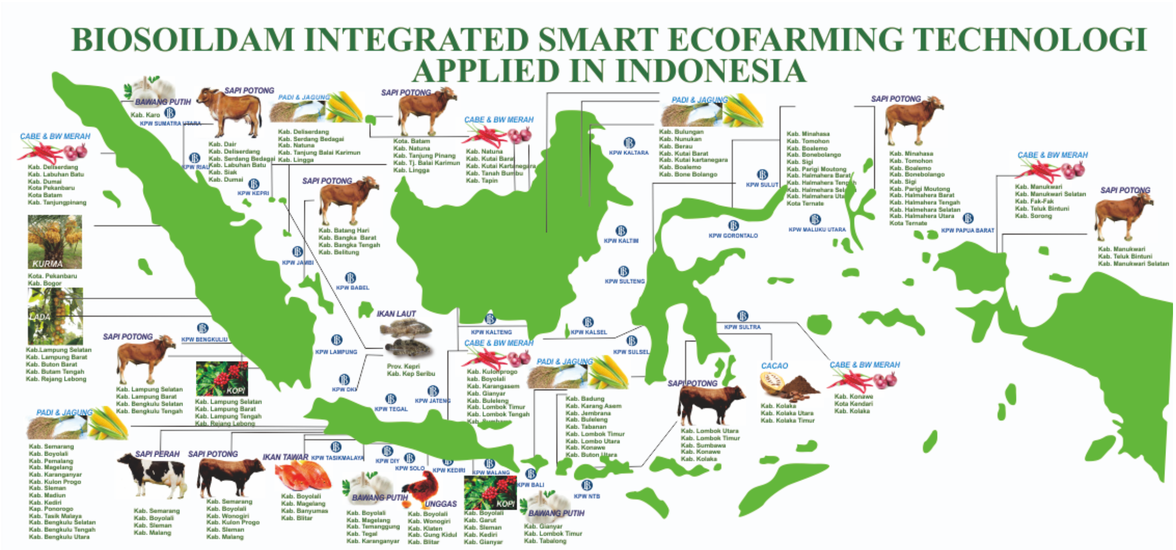


Fig 11:- Map of Biosoildam Aplied

IV. CONCLUSION

- A significant biological agent (biofertilizer) activity in alluvial soils will be seen on the 35th to 40th day with an up to 200% increase in EC values.
- Changes in soil pH (soil acidity) values from acidic to neutral conditions in alluvial soils are obtained between 35 to 45 days after the biological agent activity starts.
- Increase in the EC value is related to the pH level of the soil. The higher the EC is, the soil tends to be at a neutral pH level with a soil pH value between 5.5 to 6.5.
- Microbial activity can increase the infiltration rate and vice versa, the infiltration rate can also affect the speed of microbial activity. This relationship can be seen at EC levels of 600 to 700 uS/cm that form soil porosity with an infiltration rate of 20 to 40 cm/hour.
- 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.
- Biosoildam can be called "Active Infiltration System" since it involves microbial activities that can be useful for:
  - Expanding soil porosity that increases oxygen content as a source of soil health.
  - Increasing macro and micro soil nutrient content of the biomass elements that the microbes break down in the distribution zones from the biohole centre.
  - Improving saturated soils that have long been contaminated with chemical fertilizers and pesticides by the microbial degradation.

- Biosoildam Ability
- Respond to Biomass Parameters such as EC, Acidity, Themperature, Humidity precisely & accurately
- Display & record biomass parameters into infographics and table info for every second, minute, hour, day, week and month.
- Monitoring of biomass parameters can be done via a smart phone in real time on a very large agricultural land
- Facilitate and accelerate the assessment of all existing standards so that : Save water , Save nutrition, Continuously increase soil and plant immunity, Increasing crop yields cognitively
- Benefits of Biosoildam
- Reducing Agricultural Production Costs
- Increasing Harvest Production
- Increasing fertility and sustainability of organic agriculture
- Generating Economic Value in Multi Player Effect
- Able to face global climate change

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