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BIOHOLE EFFECTIVENESS ANALYSIS THROUGH THE DISTRIBUTION PATTERN OF MICROBES AT EACH DEPTH BY IOT ON MARGEL

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Abstrak

This research was conducted on margel soil, especially for plantations, with the aim of not only restoring the health and fertility of the soil due to the use of chemical fertilizers and pesticides as well as seeing the pattern of EC distribution at each depth from the center of the biohole based on the time of observation. Through controlled microbial activity, its spread through two types of biohole, namely horizontal and vertical biohole. This research observes in real time through soil parameter sensors connected to the micro controller to changes in soil acidity, infiltration rate, conductivity electrolyte level and porosity level through soil infiltration rate. Through simulations with 2 types of biohole, it can be seen the increase in EC in each depth to the time of observation in real time. From the observations of graphs and EC standards, it can be seen that the ability of the soil to provide nutrients in the root growth zone to support the schedule and distribution patterns of planting both during vegetative growth and generative growth periods. So that we will know the proper biohole distance and spacing in order to be able to provide vegetative and generative mass nutrition based on nutrient values monitored through sensors that change the analog parameters in the micro posesor into digital information transmitted by wifi in real time. Sand coastal soil fertility simulation based on the number of microbial populations = 10 8 / cfu with Variable 1: Soil Fertility Value or Electrolyte Conductivity / EC at a depth of 24 cm from 487 uS / cm to 1123 uS / cm on day 33 and from 1164 uS / cm down to 786 uS / cm on day 40. Varibale 2 : Soil Fertility Value or Electrolyte Conductivity / EC at a depth of 27 cm from 457 uS / cm up to 857 uS / cm on day 33 & from 892 uS / cm down to 774 uS / cm on day 39.

Key Words: Biohole, Microbial, Margel, Micro Controler, Horizontal Biohole, Vertical Biohole, Soil Acidity, Infiltration, Electrolyte Conductivity, Biosoildam.

Introduction

The potential of margel land is very large for agricultural business, but the structure of this soil layer is also easily damaged if managed incorrectly. The ability of farmers also needs to be improved, especiallyin understanding the characteristics of this soil. So that

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with Biosoildam technology it will save fertilizer use and increase crop production while preserving natural resources through soil and water conservation.

The current decline in carrying land capacity continues to expand (environement degradation) (Rees, 2018). 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) (Widiasmadi, 2022). 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 (Liu et al., 2011). 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, 1988). 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, 2013).

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 (Widiasmadi, 2022). 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 (Widiasmadi, 2022) 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 (Widiasmadi, 2020b). 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 (Widiasmadi, 2022). 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 (Widiasmadi, 2022).

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 (Wasisto, 2018).

Methods

To maximize yields, optimal soil nutrient content is required ranging from vegetative growth to generative growth so as to save the use of organic fertilizers and other nutrients. This research is to observe the number of microbes that spread radially through the horizontal & vertical biohole as the center of microbial distribution which is observed in real time using soil parameter sensors. This research will show soil characteristics in its ability to increase natural fertility and the ability to nourish the soil from toxins that come from water and air pollution.

The study was conducted on alluvial land which for decades has been the source of livelihood for the community of Jakenan Village Pati Regency Central of Java. 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 – Juli 2019, 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, ruler, Stop watch, plastic bucket, tally sheet, measuremet glass, micro scale, hydrometer dan water (Douglas, 1988).

Determining plot and sensor points

To determine plots and sensors, this study uses purposive sampling at distances 3 metre from the center of Biohole with a diameter of 0,25 & 0,3 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, 1988).

Figure 1: Double Ring Infiltrometer & Sensors

Figure 2: Instalation of Double Ring Infiltrpmeter

Figure 3. Margel Layers

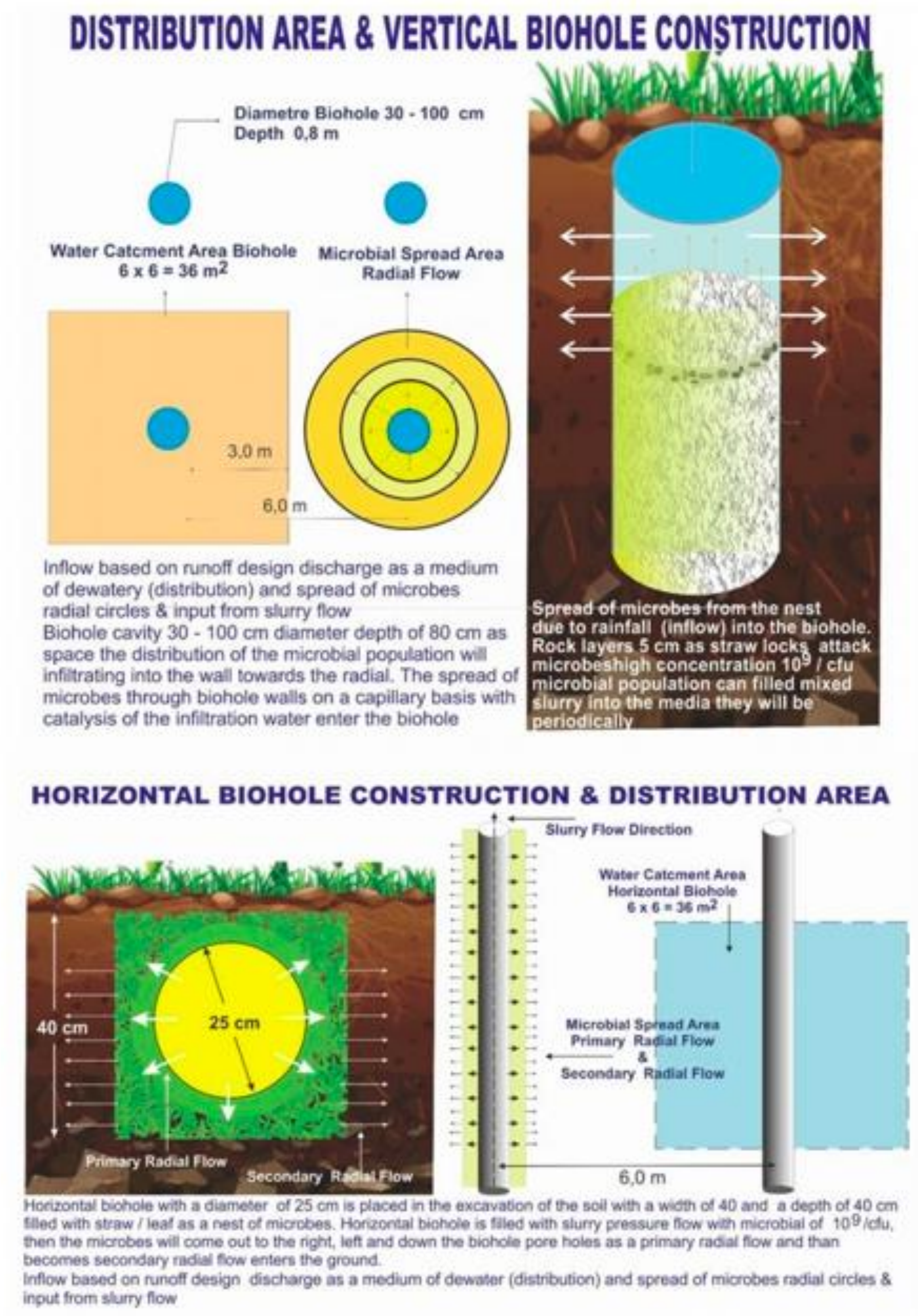


Figure 4. Distributiom & Biohole Structure

Data Processing

1. **Catalysis 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:

a) conducting a rainfall analysis,
b) calculating the catchment area, and
c) analyzing the soil/rock layers.

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

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

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

2. **Infiltration**

Infiltration is the process by which water on the ground surface enters the soil (Lili et al., 2008). It is commonly used in both hydrology and soil sciences. The infiltration capacity is defined as the maximum rate of infiltration. It is most often measured in meters per day but can also be measured in other units of distance over time if necessary. The infiltration capacity decreases as the soil moisture content of soils surface layers increases. If the precipitation rate exceeds the infiltration rate, runoff will usually occur unless there is some physical barrier. Infiltrometers, permeameters and rainfall simulators are all devices that can be used to measure infiltration rates. Infiltration is caused by multiple factors including; gravity, capillary forces, adsorption and osmosis. Many soil characteristics can also play a role in determining the rate at which infiltration occurs.

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

$f(t) = f_c + (f_o - f_c)e^{-kt}$ (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 (Widiasmadi, 2022).

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 distance from the centre of Biohole are converted in units of cm/hour with the following formula:

Infiltration rate = $(\Delta H/t \times 60)$ (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 & Shan, 1997). This observation takes place every 3 days for one month.

3. Soil Characteristics

The porosity of soils is critical in determine the infiltration capacity. Soils that have smaller pore sizes, such as clay, have lower infiltration capacity and slower infiltration rates than soils that have large pore size, such as sands. One exception to this rule is when clay is present in dry conditions. In this case, the soil can develop large cracks which leads to higher infiltration capacity.

Soil compaction is also impacts infiltration capacity. Compaction of soils results in decreased porosity within the soils, which decreases infiltration capacity. Hydrophobic soils can develop after wildfires have happened, which can greatly diminish or completely prevent infiltration from occurring.

Soil moisture content: Soil that is already saturated has no more capacity to hold more water, therefore infiltration capacity has been reached and the rate cannot increase past this point. This leads to much more surface runoff. When soil is partially saturated then infiltration can occur at a moderate rate and fully unsaturated soils have the highest infiltration capacity.

Organic materials in the soil (including plants and animals) all increase the infiltration capacity. Vegetation contains roots that extent into the soil which create cracks and fissures in the soil, allowing for more rapid infiltration and increased capacity. Vegetation can also reduce surface compaction of the soil which again allows for increased infiltration. When no vegetation is present infiltration rates can be very low, which can lead to excessive runoff and increased erosion levels. Similarly to vegetation, animals that burrow in the soil also create cracks in the soil structure.

4. 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 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

(Widiasmadi, 2020a)

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.

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 & Skrove, 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, thegreater 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) (Tian & Huang, 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 (Schwab, 2017). Thus, we can process analogue inputs of various soil parameters into digital information andprocess them via the web.

Results and Discussion

A. Rainfall Design and Frequency Duration Intensity (FDI)

The rainfall design intensity was determined using rainfall data from Pati Station in 2012-2018 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.

B. 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, 2018), 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.

C. Biohole Design

1. Vertical Biohole walls use natural walls with a 0.3 m diameter and a 0.8 m 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.
2. Horizontal Biohole walls use natural walls with a 0,25 m diameter and a 0.4 m 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 0.125 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.

D. Soil Coating Effect on Biohole

Table 2. EC rate for Vertical Biohole

DEPT H(M)	EC (uS/cm) DAY : MICROBIAL POPULATION 10^8 / CFU											
	5	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**
-2	446,0	446,0	446,0	546,0	446,0	446,0	446,0	446,0	446,0	446,0	446,0	446,0
-4	446,0	459,0	465,5	552,5	485,0	529,2	535,7	670,0	665,0	560,0	450,0	450,0
-6	446,0	465,5	472,0	630,5	663,0	698,1	704,6	590,0	570,0	465,0	460,0	555,0
-8	446,0	469,4	485,0	708,5	741,0	787,8	808,6	603,0	581,4	574,2	569,7	567,0
-10	446,0	472,0	485,0	721,5	754,0	796,9	817,7	652,5	594,0	586,8	576,0	573,3

DEPT H(M)	EC (uS/cm) DAY : MICROBIAL POPULATION 10^8 / CFU											
	5	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**
-12	446,0	478,5	498,0	734,5	767,0	871,0	824,2	666,0	627,3	594,0	580,5	577,8
-14	446,0	478,5	511,0	741,0	863,2	897,0	826,8	693,0	654,3	621,0	597,6	594,9
-16	446,0	485,0	537,0	754,0	863,2	897,0	904,8	747,0	708,3	675,0	651,6	648,9
-18	446,0	530,5	646,2	804,7	878,8	912,6	933,4	778,5	739,8	706,5	683,1	668,7
-20	446,0	595,5	811,2	869,7	943,8	977,6	998,4	823,5	784,8	751,5	728,1	713,7
-22	446,0	657,9	873,6	932,1	1006,2	1040,0	1076,4	877,5	838,8	805,5	782,1	767,7
-24	446,0	781,4	997,1	1055,6	1129,7	1163,5	1199,9	963,0	924,3	891,0	867,6	853,2
-26	446,0	720,4	1036,1	1094,6	1168,7	1202,5	1238,9	990,0	951,3	918,0	894,6	880,2
-28	446,0	790,5	1006,2	1064,7	1138,8	1201,2	1237,6	1035,0	958,5	917,1	893,7	879,3
-30	446,0	742,4	958,1	1016,6	1132,3	1194,7	1231,1	1039,5	963,0	921,6	889,2	874,8
-32	446,0	713,8	929,5	988,0	1103,7	1166,1	1202,5	1039,5	963,0	921,6	889,2	855,0
-34	446,0	622,8	838,5	954,2	1069,9	1132,3	1168,7	1035,0	958,5	917,1	884,7	850,5
-36	446,0	609,8	825,5	941,2	1056,9	1119,3	1155,7	1026,0	949,5	908,1	875,7	841,5
-38	446,0	530,5	799,5	915,2	1030,9	1093,3	1142,7	1017,0	940,5	899,1	866,7	832,5
-40	446,0	504,5	773,5	889,2	1004,9	1067,3	1116,7	999,0	922,5	881,1	848,7	814,5
-42	446,0	480,0	728,0	843,7	959,4	1060,8	1110,2	994,5	918,0	876,6	844,2	810,0
-44	446,0	476,0	702,0	817,7	952,9	1054,3	1103,7	990,0	913,5	872,1	839,7	805,5
-46	446,0	475,0	680,0	825,5	960,7	1062,1	1111,5	981,0	918,9	877,5	845,1	810,9
-48	446,0	470,0	660,0	825,5	960,7	1062,1	1111,5	967,5	905,4	864,0	831,6	797,4
-50	446,0	468,0	630,0	821,6	956,8	1058,2	1107,6	945,0	882,9	841,5	809,1	794,7
-52	446,0	466,0	610,0	819,0	923,0	1024,4	1073,8	921,6	859,5	818,1	785,7	771,3
-54	446,0	464,0	590,0	777,4	881,4	1006,2	1055,6	909,0	846,9	805,5	773,1	758,7
-56	446,0	460,0	570,0	711,1	815,1	939,9	1029,6	891,0	828,9	787,5	755,1	740,7
-58	446,0	455,0	565,0	652,6	756,6	881,4	971,1	850,5	788,4	747,0	714,6	700,2
-60	446,0	450,0	560,0	648,7	752,7	877,5	967,2	828,0	785,7	744,3	711,9	697,5
-62	446,0	446,0	550,0	647,4	751,4	876,2	965,9	810,0	767,7	726,3	693,9	679,5
-64	446,0	446,0	540,0	621,4	725,4	850,2	939,9	792,0	749,7	708,3	675,9	661,5
-66	446,0	446,0	446,0	485,0	596,7	774,8	864,5	720,0	677,7	636,3	623,7	620,0
-68	446,0	446,0	446,0	485,0	572,0	750,1	839,8	675,0	632,7	619,2	606,6	610,0
-70	446,0	446,0	446,0	485,0	465,5	620,1	709,8	660,0	620,0	609,0	608,0	605,0
-72	446,0	446,0	446,0	485,0	465,5	455,1	644,8	650,0	615,0	604,0	603,0	602,0
-74	446,0	446,0	446,0	485,0	465,5	455,1	479,8	630,0	610,0	603,0	602,0	600,0
-76	446,0	446,0	446,0	485,0	465,5	455,1	479,8	610,0	600,0	596,0	595,0	598,0
-78	446,0	446,0	446,0	485,0	465,5	455,1	479,8	600,0	592,0	591,0	590,0	594,0
-80	446,0	446,0	446,0	485,0	465,5	455,1	479,8	592,0	591,0	590,0	589,0	590,0
-82	446,0	446,0	446,0	485,0	465,5	455,1	479,8	588,0	587,0	586,0	585,0	587,0
-84	446,0	446,0	446,0	485,0	465,5	455,1	479,8	585,0	584,0	583,0	582,0	585,0
-86	446,0	446,0	446,0	485,0	465,5	455,1	479,8	585,0	584,0	583,0	582,0	583,0
-88	446,0	446,0	446,0	485,0	465,5	455,1	479,8	582,0	581,0	580,0	579,0	580,0
-90	446,0	446,0	446,0	485,0	465,5	455,1	479,8	575,0	574,0	573,0	572,0	575,0
-92	446,0	446,0	446,0	485,0	465,5	455,1	479,8	573,0	572,0	571,0	570,0	573,0
-94	446,0	446,0	446,0	485,0	465,5	455,1	479,8	571,0	570,0	569,0	568,0	570,0
-96	446,0	446,0	446,0	485,0	465,5	455,1	479,8	460,0	566,0	565,0	564,0	568,0
-98	446,0	446,0	446,0	485,0	465,5	455,1	479,8	460,0	560,0	460,0	562,0	565,0
-100	446,0	446,0	446,0	485,0	465,5	455,1	479,8	460,0	560,0	460,0	560,0	560,0

Table 3. EC rate for horizontal Biohole

DEPT	EC (uS/cm) DAY :

H (M)	MICROBIAL POPULATION 10^8 / CFU											
	5	10	15	20	25	30	35	40	45	50	55	60
-2	446,0	446,0	446,0	446,0	446,0	446,0	446,0	446,0	446,0	446,0	446,0	446,0
-4	446,0	459,0	472,0	478,5	440,0	450,0	470,0	479,0	467,0	460,0	457,0	455,0
-6	446,0	472,0	485,0	504,5	517,5	490,0	520,0	484,0	472,0	465,0	562,0	560,0
-8	446,0	485,0	591,5	511,0	530,5	582,5	608,5	489,0	477,0	570,0	567,0	565,0
-10	446,0	598,0	604,5	650,0	563,0	689,0	648,8	592,0	580,0	573,0	570,0	568,0
-12	446,0	604,5	621,4	663,0	695,5	708,5	767,0	600,0	582,0	575,0	572,0	570,0
-14	446,0	617,5	643,5	695,5	721,5	754,0	811,2	652,0	592,0	585,0	582,0	580,0
-16	446,0	617,5	676,0	715,0	761,8	806,0	864,5	677,6	650,0	628,0	592,0	590,0
-18	446,0	624,0	695,5	741,0	786,5	825,5	882,7	728,0	691,2	662,4	600,0	595,0
-20	446,0	624,0	702,0	747,5	829,4	851,5	903,5	800,0	784,0	720,0	640,0	600,0
-22	446,0	620,1	682,5	748,8	819,0	890,5	942,5	840,8	804,0	784,0	716,8	604,8
-24	446,0	611,0	644,8	728,0	799,5	897,0	968,5	842,4	823,2	784,0	736,0	624,0
-26	446,0	604,5	617,5	676,0	741,0	884,0	962,0	846,4	827,2	788,0	752,0	640,0
-28	446,0	598,0	611,0	637,0	676,0	793,0	884,0	830,4	811,2	772,0	625,0	624,0
-30	446,0	591,5	604,5	624,0	650,0	754,0	838,5	800,0	680,0	650,0	620,0	600,0
-32	446,0	585,0	598,0	611,0	637,0	682,5	780,0	750,0	640,0	600,0	571,0	570,0
-34	446,0	578,5	591,5	598,0	611,0	624,0	650,0	600,0	581,0	573,0	569,0	568,0
-36	446,0	559,0	585,0	585,0	598,0	604,5	604,5	590,0	578,0	570,0	566,0	565,0
-38	446,0	548,6	559,0	559,0	559,0	572,0	572,0	588,0	576,0	568,0	564,0	563,0
-40	446,0	446,0	446,0	552,5	552,5	562,9	562,9	583,0	571,0	563,0	559,0	558,0
-42	446,0	446,0	446,0	552,5	552,5	560,3	560,3	581,0	569,0	561,0	557,0	556,0
-44	446,0	446,0	446,0	549,9	549,9	556,4	556,4	579,0	567,0	559,0	555,0	554,0
-46	446,0	446,0	446,0	446,0	446,0	446,0	446,0	578,0	566,0	558,0	554,0	553,0
-48	446,0	446,0	446,0	446,0	446,0	446,0	446,0	575,0	563,0	555,0	551,0	550,0
-50	446,0	446,0	446,0	446,0	446,0	446,0	446,0	546,0	546,0	546,0	546,0	546,0

EC vs Depth Margel

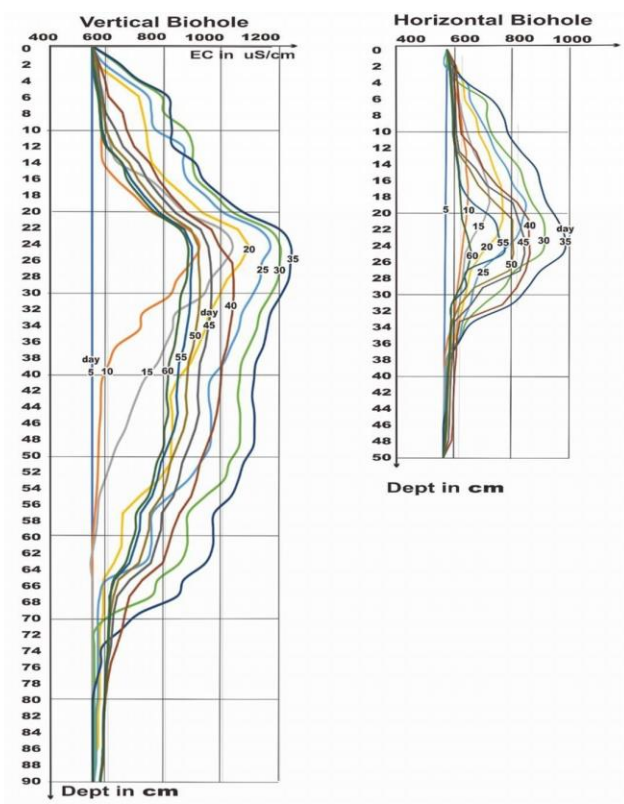


Figure 5. Graph of EC vs Depth

Margel soil fertility simulation based on biohole type with

1. Varible 1 = using vertical type Biohole diameter 30 cm depth 80 cm with microbial population 10^8/ cfu, recording soil parameters is done every 5 days for 60 days at every 10 cm depth.
2. Varibale 2 = using horizontal type Biohole diameter 25 cm depth 40 cm with Microbial Population 10^8/ cfu, recording soil parameters is done every 5 days for 60 days at every 10 cm depth.

The initial nutrient condition before simulating the soil fertility value with the Electrolyte Conductivity (EC) parameter is 546 uS / cm, a distance of 3 meters from the center of the Biohole. From one point for every 10 cm depth, the EC value was measured to a depth of 90 cm, which was observed in real time every 5 days.

E. The results of observations & recording on the Vertical Biohole variable are:

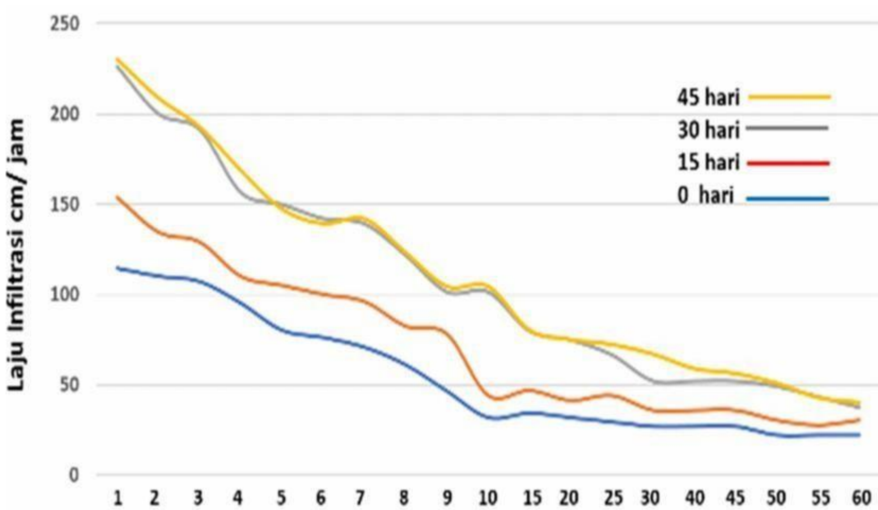
1. Value of soil fertility or Electrolyte Conductivity / EC at a depth of 10 cm
   a) from 430 uS / cm up to 729 uS / cm on day 35
   b) from 729 uS / cm down to 535 uS / cm on the 40th day
   c) from 535 uS / cm down to 493 uS / cm on the 50th day
   d) from 493 uS / cm down to 483 uS / cm on the 60th day
2. Soil Fertility Value or Electrolyte Conductivity / EC at a depth of 26 cm
   a) from 450 uS / cm to 1137 uS / cm on day 35
   b) from 1137 uS / cm down to 850 uS / cm on day 40
   c) from 850 uS / cm down to 798 uS / cm on the 50th day
   d) from 798 uS / cm down to 699 uS / cm on the 60th day
3. Value of soil fertility or Electrolyte Conductivity / EC at a depth of 40 cm
   a) from 450 uS / cm to 1012 uS / cm on day 35
   b) from 1012 uS / cm down to 895 uS / cm on day 40
   c) from 895 uS / cm down to 781 uS / cm on the 50th day
   d) from 781 uS / cm down to 713 uS / cm on the 60th day
4. Soil Fertility Value or Electrolyte Conductivity / EC at a depth of 60 cm
   a) from 450 uS / cm to 868 uS / cm on day 35
   b) from 868 uS / cm down to 722 uS / cm on day 40
   c) from 722 uS / cm down to 643 uS / cm on the 50th day
   d) from 643 uS / cm down to 593 uS / cm on the 60th day
5. Soil fertility value or Electrolyte Conductivity / EC at a depth of 74 cm
   a) from 450 uS / cm to 479 uS / cm on day 35
   b) from 479 uS / cm down to 530 uS / cm on day 40

c) from 539 uS / cm down to 593 uS / cm on the 50th day
d) from 593 uS / cm down to 600 uS / cm on the 60th day

F. The results of observation & recording on the Horizontal Biohole variable are:

1. Value of soil fertility or Electrolyte Conductivity / EC at a depth of 10 cm
   a) from 450 uS / cm up to 648 uS / cm on day 35
   b) from 648 uS / cm down to 492 uS / cm on the 40th day
   c) from 492 uS / cm down to 473 uS / cm on the 45th day
   d) from 473 uS / cm down to 468 uS / cm on the 60th day
2. Soil Fertility Value or Electrolyte Conductivity / EC at a depth of 24 cm
   a) from 450 uS / cm up to 868 uS / cm on day 35
   b) from 868 uS / cm down to 742 uS / cm on day 40
   c) from 742 uS / cm down to 684 uS / cm on the 45th day
   d) from 684 uS / cm down to 524 uS / cm on the 60th day
3. Soil fertility value or Electrolyte Conductivity / EC at a depth of 30 cm
   a) from 450 uS / cm up to 738 uS / cm on day 35
   b) from 738 uS / cm down to 739 uS / cm on day 40
   c) from 739 uS / cm down to 550 uS / cm on the 45th day
   d) from 550 uS / cm down to 598 uS / cm on day 60
4. Soil Fertility Value or Electrolyte Conductivity / EC at a depth of 40 cm
   a) from 450 uS / cm up to 467 uS / cm on day 35
   b) from 467uS / cm down to 483 uS / cm on day 40
   c) from 483 uS / cm down to 463 uS / cm on the 45th day
   d) from 463 uS / cm down to 452 uS / cm on the 60th day

INFILTRATION RATE ON MARGEL



Time (days)

Figure 6. Graph of Infilration Rate

G. 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 30 to 120 cm/h reached after 10 days with the value ranging from 300 to 600 uS/cm. The biological agent activities in alluvial soils with infiltration levels will be optimal on the 30th day.

Conclusion

In a layer of coastal sand that has a large enough porosity, the speed at which the EC value increases is large enough so that on the 35th day it has reached the maximum EC value. But it also experienced a rapid decline where after reaching the EC value at the peak point, the graph tends to decrease sharply until the initial EC value limit. So that the graphic pattern in the sand layer shows the dynamics of the dynamic EC value, namely rapidly rising and falling quickly. This pattern shows the very good properties of sand as a catalysis or a medium for transporting / spreading microbes, but very poorly as a holding medium for root development. So it is necessary to test the sand material as a filler and transport medium on soils that have good storage resistance but have low dispersibility such as clay & inceptisol.

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