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BIOHOLE EFFECTIVENESS ANALYSIS THROUGH THE DISTRIBUTION PATTERN OF MICROBES AT EACH DEPTH IN REAL TIME ON COASTAL SAND

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Abstract

This research was conducted on coastal sand, 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 26 cm from 550 uS / cm to 1238 uS / cm on day 35 and from 1238 uS / cm down to 990 uS / cm on day 40. **Varibale 2**: Soil Fertility Value or Electrolyte Conductivity / EC at a depth of 24 cm from 550 uS / cm up to 968 uS / cm on day 35 & from 968 uS / cm down to 842 uS / cm on day 40.

Keywords: biohole, microbial, coastal sand, micro controler, horizontal biohole, vertical biohole, soil acidity, infiltration, electrolyte conductivity, biosoildam

Introduction

The potential of *sand coastal* 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, especially in understanding the characteristics of this soil. So that with Biosoildam technology it will save fertilizer use and increase crop production while preserving natural resources through soil and water conservation.

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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) (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, 2018). 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, 2018).

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, 2020b). 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 (Dr, 2020b) 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 (Dr, 2020a). 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, 2020a).

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).

Method

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 Sanden Village Pandak District Bantul 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 – Juli 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, ruler, Stop watch, plastic bucket, tally sheet, measuremet glass, micro scale, hydrometer dan water (Douglas, 1988).

A. 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. Coastal Sand Layers

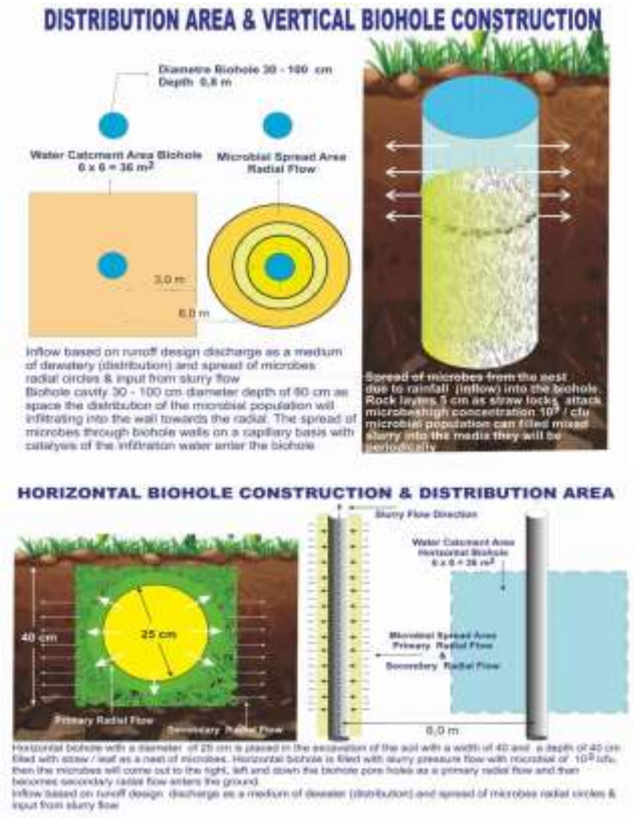

Figure 4. Distributiom & Biohole Structure

B. 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:

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 (Damayanti, 2011). 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. 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 decreases to a constant condition **fc**. One of the earliest infiltration equations developed by Horton is:

$f(t) = f_c + (f_o - f_c)e^{-kt}$ (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, 2019).

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 = (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) (Zhanbin, Lun, Suiqi, & Pute, 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 soils

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, 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.

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, 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 Laflen, Ph.D, Junilang Tian, Professor Chi-Hua Huang, 2011).

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 (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 and process 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 Bantul Station in 2008-2018 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 2013), 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^2 to 110 m^2 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

a) **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.

b) **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

If land is covered by impermeable surfaces, such as pavement, infiltration cannot occur as the water cannot infiltrate through an impermeable surface This relationship also leads to increased runoff. Areas that are impermeable often have storm drains which drain directly into water bodies, which means no infiltration occurs. Vegetative cover of the land also impacts the infiltration capacity. Vegetative cover can lead to more interception of precipitation, which can decrease intensity leading to less runoff, and more interception. Increased abundance of vegetation also leads to higher levels of evapotranspiration which can decrease the amount of infiltration rate. Debris from vegetation such as leaf cover can also increase infiltration rate by protecting the soils from intense precipitation events.

Sand soil is soil with large particles. This soil is formed from igneous and sedimentary rocks that have large and coarse grains or what is often called gravel. Sand soil has a low water fiber capacity because it is mostly composed of particles measuring 0.02 to 2 mm. Generally, sandy soils have not formed aggregates so they are sensitive to erosion. Elements contained in sandy soil are P and K elements which are still fresh and not ready to be absorbed by plants. In addition, there is also elemental N in very little levels. Sand soil is land that is spread quite a lot in the territory of Indonesia. Broadly speaking, this sand soil is divided into 3, namely:

1. Land of volcanic ash sand. This sandy soil is located in vulcanic fan areas, namely volcanic lava that flows downward in a widening shape like a fan.
2. Sand dunes This sand land usually exists in coastal areas.
3. Sedimentary rock with folded hill topography.

E. Characteristics of Coastal Sand

Sand soil does not contain water, minerals, and nutrients because the texture of the sandy soil is very weak. Sand soil also has low fertility so that very few plants can grow in sandy soil. Sand soil has a large cavity so that air exchange can run smoothly. In addition, sand soil is not sticky when wet, making sand soil easy to cultivate. Sand soil has a rough texture. There are large pore spaces between the grains so that this soil condition becomes a loose and loose structure. With such conditions, this sand soil has a low ability to bind water. Basically, sand soil is soil that is not suitable for use as a planting medium because the particles are large and can not hold water. When used as a planting medium, water will infiltrate, move down through the soil cavity, causing plants to lack water and wither.

The nutrient content in sandy soil is very limited. The phosphorus content is very little, around 5.1 - 20.5 ppm. The content of other organic matter is only around 0.4 -0.8 percent. The sodium content is around 0.05-0.08 percent and the potassium content is around 0.09-0.2 percent. This condition causes sand soil to be categorized as infertile soil. Apart from fertility, the sand surface temperature is also very high, generally above 30 degrees Celsius. This soil character is not very supportive for the growth of existing plants.

F. Sand Soil Improvement.

Because sand soil is infertile soil but because of its abundance in the territory of Indonesia, this area of sand soil can be used as reserve land or alternative land for maximum use. Efforts to improve sand soil so that it can be used as a planting medium requires the addition of organic matter. This organic material can be compost, manure, or peat. This organic material functions as a binder or adhesive. The sand grains that were originally loose and separated are bound with organic material to make them lumpy. With this mixing, the soil structure will then become crumbly. In addition, organic material which serves to absorb water. With this mixture of organic matter, finally the ability to store water increases. Organic matter, compost, or manure used to mix sandy soil is organic matter that has been ripe. The characteristics of ripe organic matter are black, odorless, and crumbly. However, if the material to be mixed is peat, it is better if half ripe peat is chosen. The characteristic of undercooked peat is that when the peat is crushed, the peat flakes that come out through the fingers are not much. The application of organic matter to sand soil is carried out with the right dose. The size of this organic matter is a minimum of 20 tonnes / ha. Apart from providing organic matter, another thing that needs to be considered is the provision of water which can be done by watering when sand soil is used as a planting medium. The nature of the sandy soil is easy to dry, so watering must be done regularly. Watering techniques in the dry season should be done more frequently than during the rainy season. In the dry season, watering can be done 2 to 3 times a day.

G. Utilization of Coastal Sand

Basically, sand soil is indeed low fertility soil. With good technology and processing techniques, this sand soil can be used for agricultural land. Various studies have been conducted to assess and improve the benefits of sandy soil. The aim of these studies is to make sand soil more productive. Sand soil that has been processed and adjusted to its needs can be used for the cultivation of chilies, shallots, dragon fruit plants, and so on. The principle is that the use of sand soil for agricultural land requires efforts to increase its fertility level so that the land changes according to the needs of the plant. This soil type is widely distributed in Bantul plains area.

Table 2
EC rate for Vertical Biohole

DEPTH (M)	EC (uS/cm) DAY : MICROBIAL POPULATION 10 ^{8} / CFU											
	5	10	15	20	25	30	35	40	45	50	55	60
-2	546,0	546,0	546,0	546,0	546,0	546,0	546,0	546,0	546,0	546,0	546,0	546,0
-4	546,0	559,0	565,5	552,5	585,0	629,2	635,7	570,0	565,0	560,0	550,0	550,0
-6	546,0	565,5	572,0	630,5	663,0	698,1	704,6	590,0	570,0	565,0	560,0	555,0
-8	546,0	569,4	585,0	708,5	741,0	787,8	808,6	603,0	581,4	574,2	569,7	567,0
-10	546,0	572,0	585,0	721,5	754,0	796,9	817,7	652,5	594,0	586,8	576,0	573,3
-12	546,0	578,5	598,0	734,5	767,0	871,0	824,2	666,0	627,3	594,0	580,5	577,8
-14	546,0	578,5	611,0	741,0	863,2	897,0	826,8	693,0	654,3	621,0	597,6	594,9
-16	546,0	585,0	637,0	754,0	863,2	897,0	904,8	747,0	708,3	675,0	651,6	648,9

-18	546,0	630,5	746,2	804,7	878,8	912,6	933,4	778,5	739,8	706,5	683,1	668,7
-20	546,0	695,5	811,2	869,7	943,8	977,6	998,4	823,5	784,8	751,5	728,1	713,7
-22	546,0	757,9	873,6	932,1	1006,2	1040,0	1076,4	877,5	838,8	805,5	782,1	767,7
-24	546,0	881,4	997,1	1055,6	1129,7	1163,5	1199,9	963,0	924,3	891,0	867,6	853,2
-26	546,0	920,4	1036,1	1094,6	1168,7	1202,5	1238,9	990,0	951,3	918,0	894,6	880,2
-28	546,0	890,5	1006,2	1064,7	1138,8	1201,2	1237,6	1035,0	958,5	917,1	893,7	879,3
-30	546,0	842,4	958,1	1016,6	1132,3	1194,7	1231,1	1039,5	963,0	921,6	889,2	874,8
-32	546,0	813,8	929,5	988,0	1103,7	1166,1	1202,5	1039,5	963,0	921,6	889,2	855,0
-34	546,0	722,8	838,5	954,2	1069,9	1132,3	1168,7	1035,0	958,5	917,1	884,7	850,5
-36	546,0	709,8	825,5	941,2	1056,9	1119,3	1155,7	1026,0	949,5	908,1	875,7	841,5
-38	546,0	630,5	799,5	915,2	1030,9	1093,3	1142,7	1017,0	940,5	899,1	866,7	832,5
-40	546,0	604,5	773,5	889,2	1004,9	1067,3	1116,7	999,0	922,5	881,1	848,7	814,5
-42	546,0	580,0	728,0	843,7	959,4	1060,8	1110,2	994,5	918,0	876,6	844,2	810,0
-44	546,0	576,0	702,0	817,7	952,9	1054,3	1103,7	990,0	913,5	872,1	839,7	805,5
-46	546,0	575,0	680,0	825,5	960,7	1062,1	1111,5	981,0	918,9	877,5	845,1	810,9
-48	546,0	570,0	660,0	825,5	960,7	1062,1	1111,5	967,5	905,4	864,0	831,6	797,4
-50	546,0	568,0	630,0	821,6	956,8	1058,2	1107,6	945,0	882,9	841,5	809,1	794,7
-52	546,0	566,0	610,0	819,0	923,0	1024,4	1073,8	921,6	859,5	818,1	785,7	771,3
-54	546,0	564,0	590,0	777,4	881,4	1006,2	1055,6	909,0	846,9	805,5	773,1	758,7
-56	546,0	560,0	570,0	711,1	815,1	939,9	1029,6	891,0	828,9	787,5	755,1	740,7
-58	546,0	555,0	565,0	652,6	756,6	881,4	971,1	850,5	788,4	747,0	714,6	700,2
-60	546,0	550,0	560,0	648,7	752,7	877,5	967,2	828,0	785,7	744,3	711,9	697,5
-62	546,0	546,0	550,0	647,4	751,4	876,2	965,9	810,0	767,7	726,3	693,9	679,5
-64	546,0	546,0	540,0	621,4	725,4	850,2	939,9	792,0	749,7	708,3	675,9	661,5
-66	546,0	546,0	546,0	585,0	596,7	774,8	864,5	720,0	677,7	636,3	623,7	620,0
-68	546,0	546,0	546,0	585,0	572,0	750,1	839,8	675,0	632,7	619,2	606,6	610,0
-70	546,0	546,0	546,0	585,0	565,5	620,1	709,8	660,0	620,0	609,0	608,0	605,0
-72	546,0	546,0	546,0	572,0	565,5	555,1	644,8	650,0	615,0	604,0	603,0	602,0
-74	546,0	546,0	546,0	572,0	565,5	552,5	579,8	630,0	610,0	603,0	602,0	600,0
-76	546,0	546,0	546,0	572,0	565,5	552,5	575,9	610,0	600,0	596,0	595,0	598,0
-78	546,0	546,0	546,0	572,0	565,5	552,5	560,3	600,0	592,0	591,0	590,0	594,0
-80	546,0	546,0	546,0	572,0	565,5	552,5	547,3	592,0	591,0	590,0	589,0	590,0
-82	546,0	546,0	546,0	565,5	559,0	552,5	546,0	588,0	587,0	586,0	585,0	587,0
-84	546,0	546,0	546,0	565,5	559,0	552,5	546,0	585,0	584,0	583,0	582,0	585,0
-86	546,0	546,0	546,0	565,5	559,0	552,5	546,0	585,0	584,0	583,0	582,0	583,0
-88	546,0	546,0	546,0	546,0	559,0	552,5	546,0	582,0	581,0	580,0	579,0	580,0
-90	546,0	546,0	546,0	546,0	552,5	549,9	546,0	575,0	574,0	573,0	572,0	575,0
-92	546,0	546,0	546,0	546,0	552,5	549,9	546,0	573,0	572,0	571,0	570,0	573,0
-94	546,0	546,0	546,0	546,0	552,5	549,9	546,0	571,0	570,0	569,0	568,0	570,0
-96	546,0	546,0	546,0	546,0	552,5	546,0	546,0	560,0	566,0	565,0	564,0	568,0
-98	546,0	546,0	546,0	546,0	552,5	546,0	546,0	560,0	560,0	560,0	562,0	565,0
-100	546,0	546,0	546,0	546,0	552,5	546,0	546,0	560,0	560,0	560,0	560,0	560,0

Table 3
EC rate for horizontal Biohole

DEPTH (M)	EC (uS/cm) DAY: MICROBIAL POPULATION 10^{8} / CFU											
	5	10	15	20	25	30	35	40	45	50	55	60
-2	546,0	546,0	546,0	546,0	546,0	546,0	546,0	546,0	546,0	546,0	546,0	546,0
-4	546,0	559,0	572,0	578,5	540,0	550,0	570,0	579,0	567,0	560,0	557,0	555,0
-6	546,0	572,0	585,0	604,5	617,5	590,0	620,0	584,0	572,0	565,0	562,0	560,0
-8	546,0	585,0	591,5	611,0	630,5	682,5	708,5	589,0	577,0	570,0	567,0	565,0
-10	546,0	598,0	604,5	650,0	663,0	689,0	748,8	592,0	580,0	573,0	570,0	568,0
-12	546,0	604,5	621,4	663,0	695,5	708,5	767,0	600,0	582,0	575,0	572,0	570,0
-14	546,0	617,5	643,5	695,5	721,5	754,0	811,2	652,0	592,0	585,0	582,0	580,0
-16	546,0	617,5	676,0	715,0	761,8	806,0	864,5	677,6	650,0	628,0	592,0	590,0
-18	546,0	624,0	695,5	741,0	786,5	825,5	882,7	728,0	691,2	662,4	600,0	595,0
-20	546,0	624,0	702,0	747,5	829,4	851,5	903,5	800,0	784,0	720,0	640,0	600,0
-22	546,0	620,1	682,5	748,8	819,0	890,5	942,5	840,8	804,0	784,0	716,8	604,8

-24	546,0	611,0	644,8	728,0	799,5	897,0	968,5	842,4	823,2	784,0	736,0	624,0
-26	546,0	604,5	617,5	676,0	741,0	884,0	962,0	846,4	827,2	788,0	752,0	640,0
-28	546,0	598,0	611,0	637,0	676,0	793,0	884,0	830,4	811,2	772,0	625,0	624,0
-30	546,0	591,5	604,5	624,0	650,0	754,0	838,5	800,0	680,0	650,0	620,0	600,0
-32	546,0	585,0	598,0	611,0	637,0	682,5	780,0	750,0	640,0	600,0	571,0	570,0
-34	546,0	578,5	591,5	598,0	611,0	624,0	650,0	600,0	581,0	573,0	569,0	568,0
-36	546,0	559,0	585,0	585,0	598,0	604,5	604,5	590,0	578,0	570,0	566,0	565,0
-38	546,0	548,6	559,0	559,0	559,0	572,0	572,0	588,0	576,0	568,0	564,0	563,0
-40	546,0	546,0	546,0	552,5	552,5	562,9	562,9	583,0	571,0	563,0	559,0	558,0
-42	546,0	546,0	546,0	552,5	552,5	560,3	560,3	581,0	569,0	561,0	557,0	556,0
-44	546,0	546,0	546,0	549,9	549,9	556,4	556,4	579,0	567,0	559,0	555,0	554,0
-46	546,0	546,0	546,0	546,0	546,0	546,0	546,0	578,0	566,0	558,0	554,0	553,0
-48	546,0	546,0	546,0	546,0	546,0	546,0	546,0	575,0	563,0	555,0	551,0	550,0
-50	546,0	546,0	546,0	546,0	546,0	546,0	546,0	546,0	546,0	546,0	546,0	546,0

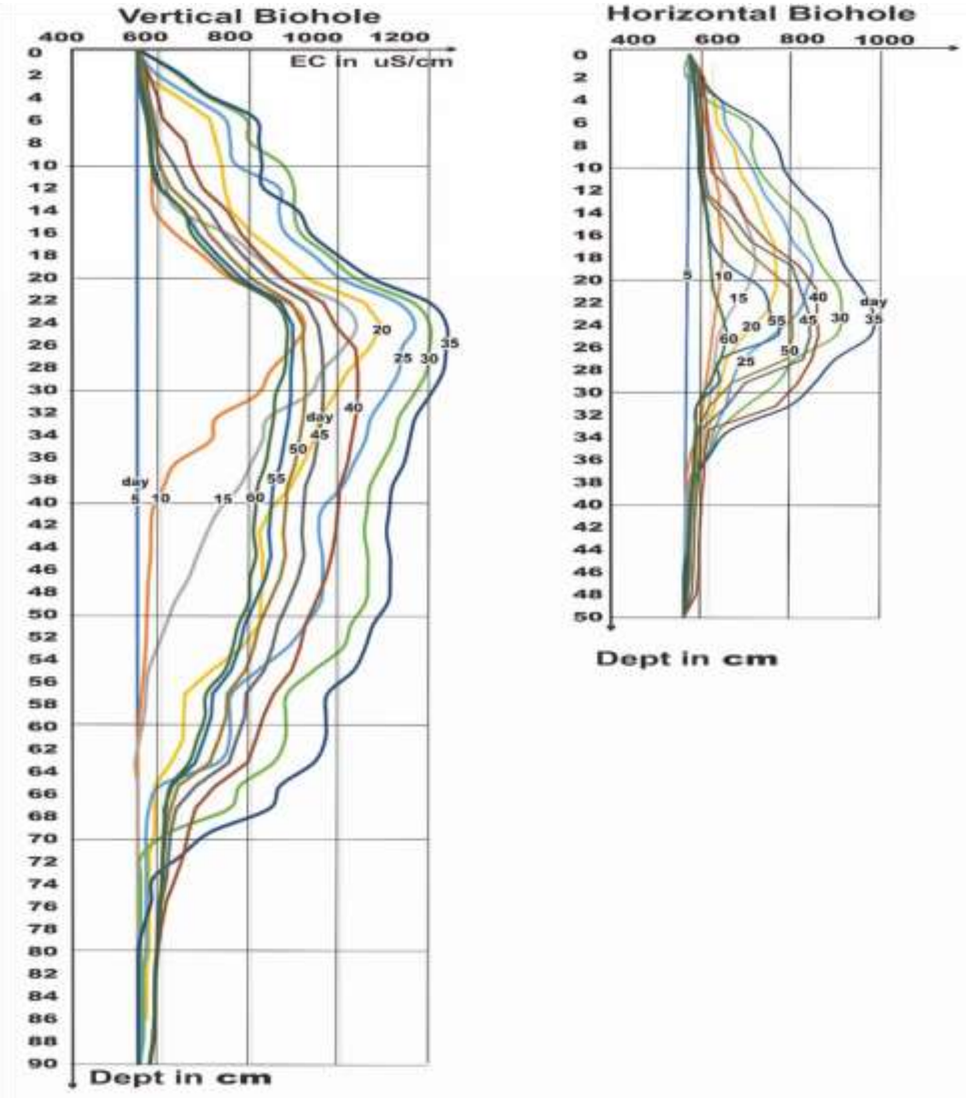

Figure 5. Graph of EC vs Depth

Coastal Sand soil fertility simulation based on biohole type with

- **Varibale 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.
- **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.

A. 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
      - from 550 uS / cm up to 817 uS / cm on day 35
      - from 817 uS / cm down to 652 uS / cm on the 40th day
      - from 652 uS / cm down to 586 uS / cm on the 50th day
      - from 586 uS / cm down to 573 uS / cm on the 60th day
   2. Soil Fertility Value or Electrolyte Conductivity / EC at a depth of 26 cm
      - from 550 uS / cm to 1238 uS / cm on day 35
      - from 1238 uS / cm down to 990 uS / cm on day 40
      - from 990 uS / cm down to 918 uS / cm on the 50th day
      - from 918 uS / cm down to 880 uS / cm on the 60th day
   3. Value of soil fertility or Electrolyte Conductivity / EC at a depth of 40 cm
      - from 550 uS / cm to 1116 uS / cm on day 35
      - from 1116 uS / cm down to 999 uS / cm on day 40
      - from 999 uS / cm down to 881 uS / cm on the 50th day
      - from 881 uS / cm down to 814 uS / cm on the 60th day
   4. Soil Fertility Value or Electrolyte Conductivity / EC at a depth of 60 cm
      - from 550 uS / cm to 967 uS / cm on day 35
      - from 967 uS / cm down to 828 uS / cm on day 40
      - from 828 uS / cm down to 744 uS / cm on the 50th day
      - from 744 uS / cm down to 697 uS / cm on the 60th day
   5. Soil fertility value or Electrolyte Conductivity / EC at a depth of 74 cm
      - from 550 uS / cm to 579 uS / cm on day 35
      - from 579 uS / cm down to 630 uS / cm on day 40
      - from 639 uS / cm down to 609 uS / cm on the 50th day
      - from 609 uS / cm down to 600 uS / cm on the 60th day

B. 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
      - from 550 uS / cm up to 748 uS / cm on day 35
      - from 748 uS / cm down to 592 uS / cm on the 40th day
      - from 592 uS / cm down to 573 uS / cm on the 45th day
      - from 573 uS / cm down to 568 uS / cm on the 60th day

2. Soil Fertility Value or Electrolyte Conductivity / EC at a depth of 24 cm
   - from 550 uS / cm up to 968 uS / cm on day 35
   - from 968 uS / cm down to 842 uS / cm on day 40
   - from 842 uS / cm down to 784 uS / cm on the 45th day
   - from 784 uS / cm down to 624 uS / cm on the 60th day
3. Soil fertility value or Electrolyte Conductivity / EC at a depth of 30 cm
   - from 550 uS / cm up to 838 uS / cm on day 35
   - from 838 uS / cm down to 800 uS / cm on day 40 from 800 uS / cm down to 650 uS / cm on the 45th day
   - from 650 uS / cm down to 600 uS / cm on day 60
4. Soil Fertility Value or Electrolyte Conductivity / EC at a depth of 40 cm
   - from 550 uS / cm up to 562 uS / cm on day 35
   - from 562 uS / cm down to 583 uS / cm on day 40
   - from 583 uS / cm down to 563 uS / cm on the 45th day
   - from 563 uS / cm down to 558 uS / cm on the 60th day

H. Infiltration Rate on Coastal Sand

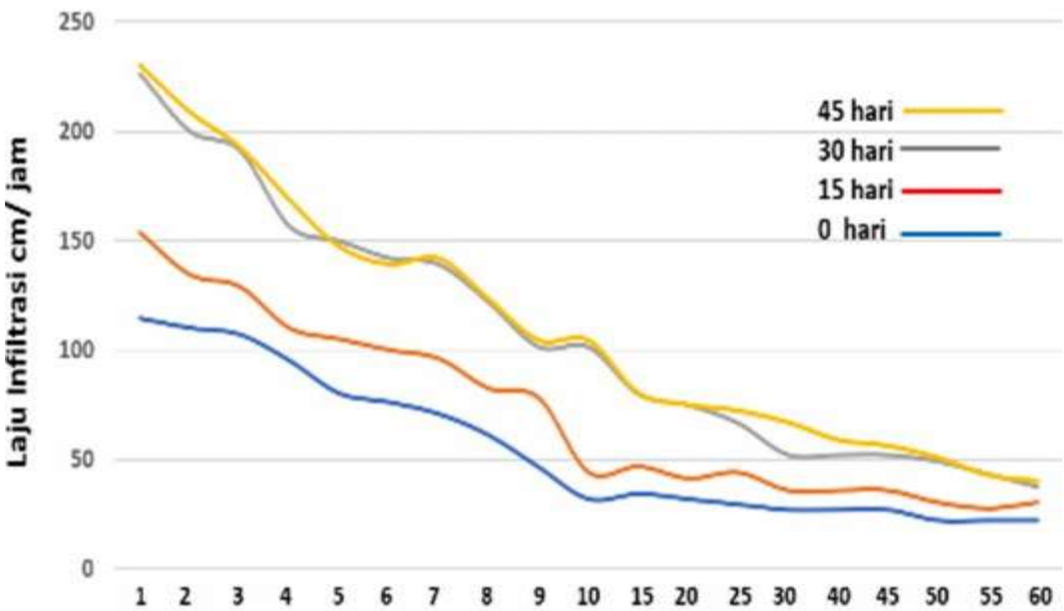

Figure 6. Graph of Infilration Rate

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 400 to 700 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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