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The effect of using biopore on soil fertility in karst area, District of Besuki, Tulungagung Regency

N I Khusna[1]*, S Amin[2], F Y Efrianinrum[3], A Bashith[4]
[1] Institut Agama Islam Negeri Tulungagung, Mayor Sujadi Street No.46 Tulungagung, Indonesia
[2,4] Department of Social Science Education, Faculty of Tarbiyah and Teacher Training, UIN Maulana Malik Ibrahim Malang, Gajayana Street No. 50 Malang, Indonesia
[2,3] Doctoral Student, Departmen of Geography Education, Faculty of Social Science, State University of Malang, Semarang Street No. 5 Malang, Indonesia

*ak.khusnaali@gmail.com

Abstract. The District of Besuki is one of the regions in Tulungagung Regency which has karst morphology. The karst area is identical to the condition of the land that is infertile. The use of biopore by incorporating organic waste into the biopore hole is expected to add nutrients in the soil so that it can increase soil fertility. This study aims to determine the use of biopore in improving soil fertility in Gambiran, Besole Village, district of Besuki, Tulungagung Regency. This type of research is an experiment. The level of soil fertility was measured by field observations and laboratory trials, such as pH meters, distilled water, and litmus paper. The results showed that the use of biopore could increased soil fertility in karst topographic areas. This is evidenced by a change in the soili.e.1) to turn soil color into dark brown; 2) to turn the texture of the soil into wet, clay, lots of leaf litter; 3) to increase Soil pH into balanced or neutral pH; and 4) to initiate land biota.

1. Introduction

Tulungagung Regency is a central part of the region of East Java province located in the south with an area of 1,055.65 km^2 [1]. The location of Tulungagung Regency which is in the south or south coast of Java Island results in this area being adjacent to the forearc zone. Forearc is the active fault zone. This area is rich in mining materials and natural resources. This is because the primary elements that make up the area of the forearc are particular [2].

The location of Tulungagung, which is near the forearc zone makes the southern part of Tulungagung, has a topography of the Karst region and produces mining goods. One of the famous mining items in Tulungagung is marble. Areas that have Karst topography generally referred to as limestone areas or areas that are rich in carbonate rocks. Indonesia is estimated to have a carbonate rock area of 15.4 hectares spread across several regions of Indonesia, and most of it is located in the southern province of Central Java-East Java [3].

One part of the area in Tulungagung Regency, Besuki sub-district, is one of the sub-districts that has karst morphology. Various typical natural features show that the domain is a visible karst region in this area where many limestone host rocks. The mining products are abundant compared to the other areas, and there is typical vegetation of the karst region, namely teak trees. From the data recorded by the sanitation POKJA in Tulungagung Regency, there is 88.72 ha of mining land used in Besuki from 123.53 ha of mining land located in Tulungagung Regency [4].

In addition to the advantages of the area in the Karst region, which is rich in mining materials, this region also has various problems that can harm places or creatures in the region. In earth science, karst is identified with a perishable area, where underlying rocks are readily soluble, and the soil is infertile [5]. Various threats can trigger damage in the area. Problems with the natural environment and erratic weather conditions add to the adverse effects of regions that have karst morphology. The high quantity of rainfall and unpredictable weather can increase the risk of natural disasters such as floods and landslides. This will have an impact on soil fertility in the area to be reduced [6] [7].

Therefore, sustainable management for the karst region needed that is environmentally friendly and can be carried out by all components of the community. The use of scientific facilities in the form of man-made products that are environmentally friendly needed as an effort to mitigate natural disasters, such as biopore. Based on the previous studies, there are some features of the use of biopore compared to other methods, namely: 1) to increase the absorption of groundwater; 2) to convert organic waste into compost; 3) to improve soil fertility; and 4) to make it easier and straightforward [8] [9].

The researcher hopes that the technology of making biopore infiltration holes can be used as a solution to increasing soil fertility. These infiltration holes are generally used in densely populated areas or areas that have minimal water catchment areas. This simple and environmentally friendly technology is still rarely used, and researchers previously suggested the need for action in the form of socialization to the public about the importance of using biopore.

2. Methods

This research design usedwas experimental research. Experimental research was a research conducted through experimental activities aimed at getting the intended results. This research employed quantitative research [10].

The instruments used in this study were 1) to measure water absorption utilizing a variety of tools such as double-ring infiltrometer, stopwatch, special ruler measuring the water speed; and 2) to measure soil fertility using field observations and various tools and materials in the laboratory, such as ph meters, distilled water, and litmus paper.

Methods of data collection consisted of observation and field studies; mapping; remote sensing; Interview; treatment/action in the form of infiltration measurements using a double-ring infiltrometer; and laboratory measurements to measure soil fertility.

Soil fertility can be measured by observing the soil around the study site and using a laboratory. The used soil samples are those without biopore (as a control variable) and those with biopore (as variables subject to action).

Data analysis using formulas:

$$R\ O1\ \ X\ \ O2$$

$$R\ O3\ \ -\ \ O4$$

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Information:

R	= control group and experiment taken by random method.
O1 & O3	= Both of these groups observed by carrying out the pretest.
O2	= variable that has been subject to quality control.
O4	= variable that is not subject to quality control.

The hypothesis was that if O2 was more significant than O1, the quality of control group had a positive effect. If O2 was smaller than O4, it had a negative impact [11].

3. Results and Discussion

3.1. Description of Pre-action Soil Fertility Data

Pre-action measures soil fertility is done as a pretest. The pretest is done by taking a sample at two, which is the same as the place for measuring water absorption. The following table shows the results of field and laboratory analysis of the pretest soil to determine its fertility.

Table 1. Field Observation and Soil Laboratory Test Results

No	Characteristics	Soil Condition	
		Site1	Site2
1.	Color	Light brown	Light brown
2.	Texture	Dry Hard	Dry Hard
3.	Particle Size	Small After adding water to the clay	Small After adding water to the clay
4.	Limiting factors for soil	Limestone	Limestone
5.	Soil pH	6	6,7
6.	Depth of soil layer	Shallow	Shallow
7.	Land biota	No	No
8.	Plants around	A little grass, cocoa trees	A small grass, cocoa trees
9.	pH of water	6,7	6,7

The characteristics of the soil at site 1 and 2 were similar,except for the soil pH.Site 1 had 6 soil pH, and site 2 had 6.7 soil pH. The soil characteristics were as follows: 1) the color was light brown, 2) the texture was dry hard, 3) particle size was small, 4) soil type was limestone, 5) the depth of soil was shallow, 6) biota was unavailable, 7) the plants were grass and cocoa trees, and 8) water pH was 6.7. From the table 1, it implies that the two samples used as pretest have almost similar characteristics or conditions.

3.2. Data Description of First Action on Soil Fertility

The first action to measure soil fertility was carried out at five predetermined points and was the same as the place for measuring water absorption. The data analysis of soil fertility obtained in the field and laboratory is as follows.

Table 2. The Results of Field Observation and First Action at Soil Laboratory Test

No	Characteristics	Soil				
		A	B	C	D	E (control)
1.	Color	Light brown	Light brown	Light brown	Dark black brown	Light brown
2.	Texture	Dry Hard	Dry Hard	Dry Hard	Dry more crumbs	Dry Hard
3.	Particle Size	Small	Small	Small	Larger,	Small

		After adding water to the clay	After adding water to the clay	After adding water to the clay	rough and hollow	After adding water to the clay
4.	Limiting factors for soil	Limestone	Limestone	Limestone	Limestone	Limestone
5.	Soil pH	6	6	6	6	6
6.	Depth of soil layer	Shallow	Shallow	Shallow	Shallow	Shallow
7.	Land biota	No	No	No	No	No
8.	Plants around	A little grass, cocoa trees	A small grass, cocoa trees	A little grass, cocoa trees	A little grass, cocoa trees	A little grass, cocoa trees
9.	pH of water	7	7	7	7	7

From observational and laboratory test data, soil characteristics from points A, B, C and Ewere similar, except for point D.The soil characteristics from point A, B, C, E were as follows: 1) the color was light brown, 2) the texture was dry hard, 3) particle size was small, 4) soil type was limestone, 5) the depth of soil was shallow, 6) biota was unavailable, 7) the plants were grass and cocoa trees, and 8) water pH was 7. While, the soil characteristics from point D weredark brown color, dry and more crumb texture, Larger, rough and hollow particle size, Limestone soil type, shallow depth of soil, unavailable biota, little grass and cocoa trees, and 7 for pH water. The characteristic differences were only at point D and point E. At point D, the color characteristics of the soil were dark-brown, dark-textured, more crumbly, and have a more substantial, coarser, and hollow particle size. As for the aspects of the soil properties at point E, it was light brown with hard, and dry soil texture.

3.3. Data Description of Second Action on Soil Fertility

In the second action, to obtain data on soil fertility was still the same as the previous action mechanism. Data on soil fertility analysis in the second action are as follows:

Table 3. The Results ofField Observation and Second Action at Soil Laboratory Test

No	**Characteristics**	**Soil**				
		A	**B**	**C**	**D**	**E (control)**
1.	Color	Dark brown	Dark brown	Dark brown	Dark brown	Light brown
2.	Texture	Wet, clay, lots of leaf litter	Wet, clay, lots of leaf litter	Wet, clay, lots of leaf litter	Wet, clay, lots of leaf litter	Dry Hard
3.	Particle Size	Small After adding water to the clay	Small After adding water to the clay	Small After adding water to the clay	Small After adding water to the clay	Small After adding water to the clay
4.	Limiting factors for soil	Limestone	Limestone	Limestone	Limestone	Limestone
5.	Soil pH	6,7	6	6	7	6
6.	Depth of soil layer	Shallow	Shallow	Shallow	Shallow	Shallow
7.	Land biota	Soil Ant	No	No	No	No
8.	Plants around	A little grass, cocoa trees	A little grass, cocoa trees	A little grass, cocoa trees	A little grass, cocoa trees	A little grass, cocoa trees

9.	pH of water	7	7	7	7	7

From observational and laboratory test data, soil characteristics from all points were similar, except for pH, biota, and color. The soil pH were varied, namely A (pH 6.7), B (pH 6), C (pH 6), D (pH 7) and E (pH 6). The soil colors from A, B, C, D wereDark brown, while the color of point E was light brown.The only biota found was at point A, while the other points were not found.

3.4. Data Description of Third Action on Soil Fertility

The third action was carried out one week after the second action. Soil fertility in the third action was measured at five points, such as the mechanism in previous actions. Data from observations and soil fertility lab tests in the third action are as follows.

Table 4. the result of Field Observation and Third Action at Soil Laboratory Test

No	Characteristics	Soil				
		A	B	C	D	E (control)
1.	Color	Dark brown	Dark brown	Dark brown	Dark brown	Light brown
2.	Texture	Wet, clay, lots of leaf litter	Wet, clay, lots of leaf litter	Wet, clay, lots of leaf litter	Wet, clay, lots of leaf litter	Dry Hard
3.	Particle Size	Small After adding water to the clay	Small After adding water to the clay	Small After adding water to the clay	Small After adding water to the clay	Small After adding water to the clay
4.	Limiting factors for soil	Limestone	Limestone	Limestone	Limestone	Limestone
5.	Soil pH	7,2	6,7	6,7	7,1	6
6.	Depth of soil layer	Shallow	Shallow	Shallow	Shallow	Shallow
7.	Land biota	Soil Ant, earthworms	No	earthworms	Soil Ant	No
8.	Plants around	A little grass, cocoa trees	A little grass, cocoa trees	A little grass, cocoa trees	A little grass, cocoa trees	A little grass, cocoa trees
9.	pH of water	7	7	7	7	7

From the data above, the characteristics of soil from all points were similar, except for color, texture, soil pH and biota.The colors from A, B, C, D were dark brown, while point E was light brown. Soil pH at point A, B, C, and D, were above 6. Soil biota was found at point A (ant, earthworms), C (earthworms), D (ant), while the other two points were not found. The texture from A, B, C, D were Wet, clay, lots of leaf litter, yet point E was dry hard.

Point E still had the same characteristics as last week, which showed a condition of infertility. In addition to soil pH and soil biota, the four points imposed by the action had the similar characteristics such as dark brown soil color, wet clay texture and lots of leaf litter, reduced soil particle size, presence of limiting factors in the form of limestone, shallow depth of soil, 7 water pH, and plants around the location were a little grass and cocoa trees.

3.5. Data Description of Fourth Action on Soil Fertility

The fourth action was the last action carried out by researchers in collecting data. The mechanism used in the previous step was still the same as the last mechanism through direct observation and testat the laboratory. Data from the fourth action to measure soil fertility are as follows.

Table 5. The results of Field Observation and Fourth Action at Soil Laboratory Test

No.	Characteristics	Soil				
		A	**B**	**C**	**D**	**E (control)**
1.	Color	Dark brown	Dark brown	Dark brown	Dark brown	Light brown
2.	Texture	Wet, clay, lots of leaf litter	Wet, clay, lots of leaf litter	Wet, clay, lots of leaf litter	Wet, clay, lots of leaf litter	Dry Hard
3.	Particle Size	Small After adding water to the clay	Small After adding water to the clay	Small After adding water to the clay	Small After adding water to the clay	Small After adding water to the clay
4.	Limiting factors for soil	Limestone	Limestone	Limestone	Limestone	Limestone
5.	Soil pH	7,2	6,7	7,0	7,1	6
6.	Depth of soil layer	Shallow	Shallow	Shallow	Shallow	Shallow
7.	Land biota	Soil Ant, earthworms	Soil Ant	Soil Ant, earthworms	Soil Ant	No
8.	Plants around	A little grass, cocoa trees	A little grass, cocoa trees	A little grass, cocoa trees	A little grass, cocoa trees	A little grass, cocoa trees
9.	pH of water	7	7	7	7	7

From the data above, the characteristics of soil from all points were similar, except for color, texture, soil pH and biota.The soil colors from A, B, C, D were Dark brown, while the color of point E was light brown. The texture from A, B, C, D were Wet, clay, lots of leaf, while point E was Dry Hard.The soil pH was varied i.e. A (pH 7.2), B (pH 6.7), C(pH 7.0), D (pH 7.1), E (pH 6). The biota was found at point A (ant and earthworm), B (ant), C (ant and earthworm), D (ant), while point E was not found.

The results of the research were that the use of biopores enhanced some elements of soil fertility i.e. 1) to turn soil color into dark brown; 2) to turn the texture of the soil into wet, clay, lots of leaf litter; 3) to increase Soil pH into balanced or neutral pH; and 4) to initiate land biota. Of the several elements that have changed, the soil made by the action gets additional nutrients. With the increased nutrients in the soil, the soil becomes more fertile than previous one.

3.6. Use of Biopori to Increase Soil Fertility

The research area that has a karst topography is very synonymous with infertile regions. According to the literature review and the real conditions in the field indicate that this area will lack agricultural land. Plants that grow there show homogeneous properties, some of which are in the form of teak plants in hilly areas and cocoa in the field of the yard. Soil conditions in this area appear dry and barren.

To obtain data accuracy about soil conditions, careful observation, and laboratory tests were conducted. At each point, it received similar treatments to get accurate data results. Similarly, in measuring water absorption, measurements of soil fertility are carried out at points, which also measured for water absorption.

The soil in the research area, which is originally rough becomes wet.The soil is loose as seen by the leaf litter. Soil nutrients at A, B, C, and D also increase which is marked with the color change of the soil, the leaf litter and the presence of several soil biota. The soil pH initially included a balanced criterion, but it was at the threshold of the limit value.After biopore technology was used, the soil pH was at the average value of neutral and balanced soil conditions. Neutral soil pH is a state of soil that is not acidic or alkaline.Neutrality of pH accompanied by indicators mentioned previously shows that the soil is fertile.

Table 6. Development of Soil Conditions

Indicator	Action 1	Action 2	Action 3	Action 4
Color	Dark black brown	Dark brown	Dark brown	Dark brown
Texture	Dry more crumbs	Wet, clay, lots of leaf litter	Wet, clay, lots of leaf litter	Wet, clay, lots of leaf litter
Particle Size	Larger, rough and hollow	Small After adding water to the clay	Small After adding water to the clay	Small After adding water to the clay
Limiting factors for soil	Limestone	Limestone	Limestone	Limestone
Soil pH	6	7	7,1	7,1
Depth of soil layer	Shallow	Shallow	Shallow	Shallow
Land biota	No	No	Soil Ant	Soil Ant
Plants around	A little grass, cocoa trees	A little grass, cocoa trees	A little grass, cocoa trees	A little grass, cocoa trees
pH of water	7	7	7	7

Based on the data in the table 6, it shows that the soil changes into better condition. The soil texture starts to change from dry and hard to wet, clay, and leaf litter. Soil pH also shows a balanced soil condition, not acidic or base. Biota in the soil isalso found after biopore was applied.

With the use of biopore, some indicators of soil fertility have changed to better conditions. we can compare this with the development of land conditions at point E without the use of biopore technology. At the point, E shows the consistency of the condition of the land which describes the soil as infertile. Various soil conditions, namely light brown soil, hard and dry texture, there are limiting factors for the soil, the absence of soil biota, and a pH of 6 is sufficient to indicate the condition of the soil that is not fertile.

Soil is considered fertile if it has profiles that aremore than 150 cm in-depth, has a loose structure, balanced soil pH(6.0 - 7.5),has sufficient nutrients for plants, and there is no limiting factor for the growth of a plantin the soil [12]. In addition, an area can be considered fertile ifthere are various kinds of plants that live well [13].

Based on the theory, land that is treated using biopore technology can become fertile soil [14] [15]. The soil in the research area, which is originally rough becomes wet. The soil is loose as seen by the leaf litter. Soil nutrients at A, B, C, and D also increase which is marked with the color change of the soil, the leaf litter and the presence of several soil biota. The soil pH initially included a balanced criterion, but it was at the threshold of the limit value. After biopore technology was used, the soil pH was at the average value of neutral and balanced soil conditions.Neutral soil pH is a state of soil that is not acidic or alkaline. Neutrality of pH accompanied by indicators mentioned previously shows that the soil is fertile.

The action within a month has shown the addition of nutrients to the soil and the better soil conditions if this action is carried out in a long time and is consistent then the condition of the soil will be good, and it expected that many plants could live in areas known for their sterility [16]. Thus, the use of biopore infiltration technology can increase soil fertility in the karst area.

4. Conclusions
The use of biopore can increase soil fertility in the karst topography area, especially Gambiran Hamlet, Besole Village, Besuki District, Tulungagung Regency. Several soil characteristics in the study area have changed after the action isconducted using biopore infiltration holes. During one month with four action times, the actions affect many differences on the soil elements showing the increased fertility. Some of these characteristics indicate that the result of using biopore infiltration holes can enhance soil fertility.

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