Test the Effectiveness of Biopore in the Framework of Eco-Campus Development at Universitas Pendidikan Indonesia

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Abstract. The purpose of this study was to test the effectiveness of biopore and to determine the number of biopore in the development of eco-campus UPI. The method used was experiments using biopore and infiltration engineering tools. The tool is placed on three test plots with different treatments, that is test plots placed in biopore holes but without grass, test plots only planted by grasses and biopore test plots and also planted with grass. Rainfall measurements were carried out for 19 days at the site of the test plot to determine the duration and volume of rain. The rainfall measurement results are then compared with the run off volume of each test plot. The results showed that biopore test plots with the highest effectiveness were biopore accompanied by grass plants. The calculation of the number of biopores around the piloting site at Faculty of Social Science Education of Indonesia University of Education is 28 biopore point. Therefore, in the development of eco-campus at Indonesia University of Education need to be considered biopore design that can increase the capacity of infiltration and reduce the run off. The number and distribution of biopore plots need to be considered, so their function can be more effective.

1. Introduction

Sustainable development has become a rational and responsible choice by many countries in the world. Around 178 countries have accepted and implemented the concept of sustainable development in their respective countries [1]. The concept of development is implemented in various fields. One of them is in the field of education. In sustainable education, there is an opportunity to educate young people who are open, have a philosophy that is responsible for the earth, environment, forests, energy and water conservation [2].

Eco-campus has the same meaning as green campus and sustainability university. For the first time the concept of green university is used by Tsinghua University in China. The concept was proposed to support green university in 1998. The main elements of green university should include policy, operations, evaluation, and optimization that need to be considered interactively [3]. An eco-campus requires a balance between economic, social and environmental objectives in the formulation of campus policy as well as the long-term thinking of current activities [4].
Universities that develop eco-campus use diverse issues. However, several issues often raised are the issues of transportation, water consumption, waste management and energy consumption. Transportation produces direct and indirect effects, so it should occupy a central position in university policy [5]. For initial action, other experts chose the issue of water consumption as an important issue. Efforts to reduce water consumption act as a preliminary action in sustainability practices at a university [6].

A number of experts also recommend the scope of development ecocampus i.e.: (1) sustainability in policy, planning, and administration (2) sustainability in the curriculum, (3) research and science, (4) campus operations, and (5) target and service [7]. a model 'the sustainable university classification model'. The concept of "LIFE" as an abbreviation of 'L' as the limit, 'I' as independent, 'F' as fundamental changes and 'E' as equity [8].

Indonesia University of Education or UPI as one of the campuses in Indonesia wishes to make its campus an Eco-campus. One phenomenon that occurs at UPI is the existence of massive campus development. As a result, a lot of open land is built up. The implication is that the infiltration area is more limited, so it can then reduce the amount of water that seeps into the soil. One solution to this problem is Biopore. Biopore is a cavity or pore in the soil resulting from the formation of living things such as soil fauna and plant roots [9]. Biopore are cylindrical holes made into soil with a diameter of ten to thirty centimeters [10].

Biopore is the choice of many people to make and use it. However, biopore themselves can be affected by settlements and low environmental awareness. In addition, the effectiveness of biopore varies, so it is necessary to continue testing its activities. The purpose of this study was to examine the effectiveness of biopore on the UPI campus with its various physical characteristics and to determine the number and distribution of biopore on the UPI campus. The results are expected to be a guide to future eco-campus development.

2. Method
The development of biopore as a piloting of Eco-campus development is based on the result of previous research which shows that surface run off still flow on UPI campus. This surface flow will be out into the environment around the UPI campus thus adding to the surface flow in the area. UPI has responsibility for the run off water can be infiltrated on campus, so that UPI become water impregnation area. A number of methods can be used to reduce runoff, one that is quite efficient and effective is biopore. Before developing biopore on campus UPI first test effectiveness of biopore at UPI campus with a number of physical characteristic that is land, vegetation and rain itself.

(a) 
(b) 

Figure 1. Biopore test equipment (a) Plate Box (b) Placement of biopore test equipment on open land.
In biopore development, biopore effectiveness test is done first with experimental design. The effectiveness test of biopore is done in UPI campus area. The tool used in the form of metal plate box measuring 1 m² and height 35 cm, bucket run off, simple rain gauge, soil drill to make a hole biopore, rainwater run off sample bottles, and pipe for biopore. Duration of effectiveness test is done within 19 days(Figure 1).

3. Result and Discussion

3.1. Biopore Effectiveness Test

Biopore test has been done using biopore and infiltration tools. Biopore and infiltration tools are installed in the parking, the field near the Indonesia University of Education Stadium. Selection of the site of biopore preferably in a place sufficiently free from human passage. Viewed from its function as a water vapor, the location of biopore is selected where the water will be gathered, or it could be by arranging for water to flow into the hole biopore. Water drainage can be done by making the grooves and biopore holes created at the end or at the base of the groove. The existence of the groove will make people avoid to step on. The measurements of the duration of rain and the volume of rainwater that is collected can be seen in the following table.

| Number | Measurement Time       | Rain Time Began | Rain Time Finish | Duration (minute) | Bottle Sample (ml) A | Bottle Sample (ml) B | Average |
|--------|------------------------|-----------------|------------------|-------------------|----------------------|----------------------|---------|
| 1      | Sunday, October 22, 2017 | 12.50           | 13.57            | 67                | 90                   | 90                   | 90      |
| 2      | Monday, October 23, 2017 | 15.38           | 16.43            | 65                | 180                  | 190                  | 185     |
| 3      | Monday, October 23, 2017 | 17.04           | 17.35            | 31                | 33.4                 | 41.7                 | 37.55   |
| 4      | Monday, October 23, 2017 | 22.52           | 23.27            | 35                | 4                    | 5                    | 4.5     |
| 5      | Tuesday, October 24, 2017 | 18.38           | 19.32            | 54                | 91.4                 | 90.3                 | 90.85   |
| 6      | Thursday, October 26, 2017 | 10.47           | 11.44            | 57                | 99                   | 81                   | 90      |
| 7      | Thursday, October 26, 2017 | 16.15           | 19.27            | 192               | 105                  | 99                   | 102     |
| 8      | Friday, October 27, 2017 | 15.35           | 18.19            | 154               | 87                   | 96                   | 91.5    |
| 9      | Saturday, November 4, 2017 | 11.35           | 12.28            | 53                | 220                  | 240                  | 230     |
| 10     | Saturday, November 4, 2017 | 21.08           | 22.04            | 56                | 40                   | 30                   | 35      |
| 11     | Monday, November 5, 2017 | 13.15           | 15.10            | 115               | 100                  | 120                  | 110     |
| 12     | Monday, November 6, 2017 | 18.23           | 20.44            | 141               | 140                  | 140                  | 140     |
| 13     | Tuesday, November 7, 2017 | 10.12           | 10.55            | 43                | 170                  | 170                  | 170     |
| 14     | Thursday, November 9, 2017 | 12.01           | 12.57            | 56                | 450                  | 430                  | 440     |
| 15     | Thursday, November 9, 2017 | 13.14           | 14.02            | 48                | 210                  | 190                  | 200     |
| 16     | Thursday, November 9, 2017 | 16.08           | 18.29            | 131               | 440                  | 440                  | 440     |
| 17     | Thursday, November 9, 2017 | 18.50           | 20.10            | 80                | 180                  | 200                  | 190     |
| 18     | Friday, November 10, 2017 | 12.04           | 14.01            | 117               | 620                  | 600                  | 610     |
| 19     | Saturday, November 11, 2017 | 15.26           | 17.11            | 105               | 300                  | 320                  | 310     |
| 20     | Saturday, November 11, 2017 | 18.11           | 19.32            | 82                | 260                  | 210                  | 235     |
| 21     | Sunday, November 12, 2017 | 18.21           | 00.04            | 343               | 550                  | 540                  | 545     |
| 22     | Monday, November 13, 2017 | 13.33           | 23.44            | 611               | 320                  | 325                  | 322.5   |
| 23     | Tuesday, November 14, 2017 | 15.22           | 16.43            | 81                | 120                  | 120                  | 120     |
| 24     | Tuesday, November 14, 2017 | 18.17           | 22.10            | 237               | 610                  | 620                  | 615     |
| 25     | Thursday, November 16, 2017 | 15.10           | 22.32            | 442               | 400                  | 390                  | 395     |
| 26     | Friday, November 17, 2017 | 13.45           | 17.03            | 198               | 560                  | 575                  | 567.5   |
| 27     | Saturday, November 18, 2017 | 12.48           | 15.17            | 149               | 25                   | 20                   | 22.5    |
| 28     | Sunday, November 19, 2017 | 12.41           | 19.43            | 422               | 260                  | 260                  | 260     |
Table 1 shows the result of measurement of rain duration and rain volume. Measurements were conducted within 19 days with the frequency of rain events as much as 28 times rain. The measurement results show that the minimum rainfall of 31 minutes and the maximum rainfall of 611 minutes. Rainfall collected in the bottle ranges from 6.5 mL - 615 ml and the mean rainfall amount is 6648.9 ml. Rainfall data is an input to test the effectiveness of biopore. Biopore test results can be seen in the following table 2.

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Table 2. Results of Biopore Effectiveness Measurement Test

| No  | Measurement Time          | Time (hours) | Rain Average (mm) | Rain Intensity (mm/jam) | Rain Volume (cm³) | Runoff Volume at condition Biopore Grass |
|-----|---------------------------|--------------|-------------------|------------------------|-------------------|------------------------------------------|
| 1   | Sunday, October 22, 2017  | 1.12         | 4.47              | 4.01                   | 4,474             | 0                                        |
| 2   | Monday, October 23, 2017  | 1.08         | 9.20              | 8.49                   | 9,197             | 0.4954                                   |
| 3   | Monday, October 23, 2017  | 0.52         | 1.87              | 3.61                   | 1,866             | 0                                        |
| 4   | Monday, October 23, 2017  | 0.58         | 0.22              | 0.38                   | 223               | 0.29724                                  |
| 5   | Tuesday, October 24, 2017 | 0.90         | 4.52              | 5.02                   | 4,516             | 0                                        |
| 6   | Thursday, October 26, 2017| 0.95         | 5.84              | 6.15                   | 5,844             | 0                                        |
| 7   | Thursday, October 26, 2017| 3.20         | 6.62              | 2.07                   | 6,623             | 0                                        |
| 8   | Friday, October 27, 2017  | 2.57         | 5.94              | 2.31                   | 5,941             | 0                                        |
| 9   | Saturday, November 4, 2017| 0.88         | 14.94             | 16.91                  | 14,935            | 0.39632                                  |
| 10  | Saturday, November 4, 2017| 0.93         | 2.27              | 2.44                   | 2,272             | 0                                        |
| 11  | Monday, November 5, 2017  | 1.92         | 7.14              | 3.73                   | 7,142             | 3.76504                                  |
| 12  | Monday, November 6, 2017  | 2.35         | 9.09              | 3.87                   | 9,090             | 0                                        |
| 13  | Tuesday, November 7, 2017 | 0.72         | 11.04             | 15.40                  | 11,038            | 2.477                                    |
| 14  | Thursday, November 9, 2017| 0.93         | 28.57             | 30.61                  | 28,571            | 12.8804                                  |
| 15  | Thursday, November 9, 2017| 0.80         | 12.99             | 16.23                  | 12,987            | 3.17056                                  |
| 16  | Thursday, November 9, 2017| 2.18         | 28.57             | 13.09                  | 28,571            | 10.2052                                  |
| 17  | Thursday, November 9, 2017| 1.33         | 12.34             | 9.25                   | 12,337            | 2.477                                    |
| 18  | Friday, November 10, 2017 | 1.95         | 39.61             | 20.31                  | 39,610            | 9.4126                                   |
| 19  | Saturday, November 11, 2017| 1.75        | 20.13             | 11.50                  | 20,129            | 1.9816                                   |
| 20  | Saturday, November 11, 2017| 1.37        | 15.26             | 11.17                  | 15,259            | 1.4862                                   |
| 21  | Sunday, November 12, 2017 | 5.72         | 35.39             | 6.19                   | 35,389            | 20.0142                                  |
| 22  | Monday, November 13, 2017 | 10.18        | 20.94             | 2.06                   | 20,941            | 8.4218                                   |
| 23  | Tuesday, November 14, 2017| 1.35         | 7.79              | 5.77                   | 7,792             | 9.908                                    |
| 24  | Tuesday, November 14, 2017| 3.95         | 39.94             | 10.11                  | 39,935            | 23.7792                                  |
| 25  | Thursday, November 16, 2017| 7.37        | 25.65             | 3.48                   | 25,649            | 7.431                                    |
| 26  | Friday, November 17, 2017 | 3.30         | 36.85             | 11.17                  | 36,850            | 10.4034                                  |
| 27  | Saturday, November 18, 2017| 2.48        | 1.46              | 0.59                   | 1.461             | 0                                        |
| 28  | Sunday, November 19, 2017  | 7.03         | 16.88             | 2.40                   | 16,883            | 0.9908                                   |

Table 1 shows the duration of rain during the measurement. Column 2 shows the average of rainfall from two rain gauges mounted on the UPI campus adjacent to the biopore test kits. Rain intensity is obtained from the amount of rain per unit time. The measurement results show the maximum rain intensity reaches 30.61 mm/hr and the smallest rain intensity reaches 0.38 mm/hr. The relationship between rainfall intensity and rainfall can be seen in the following graph.
Figure 2. Correlation between Rain Intensity (mm/hr) and Rain Duration (hr)

The picture above shows that the relationship between rainfall intensity and rainfall is a negative relationship. There is a trend of longer rain, less rain intensity, although the relationship is relatively small. This happens because generally the rain in a large intensity does not last long, and vice versa. Biopore effectiveness can be observed from the data of runoff water measurement results. The effect can be seen by comparing the 3 test plots, the test plots that are placed biopore holes but without grass, test plots that are only planted by grasses and biopore test plots and also planted with grass.

Figure 3. The relationship between rain intensity and run off on test plots with biopore, grass and biopore with grass
There is a tendency of test plots that only biopore still shows the existence of running water or run off. In plots that are only grass (without biopore) appear to run off more with a relatively more percentage compared to non-grass biopore. The run-off numbers appear very small on the test plots equipped with biopore and grass. The results of these measurements show that biopore without grass is not effective enough to reduce run-off rate. This can happen because water entering into biopores contains sediments that over time cover the pores of the soil in biopore holes and then decrease the ability of biopore to absorb runoff water.

In the test plots that are only planted by grass, surface runoff has tended to decrease compared to the plots placed in the biopore inside. However, there is still a runoff that is then accommodated in the bottle of water runoff. The existence of runoff on the plot is possible because the ability of the soil with grass on it will decrease in absorbing rainwater when the rain occurs continuously and in considerable intensity.

In the test plots that are placed biopore and the grass in it shows the runoff water does not occur despite the large rain intensity. The rain water entirely absorbs into the grassy soil and into the biopore hole. Consequently the runoff water vessel is not filled with water.

The results show that biopores will be effective in reducing surface runoff rates if accompanied by plant cover, eg grass plants. Installation of biopore alone without grass still shows surface runoff. In fact, the effectiveness is not better than just planted grass alone. If we compare it with the old variables of rain (hours) and rainfall (mm), in relation to the percentage of surface runoff the results show the same tendency. Biopore will be effective if accompanied by grass. The following figure illustrates the long-rain relationship with surface runoff and the amount of rainfall with surface runoff.

![Figure 4. The relationship between long rain and run off on test plots with biopore, grass and biopore with grass](image)

- Biopori
- Grass
- Biopore + Grass
3.2. Implementation of Biopore Piloting in Ecocampus Development Framework

Biopore experiment results show effective results in reducing run off. Therefore, the development of biopore for water conservation in UPI campus is feasible to be implemented. The next question is how many biopore holes should be made to effectively reduce the surface runoff rate. Since the piloting is done in Faculty of Social Science Education, then the first is how many effective biopore holes reduce run-off in the environment.

Table 3. Number of Biopore Every Catchment Area

| Catchment | Area (m²)   | Number of Biopore |
|-----------|-------------|-------------------|
| 1         | 25959.03429 | 67                |
| 2         | 30566.48755 | 79                |
| 3         | 46674.50926 | 120               |
| 4         | 23986.18591 | 62                |
| 5         | 39384.46796 | 102               |
| 6         | 42901.89793 | 111               |
| 7         | 13496.5186  | 35                |
| 8         | 60396.27876 | 156               |
| 9         | 47545.38129 | 123               |
| 10        | 41790.45311 | 108               |
| Total     | 926         |                   |

Total run-off in one year and percolation capacity at each catchment. Then the next thing is the determination of the number of biopore suggested by researchers to be made on UPI campus.
of the number of biopore is calculated by ratio between total runoff divided by percolation capacity. Then, obtained the number of biopore that must be made on the campus of UPI is 962 biopore. For the distribution of the 962 is based on the catchment area, so obtained the number of biopore that must be made on each catchment (Table 3).

As previously explained that Faculty of Social Science Education belongs to catchment 3 which consists of 120 biopore recommendations. Catchment 3 consists of Building Faculty of Economy and Business Education (Garnadi Building) to the gate of Isola Elementary School. After analyzing the land. The number of biopore for Faculty of Social Science Education building area is 28 points Biopore. The distribution of biopore points can be seen in Figure 6.

![Biopore Distribution at Piloting site Ecocampus at Faculty of Social Science Education UPI](image)

**Figure 6.** Biopore Distribution at Piloting site Ecocampus at Faculty of Social Science Education UPI

### 4. Conclusions

In general, biopore is able to reduce surface runoff. Biopore effectiveness test results indicate that biopore will effectively reduce the rate of surface runoff if accompanied by the presence of grass plants in the vicinity. Based on the calculation, at least 28 biopore needed to be made around the building Faculty of Social Science Education UPI Bandung.
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