Growth rate and survivorship of Acropora sp. fragments that transplanted on the artificial substrate made from fly ash and bottom ash

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Abstract. The purpose of this research is to analyze the success the transplantation method using kerbstone media from blocks made of coal waste (fly ash and bottom ash) from Thermal Power Station (PLTU). The research was done from March to August 2018 in the waters of Paiton, Probolinggo, East Java, Indonesia. The method applied in this research a 7-block design with “H” formation for every module. The coral fragments of Acropora formosa, Acropora pulchra, Acropora intermedia, and Acropora gomezi was 10 cm in average size with 30 repetitions for each size. The average growth rate showed different values during five months of research since the transplantation was done. Acropora formosa had the highest growth rate of 1.958 cm/month. Acropora intermedia 1.730 cm/month, Acropora pulchra 0.958 cm/month, and 0.756 cm/month for Acropora gomezi. By using Kruskal Wallis test for data analysing, obtained a survival rate of over 80% for all types, with Acropora formosa as the highest (92.3%) and Acropora gomezi as the lowest (82.61%). Therefore, kerbstone is considered feasible as a growth media for the coral reef as an effort to support CTI (Coral Triangle Initiative) program in overcoming global warming as an innovation.

1. Introduction
The bleached coral reefs could be naturally recovered when the environment pressure decreased. The environment supported the growth of coral reef, and symbiont algae could be re-recruited by the corals. This condition was allegedly playing a role in the coral recovery in Paiton water. Based on the hard coral cover enhancement as the primary component ecosystem forming a coral reef, an increase in hard coral cover occurred. The average percentage of hard coral cover in Paiton waters in 2013 was 73.38\% [1], in 2015 was 75.48\%; and in 2018 was 76.96\% [2]. Those values indicated that the coral reefs in Paiton waters were in good condition. The return of coral cover after disturbance became one of the recovery measures [3].

This research carries out a try out in coastal waters around PLTU Paiton using fly ash and bottom ash (faba) kerbstone as the coral transplantation growth media. Faba kerbstone is a product innovation similar to paving blocks/bricks made of fly ash and bottom ash (80\%), which is the dominant waste utilized by PT Jawa Power in the form of ash waste. Ash waste has been utilized as the raw material in paving block and brick making. Faba kerbstone has dimensions of length 40 cm, width 25 cm wide, and height 15 cm. The material was stated as harmless. (SK.183/MenLHK/Setjend/PSLB.3/3/2016) [4]. The
laboratory test result of ALS Indonesia about *Toxicity Characteristic Leachate Procedure* (TCLP) test of fly ash and bottom ash indicated that fly ash and bottom ash contained elements including magnesium, calcium, potassium, ferrum (iron) and silicate (SiO2) which were needed by coral planula larvae to settle in the form of juvenile corals. Therefore, it would give effect and contribute to the life needs of *acropora sp*. It also supported the speed of growth of *acropora sp* and provided a better value in waste utilization and rehabilitation efforts for the coastal waters environment, especially the coastal waters of the power plant (PLTU).

There were no artificial media/growth reefs made from ash waste of the power plant for coral transplantation until now. As an effort to enrich the ash waste, an innovation that contributes important values for coastal waters is needed. For this purpose, this research becomes essential as an effort to give a real contribution to supporting the recovery program of the world’s coral reef ecosystem.

The purpose of this research is to analyze the successful use of faba kerbstone transplantation method, which is a block made from coal ash waste of the power plant as a waste utilization effort and damaged coral reef rehabilitation due to the bleaching phenomena in 2016 in Paiton Waters, Probolinggo, East Java, Indonesia.

2. Material and Methods

2.1. Study site

This research was carried out from March to August 2018 in Paiton Power Plant waters in Probolinggo, East Java, Indonesia. The coordinate position of S 07°42’26.96” T 113°34’12.83” and location map of coral reef transplantation activities was presented in Figure 1.

![Figure 1. Research Site](image-url)
2.2. Preparation of substrate and coral transplants

This research used a field experiment method, that was a way to determine a causal relationship by giving one or more treatments and comparing the result to see the effect on the research object carried out in the field.

The method used in this result was the basic escape method with H-shaped kerbstone as the substrate with each unit (module) consisting of seven blocks of faba kerbstone. One unit of faba kerbstone had a size of 40 x 25 x 15 cm at a depth of 7-8 cm.

Every unit was made six holes as the place to stick out the coral fragment to be transplanted. The size of Acropora coral fragment used was 8 cm. The types that were transplanted were Acropora pulchra, Acropora formosa, Acropora intermedia, and Acropora gomezi. Each type was transplanted on five units of kerbstone.

Coral transplantation was carried out in March 2018. The observations on the growth of coral fragment that was planted once in two months for five months (March–August 2018) with intensive control on monitoring the coral growth by measuring the height of coral fragment using caliper. The care of coral fragment was carried out together with the observation process to prevent coral fragment deaths. Some activities carried out in the treatment process were checking the coral fragment position on the substrate, observing the coral fragment health, and cleaning the kerbstone substrate.

2.3. Data collection and analysis

2.3.1 Coral survival rate

In this study, the definition of “survival” for a fragment of coral was a specific fragment coral which still had a polyp in the coral structure, whether the coral bleaching occurred. (i.e., a coral was considered alive if there remained some living coral tissue).

2.3.2 Absolute growth

The coral growth within a certain time could be calculated using the following equation [5]:

\[ \beta = L_t - L_0 \]

Where:

\[ \beta \] = Growth (mm)

\[ L_t \] = Average height after the t-observation

\[ L_0 \] = Average height at the beginning of the study
3. Result and discussion
3.1. The growth rate of transplants
The result of the growth rate of coral fragment Acropora formosa, pulchra, intermedia, and gomezi in Paiton water is presented in Figure 3 below:

Figure 3. The Growth Rate of transplanted Acropora sp on faba kerbstone for Five Months

During five months since the Acropora corals transplanted, a different average growth rate was obtained. Acropora formosa had the highest rate of 1.958/month, Acropora intermedia of 1.730 cm/month, Acopora pulchra of 0.958 cm/months; and 0.756 cm/month for Acropora gomezi (Figure 3). The growth rate of the four types of Acropora was not to be compared since each of them had different morphological characters. This study intended to clarify if kerbstone was the suitable media for all types of Acropora.

3.2. Survivorship of transplant
After five months, Acropora was being transplanted on faba kerbstone substrate. They had different survival rates. Acropora Formosa had a survival rate of 82.61%; A. Pulchra had a lower survival rate of 80.95 %; A. Intermedia had 78.26 %; and 73.91% for the survival rate of A. Gomezi. It was indicated that both types of Acropora were commonly found in natural habitat in Paiton Waters’s environment.

Figure 4. The Survival rate of Acropora sp transplanted by FaBa kerbstone for five months
When the Kerbstone exposed to seawater, it would experience leaching as a result of a chemical and physical process [6]. This such leaching allowed calcium, magnesium, aluminum, and silicates (and other compounds in the kerbstone) to be diluted in the seawater, providing the minerals needed by the corals for biomineralization. Regarding this, coral fragments in the kerbstone were expected to have a higher growth rate than other types of transplantation media. The result of this result indicated that the growth rate of coral fragments of these four types of Acropora was not significantly different. This result was thought due to the relative needs of Acropora to those compounds. The difference in particle size of fly ash and bottom ash caused the washing process did not occur in a short time [7].

The growth rate of coral fragments transplanted on the kerbstone varied. It was thought to be caused by the contents of silica, alumina, magnesium, and calcium compounds in the material. The kerbstone contained 37.43% of silica, 20.62% of calcium, 10.99% of aluminium, and 6.74% of magnesium.

Silica was amorphous and would quickly harden when it was mixed with cement, forming calcium silicate compounds that were difficult to dissolve in the water [8].

4. Conclusion
The result of this research indicated that kerbstone made of coal ash waste (fly ash and bottom ash) could be used as the artificial reef unit for coral transplantation of Acropora sp. The utilisation of coal ash waste from the power plant was an effort to give a real contribution to support the world’s coral reefs ecosystem recovery.

5. References
[1] Saptarini D and Farid K M 2010 Proceeding Japan - Indonesia Workshop on Estuary and Climate Change 2010, Institut Teknologi Sepuluh Nopember. Surabaya. August 8 th -10th [Indonesia]
[2] Khasanah R I 2018 Monitoring Report of Paiton Coral reef. Probolinggo. East Java. [Indonesia]
[3] Berumen M L and Pratchett M S 2006 Coral Reefs. 25, 647-653
[4] Suprianto 2016 Inovasi Pengelolaan Limbah Bahan Berbahaya dan Beracun PLTU Paiton Unit 5&6. Jawa Power. Probolinggo. Fillapress. [Indonesian]
[5] Dent D and Young A 1981 Soil Survey and Evaluation. (London: George Allen and Unwin)
[6] Suprenant B 1991 Designing Concrete for Exposure to Seawater (USA: Magazine Engineering, University of Colorado)
[7] Muzaki F K 2019 Biodiversitas 20, 1555-1559
[8] Wikana I and Wantutrianus 2014 Pengaruh pemakaian fly ash abu batu sebagai penambah sebagian semen pada kuat tekan beton mutu tinggi. Majalah Ilmiah UKRIM 1: 41-52. [Indonesian]

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