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Development of Biological Understanding Materials For Architecture

Case study: Pineapple Fibre, "Nata de Coco", Waste Paper

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ABSTRACT
Construction and building waste have stimulated an environmental movement; from reuse and recycle activities to the development of biodegradable materials, these features have stimulated an instant trend in the global world. Conventional building material contributes to more pollution and warmer environment, and some may contain toxic or dangerous substances that can be harmful to humans and other organisms. This paper investigates three potential biodegradable materials that are easily found in Indonesia, namely: pineapple fibre, "Nata de Coco", and recycle paper. This study aims to create a base that is to develop more advanced biodegradable material research in the near future. The experimentation is planned to be possible at home or small industry; it is economical and userfriendly and can be equipped with simple instruments like household utensils. By doing so, the research intends to target a bigger audience for implementation, as the material can be easily produced and used at the domestic level. This method uses a trial to set the basis and development of biodegradable building material samples. Steps are generally divided by two: basic tests (heating, cooling, roasting, drying process) and starter (preserving, decomposition, reunification process). The result is a kick-starter in a powder form, tested to produce sample material sheets in order to present the prospective development of Indonesian biodegradable building materials.
Keywords: *Architecture, Biodegradable, Natural, Material, Sample*

1. INTRODUCTION

The phenomenon of world attention on building waste encourages the need to minimize the use of building and construction materials, including support for green environmental planning [1]. Recycling and reuse actions need to be considered as a planned effort to reduce building waste. Innovation and material discovery can contribute not only to reducing waste but also to achieving zero waste in green buildings. However, inspiration needs to study locality and familiarize yourself with the natural material that can be found around us [2]. The aim is to reduce the carbon footprint and pay attention to the material decomposition process cycle; this action needs to become our daily agenda, including its application to buildings. An awareness of biodegradable materials' importance can be planned to become building construction materials [3]. The benefits of the research are to develop the concept of biodegradable building materials based on local materials in order to foster a love of domestic natural materials and support the development of green building designs in Indonesia.

A Sustainable environment is one of the global directions in building design that receives serious attention; not only because of the effects of global warming but also because it involves many of the world's problems including its links to urban planning. Green building design contributes to the improvement of economic, social, political and cultural conditions from the use of community resources to building waste [1]. Based on environmental care, building construction waste is included in the percentage of serious waste problems to be considered [4]. One of the essential issues that locally and globally need to be implemented immediately include: waste minimization, recycling planning and the use of biodegradable building materials [5]. However, the process of reducing waste by recycling has not been categorized as a productive effort; the evidence is that 79% of waste destined for final disposal is still classified as waste [6].

Environmentalists, including architects in this context, need to be invited to take a role in planning strategies in making innovations to achieve zero waste architecture. Similarly, industry and users need to be allowed to develop building materials [1]. It means that the cycle and system in building design can invite active participation from direct actors so that in the future, they are actively aware of the actions of using products and are willing to take a role in waste treatment and the use of biodegradable materials. Inspiration is drawn and learned from natural materials and experimental tools that can be found at home and around the environment. The goal is that the natural process cycle's characteristics can not only be applied to building construction [3], but also in daily life. To take root in culture, memory, and design, landscape as a verb suggests the development of a symbiotic sample [7]. Biodegradable material needs to be found in the neighborhood and can be implemented on a home industry scale. This is the simplest development strategy for basic biodegradable materials, which are gradation and can be implemented on a minimum scale, before further development.

2. RESEARCH METHODS

The research chooses the material studied based on the criteria; 1) Easy to find around the environment; 2) Economical/cheap; 3) Ready; 4) Harmless; 5) Non-toxic; and 6) Natural. Forming material is divided into 3, namely; 1) Pineapple fibre as a representative fibre, has the character of insulation, in the form of threads and is often used in textiles, crafts and animal husbandry; 2) “Nata de Coco”, derived from liquid, translucent and translucent transparent fields, used as a food; 3) Recycled paper representation of sheets, formed from the pulp, field-shaped used for stationery, decoration, and crafts. Recycled paper representation of sheets, formed from the pulp, field-shaped used for stationery, decoration, and crafts.

This method uses a trial to set the basis and development of biodegradable building material samples. Steps are generally divided by two: basic tests (heating, cooling, roasting, drying, immersion process) and starter (preserving, decomposition, reunification process) (table 1).

Table 1 Trial Methods

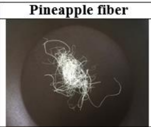
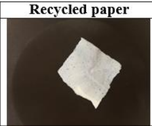
No	Method	Information
1	Heating Process	Use Teflon on the stove with an internal temperature of 75-100 degrees Celsius for 1-5 minutes until saturated exposure.
2	Cooling Process	Use a refrigerator with a temperature of 0-5 for 30 days.
3	Roasting process	I was using an orange-blue flame with the temperature of 1000-1500 degrees Celsius to produce coals/charcoal/burnt results.
4	Drying process	Direct exposure to sunlight for 30 days in Jakarta’s tropical temperatures varies from 22 degrees Celsius to 38 degrees Celsius, a maximum humidity of 80%, and winds of 15 km/hour.
5	Immersion process	Using H_2O (aqua, PH: 7) for 30 days. The condition of the material is submerged/half submerged.
6	Preserving Process	Lime powder ($CaCO_3$) dissolved in H_2O (aqua, PH: 7) as a variation of immersion process material considering the dominance of wood-containing test material. Preserving process material origin containing cane sugar ($C_{12}H_{22}O_{11}$) and salt (NaCl) and acetic acid ($C_2H_4O_2$)
7	Decomposition Process	Material is dried by the drying process, roasted, manually crushed with collisions, filters, and grated to produce a powder.
8	Reunification Process	Using H_2O (aqua, PH: 7) to produce a paste, then dried through drying process to produce solids.

3. RESULTS AND DISCUSSION

3.1 Basic Biodegradability Test

With the target of the ability to melt in the environment, biodegradable building materials need to be planned to be able to melt into nutrients that are nourishing the soil, plants, or become a food source for organisms. Smelting can occur through the influence of weather, microorganisms, or human intervention, for example, pouring certain substances or components into a material whose melting results are not harmful to the environment. Although the ability and results of the fusion vary; The ultimate goal of biodegradable building materials is to return to the landscape as its natural environment. Therefore, in this case, time determines the durability of the material that can determine its use as a temporary or permanent building material. Temporary building material means that the building material will biodegrade itself (automatically through decomposed time control), suitable for use in pavilions, camps, exhibitions, landscapes, and so on. Permanent building material means building materials will biodegrade with additional component interventions while remaining as useful as conventional building materials if not without intervention. Permanent building materials are suitable when used for simple houses, interiors, etc. Therefore, to test the level of material resistance, the following trials are carried out: while remaining as useful as conventional building materials if not without intervention. Permanent building materials are suitable when used for simple houses, interiors, etc. Therefore, to test the level of material resistance, the following trials are carried out:

Table 2 Heating Process

No.	Time	Pineapple fiber	“Nata de Coco”	Recycled paper
1	1st Minute			
2	2nd Minute			
3	3rd Minute			
4	4th Minute			

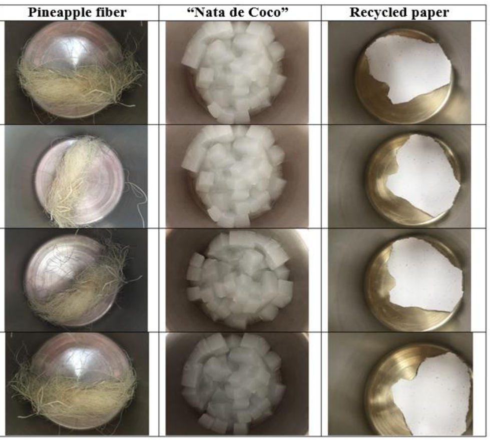
The findings on the heating process the material using Teflon on a stove with an internal temperature of 75-100 degrees Celsius for 1-5 minutes until saturated exposure refers to the following:

1. Pineapple fibres gather before grading partially roasting process and break down into fibre flakes.
2. “Nata de Coco” gradually shrinks, followed by a roasting process angle.

3. Recycled paper changes shape at the maximum temperature the flame ignites and burns.

Pineapple fibre in this trial is a biodegradable material because it is the least dense but leaves the most durable fibre structure. "Nata de Coco" material is the fastest to change shape because it contains a lot of liquid but is the most difficult to burn and leaves the most reliable material. Recycled paper is the hardest material to burn, but when ignited, embers will easily strike and produce the least solid structure (Table 2).

Table 3 Cooling Process



No.	Time	Pineapple fiber	"Nata de Coco"	Recycled paper
1.	1st Week			
2.	2nd Week			
3.	3rd Week			
4.	4th Week			

The findings of the cooling process the material using a refrigerator with a temperature of 0-5 for 30 days refer to the following:

1. Pineapple fibre does not show the significant shape and colour changes in the overall shape and fibre, becomes moist, but easily loses moisture when exposed to air outside the refrigerator.
2. "Nata de Coco" loses about 5-10% humidity every week, which affects the overall shape; it is difficult to lose moisture when exposed to air outside the refrigerator.
3. The recycled paper shows no change at all, minimal humidity, and does not easily lose moisture when exposed to air outside the refrigerator.

In general, only "Nata de Coco" shows significant deformation and moisture reduction due to its original water content, while others do not show significant deformation or humidity (Table 3).

Table 4 Roasting Process

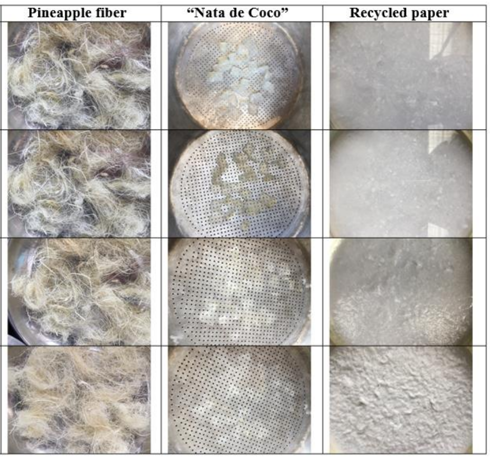
No.	Time	Pineapple fiber	"Nata de Coco"	Recycled paper
1.	5th Second			
2.	10th Second			
4.	-			
5.	-			

The findings on the roasting process using blue-orange fire with a temperature of 1000-1500 degrees Celsius to produce the following references:

1. Pineapple fibre burns unevenly, flammable on the outside, but fibre breaks make the clot core not flammable. The resulting burnt in the form of fine fibre charcoal.
2. "Nata de Coco" is the most difficult material to burn, beginning with shrinking, bubbles appear on the epidermis, roasting process of the epidermis into charcoal. Roasting process occurs per layer and leaves a lump of moist charcoal.
3. Recycled paper burns evenly immediately and becomes charcoal dust in a few seconds.

Its findings were that recycled paper was the most flammable material and produced the most brittle final waste as dust. Pineapple fibre is flammable only at the edges and leaves charcoal in the form of a rigid fibre structure. "Nata de Coco" is the most difficult to burn because it contains water and leaves a lump of charcoal that is moist and fused (Table 4).

Table 5 Drying Process



No.	Time	Pineapple fiber	"Nata de Coco"	Recycled paper
1.	1st Week			
2.	2nd Week			
3.	3rd Week			
4.	4th Week			

The findings in the form of the drying process in the form of direct exposure to sunlight for 30 days in tropical Jakarta temperatures vary from 22 degrees Celsius to 38 degrees referring to:

1. Pineapple fibre loses moisture, loss of humidity 20-30% every week depending on the weather, 75% dry in the 2nd and 3rd week. The texture changes from moist and soft, too stiff and rough, in the 4th week, there is a loss of fine fibre flakes.
2. “Nata de Coco” loses 10-15% humidity every week, and some decomposition process is aided by organisms such as bacteria and ants. Leaving 10% solid material translucent and fragile but flexible.
3. The pulp loses its moisture, the loss of humidity is 20-30% every week depending on the weather, preceded by the loss of the fusing liquid, leaving a paste, ending with a paste that dries 90-95% with fine dust and mildew on the surface.

Because of different characters, materials, and erratic weather situations, it isn’t easy to compare the three under the same conditions. However, because the exposure is carried out simultaneously, the three terms can be assessed for durability in the following order: Pineapple fibre, paper, and “Nata de Coco” while the biodegradability is sorted the opposite (Table 5).

Table 6 Immersion Process

No.	Time	Pineapple fiber	“Nata de Coco”	Recycled paper
1.	1st Week			
2.	2nd Week			
3.	3rd Week			
4.	4th Week			

The findings on the immersion process using H_2O (aqua, PH: 7) for 30 days with submerged material refer to the following:

1. Pineapple fibre is kept moist; the fibre’s overall texture remains moist; there are fine fibres that are detached from the fibre structure.
2. “Nata de Coco” does not undergo significant deformation but starts to give off an unpleasant odor.
3. Gradually recycled paper is destroyed but not completely destroyed.

In general, the immersion process mostly affects the structure of recycled paper; because, in addition to visually experiencing destruction, the texture of the paper becomes fragile. Pineapple fibre experiences mild destruction in only a portion of fine fibre. “Nata de Coco” does not appear to have been destroyed but has undergone a process of decay, which is indicated by smell (Table 6).

3.2 Changes Itself towards Biodegradable Building Materials

Nature change is the process of changing natural materials found around the environment to become compounds for designing biodegradable building materials. Through a series of trials, in this natural study materials found around are broken down into the smallest structures so they can be used as the basis for building biodegradable building materials. After being formed into a sample of biodegradable building materials, these natural materials still have similar characteristics to their origin, but have changed their function and durability so that they can be used as building materials. However, in this study, the experiment only focused on developing material samples and did not produce building materials that were ready to be commercialized.

Table 7 Preserving Process

No.	Time	Pineapple fiber	“Nata de Coco”	Recycled paper
1.	1st Week			
2.	2nd Week			
3.	3rd Week			
4.	4th Week			

The findings on preserving lime powder ($CaCO_3$) dissolved in H_2O (aqua, PH: 7) refer to the following:

1. Pineapple fibre does not experience significant changes compared with the conventional drying process, but lime makes the fibre feel coarser with the amount of loss of fine fibre more about 10-20% than just using water.
2. “Nata de Coco” does not seem to experience significant changes when compared with the conventional drying process, but when observed weekly changes, more fluid is lost. However, ants are rarely seen.
3. The recycled paper does not show significant changes when compared with the conventional drying process. However, lime powder is found on the surface of the paper, and no mould/fungus is found in the 4th week.

Preserving process does not change the overall shape and decomposition process when compared with the use of aqua; however, lime has been shown to accelerate the decomposition process while preventing ants, mould, or mildew on the material even though it leaves powder on the surface (Table 7).

Table 8 Decomposition Process

No.	Time	Pineapple fiber	"Nata de Coco"	Recycled paper
1.	1st Week			
2.	2nd Week			
3.	3rd Week			
4.	4th Week			

The findings in the decomposition process by the destruction of dry material through the drying process, roasting process, manually crushed with collisions, filters, and a grater to produce powder refers to the following:

1. Pineapple fibre produces the most varied description, namely fine fibres into powder of light grey and brown, the structure of the fibre partially becomes charcoal yarn grey and black. The collision produces powder with heterogeneous variations in colour and texture from light to dark.
2. "Nata de Coco" is the most difficult to decompose, producing the fewest descriptions. With the dominance of lumps of light grey and old grey, the decomposition process results still need to be dried/roasted for mutually perfect results.
3. Recycled paper produces a moderate amount of description, with high fragility and is dominated by dark grey and black dots with almost homogeneous colours.

In brief, the three materials produce contrasting results. In contrast, pineapple fibre produces the most breakdown with heterogeneous colour and texture variations. Paper waste shows the opposite character, while "Nata de Coco" is the most difficult to decompose (Table 8).

Table 9 Reunification Process

No.	Time	Pineapple fiber	"Nata de Coco"	Recycled paper
1.	1st Week			
2.	2nd Week			
3.	3rd Week			
4.	4th Week			

Integration is done by dissolving the breakdown results using H_2O (aqua, PH: 7) to produce a paste then dried through drying process to produce solids and refer to the following results:

Pineapple fibre produces a paste that is heterogeneous has a rough texture and does not blend perfectly. The resulting solids are the most fragile and show contrasting colours. The darker the colour of the texture of the solid, the more fragile the bonding material.

"Nata de Coco" produces chewy pasta with uneven colours. The fusion process results in a gradation of change from the slimy paste, the doughy dough then produces a chewy solid. However, there are gradations of texture colour in the final result.

Recycled paper produces a paste that blends perfectly in both colour and texture; however, the final result shows the fragility and is most easily overgrown with mould or mildew.

In general, "Nata de Coco" produces a unique texture with a moderate level of integration. Recycled paper produces results similar to the original form with a high degree of fusion, while pineapple fibre produces the most fragile heterogeneous solids (Table 9).

4. CONCLUSIONS

Research focusing on developing three materials with different characters exposes contrast, which can open up variations in function. However, research has the disadvantage that even if the three types of material are compared by doing the same specific exposure, the three materials cannot be exactly treated, both from the handling and during the process of changing nature. The final process that transforms processed into powder form has opened opportunities for even more parallel treatment and proved the development of this material can be done on a household scale. Through this research, it can be concisely concluded that pineapple fibre has the strongest structural strength, making it the most difficult to decompose. The shape of the fibre resembles a thread causing pineapple fibre cannot be unravelled evenly at the same time. However, pineapple fibre has the potential to be good insulation of sound, fire, water, which is higher than other materials. "Nata de Coco" has a high liquid, flexible, translucent, fire insulator and can be developed into a non-combustible material.

However, "Nata de Coco" is susceptible to heat exposure, is easily deformed due to changes in temperature, and becomes a magnet for organisms so that decomposition process time is more difficult to control. Recycled paper has a material homogeneity, high adhesion easily blends with additional material and has moderate decomposition process time so that it is easily controlled. However, recycled paper is combustible, destroyed by liquid. It can be fatal because it is most structurally fragile in certain situations and conditions.

The final sample in the form of processed materials still showed variations in character according to each material's strengths and weaknesses even though it was in the form of solids even though the change in shape, durability, and ease of mixing became easier. The results of this study can develop further research, for example, to examine derivative materials, combination materials, and the development of prototype functions and other fields: landscape, interior, or exterior.

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