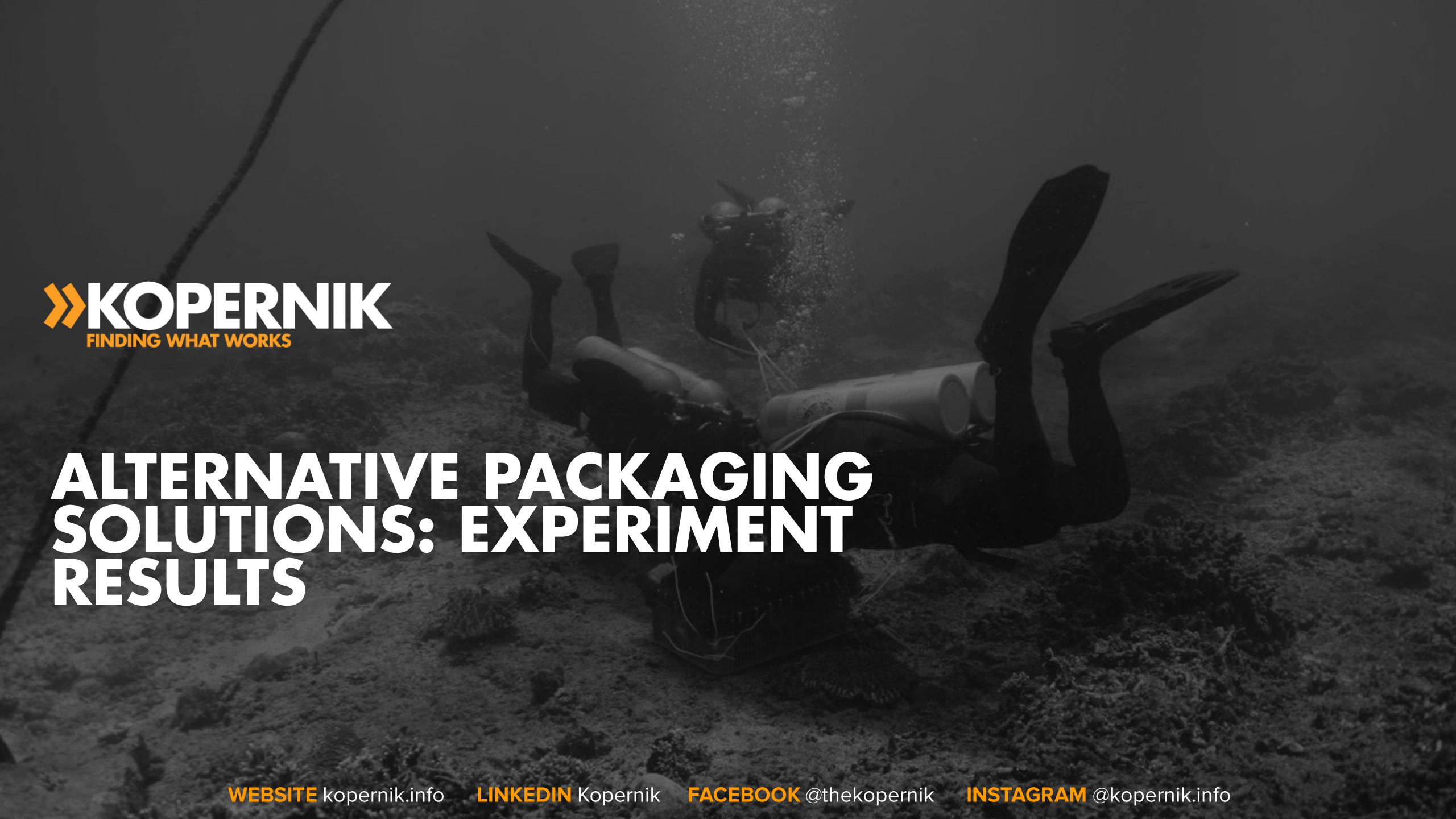

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ALTERNATIVE PACKAGING SOLUTIONS: EXPERIMENT RESULTS

Photo Credit: Livingseas

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THE PROBLEM

Indonesia generates around 6.8 million tonnes of plastic waste per year, with this figure growing by 5%, annually. The flow of plastic waste into the country's water bodies is projected to grow by 30% between 2017 and 2025, from 620,000 tonnes per year to an estimated 780,000 tonnes per year.[1]

The amount of plastic that's actually recycled is very small - globally, only 9% of plastic ever produced has been recycled, while 12% is incinerated, and 79% has accumulated in landfills or the natural environment.[2] The most commonly found items found in the natural environment during clean up events are plastic food wrapping, plastic cups and bottles, plastic bags, plastic straws and styrofoam packaging.[3]

Indonesia's informal sector of waste pickers only collects the types of post-consumer packaging with sufficient value on the recycling market. In Indonesia, the flexible/soft plastics, such as sachets, plastic bags and straws, lack sufficient value to be collected and recycled and therefore are more likely to end up in landfills or in the open environment.

1. https://globalplasticaction.org/wp-content/uploads/NPAP-Indonesia-Multistakeholder-Action-Plan_April-2020.pdf
2. https://advances.sciencemag.org/content/3/7/e1700782.full
3. http://ppid.menlhk.go.id/siaran_pers/browse/1696

THE SOLUTION

As awareness around the challenges associated with single-use plastics increases, there are more efforts to develop environmentally friendly alternative packaging solutions that can degrade quickly. There are commercially available packaging alternatives to conventional plastics which are marketed as “Biodegradable”, or “Compostable” (typically within 3-6 months), as well as “oxo-biodegradable” (all referred to in this experiment as ‘packaging alternatives’).

Because many of the packaging alternatives look like conventional plastic they are likely to be disposed of in a similar way to conventional plastic.

We therefore wanted to conduct an experiment to see whether the packaging alternatives degrade in the expected time periods should they end up in a range of environments that are typically polluted by plastic, or if they pose similar pollution challenges to those caused by conventional plastics. The experiment aims to record the degradation of packaging alternatives over a six-month period in various real-life environments.

THE EXPERIMENT DESIGN

The aim of this experiment was to analyze if alternative packaging can provide solutions for conventional plastic pollution by determining if they degrade fast enough to prevent pollution. We therefore created a photo record to analyze if 10 types of alternative packaging items placed in 5 environments, that are typically polluted by plastic, degraded over a six month period to be considered as a possible solution for conventional plastic pollution or if they pose similar pollution challenges to those caused by conventional plastics.

Methodology: We measured and photographed the surface area of all items before introduction into each test environment and then measured and photographed each item at one month intervals in each environment. We aimed to create a photo and written record of the degradation of each item as measured by surface area loss.

We tested 11 types of single-use alternative packaging items in 5 types of environmental conditions and a control environment:

- 4 types of shopping bags: 1 local brand of Oxo-biodegradable and 3 local brands of compostable cassava starch
- 1 brand of oxo-biodegradable shopping bag
- 1 Paper Bag
- 1 type of clear compostable cup
- 3 types of Food Containers: clear oxo-biodegradable, molded fiber bagasse and paperboard
- 2 types of straws: oxo-biodegradable and compostable

The parameter we will measure is:

- Surface area loss by visual observation

Duration:

The experiment was conducted between June – September 2019 for the Quasi-Industrial Composting facility, June – November 2019 for the Control, Home Composting, Buried in Soil and Open Air environments, and September 2019 – February 2020 for the marine environment.

THE EXPERIMENT DESIGN

The tests of the degradability of each of the packaging alternatives will be conducted in the following environments:

Isolated (control)

Home Compost

Quasi-Industrial composting

Submerged in Ocean

Buried in soil

Exposed in Open Air

DESIGN: ALTERNATIVE PACKAGING SAMPLES USED IN THE EXPERIMENT

BAGS

B1

B2

B3

B5

FOOD CONTAINER

F1

F2

F3

CUP AND STRAWS

C1

S1

S2

CATEGORY	CODE	SAMPLE NAME
Bag	B1	Oxo-degradable bag
	B2	Cassava starch bag 1
	B3	Cassava starch bag 2
	B4	Cassava starch bag 3
	B5	Recycled paper bag (for comparison)
Cup	C1	PLA Cup
Food container	F1	Oxo-degradable thinwall
	F2	Bagasse food container (for comparison)
	F3	Cardboard box (for comparison)
Straw	S1	Oxo-degradable straw
	S2	PLA Straw

ADDITIONAL ITEMS TESTED IN MARINE ENVIRONMENT

B1*
* 21x34
transparent bag

B2*
*28x34
white cassava bag

B4

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RESULTS: ISOLATED ENVIRONMENT (CONTROL GROUP)

The control group samples were placed inside a carboard box and kept at room temperature (approximately 24°C) for 6 months. Each month, the samples were visually checked for any changes. In a controlled environment, no visual degradation occurred after a six month period.

Control box was placed inside Kopernik's storage room.

AFTER 6 MONTHS


B1


F1

S1


C1

S2


F2


B2

B3


F3


B5

CONCLUSION: NO VISUAL CHANGE FOR ALL PACKAGING


1st month


2nd month


3rd month


4th month


5th month

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DESIGN: HOME COMPOSTING

Some items are marketed as ‘compostable, even in your home backyard’ during a 4-6 month period. Therefore we wanted to test whether the alternative packaging items would indeed disintegrate or lose a significant amount of surface area within the six-month experiment period. To ensure that the home compost was built and managed effectively, we partnered with Eco Bali who specialize in building home compost systems, to set up the home composting experiment at the Kopernik office.

Sample preparation

One set of packaging alternative samples are placed in each compost bin

One set of samples are removed from one compost bin each month

Visual degradation analysis

6 compost bin installed by Eco Bali.

Samples removed from one compost bin each month for analysis.

Our Partner :

ecoBali

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RESULTS: HOME COMPOSTING

SAMPLE CODE	1st month	2nd month	3rd month	4th month	5th month	6th month
B1 Oxo-degradable bag						
F1 Oxo-degradable thinwall						
S1 Oxo-degradable straw						
C1 PLA cup						
S2 PLA straw						

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RESULTS: HOME COMPOSTING

SAMPLE CODE	1st month	2nd month	3rd month	4th month	5th month	6th month
F2 Bagasse food container					degraded	
B2 Cassava bag 1						
B3 Cassava bag 2						
F3 Cardboard box				degraded		
B5 Recycled paper bag			degraded			

DESIGN: QUASI-INDUSTRIAL COMPOSTING/BSF FARM

Some alternative packaging items which are marketed as compostable, require the conditions of industrial composting facilities for the materials to begin to break down and finally biodegrade. Industrial composting facilities use composting methods wherein the oxygen supply, temperature, PH and moisture are highly controlled for aerobic biodegradation. There are no industrial composting facilities in Bali, making the industrial composting process unrealistic in Bali. However, we identified the next best facility we could find which was a BSF farm which produces compost, in Baturiti, Tabanan. The facility produces significant amounts of compost using a mixing and aeration method, maintaining a temperature between 40-70°C. The typical composting cycle at the facility is four months, therefore this component of the experiment was conducted over a four-month period, as the compost is considered to be 'mature' at that point.

Sample preparation

Samples are buried inside compost piles and treated weekly using the facility's standard methods

Take out one set of samples from one compost pile each month for 4 months

Visual degradation analysis

Samples ready to be buried.

Compost management by Madefficient: Immature compost stirred and aerated to maintain correct moisture levels.

Thermal control : 1st week 70°C second week 40°-50°C , and third week temperature was stable at 40°C.

Our Partner :

MADEFFICIENT

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RESULTS: QUASI-INDUSTRIAL COMPOSTING/BSF FARM

The Quasi-Industrial Composting process lasts for 4 months only as the compost is considered mature at that point.

SAMPLE CODE	1st month	2nd month	3rd month	4th month	5th month (finished)	6th month (finished)
B1 Oxo-degradable bag					N/A	N/A
F1 Oxo-degradable thinwall					N/A	N/A
S1 Oxo-degradable straw					N/A	N/A
C1 PLA cup					N/A	N/A
S2 PLA straw					N/A	N/A

KOPERNIK FINDING WHAT WORKS

RESULTS: QUASI-INDUSTRIAL COMPOSTING/BSF FARM

The Quasi-Industrial Composting process lasts for 4 months only as the compost is considered mature at that point.

SAMPLE CODE	1st month	2nd month	3rd month	4th month	5th month (finished)	6th month (finished)
F2 Bagasse food container		degraded			N/A	N/A
B2 Cassava bag 1					N/A	N/A
B3 Cassava bag 2					N/A	N/A
F3 Cardboard box		degraded			N/A	N/A
B5 Recycled paper bag		degraded			N/A	N/A

DESIGN: MARINE ENVIRONMENT

Plastic packaging which ends up in the ocean typically makes its way to the bottom of the ocean, polluting the marine environment and harming marine life.[1] This component of the experiment was conducted in Padang Bai by placing the alternative packaging samples in a net bag at a 2 meter depth.

Sample preparation (1 set of samples placed in six net bags) › Samples placed at bottom of ocean at two meter depth › Remove one set of samples each month › Visual degradation analysis

Samples placed in Padang Bai and kept in a net at two-meter depth.

Monthly monitoring by Livingseas.

Our Partner :

Livingseas

1. https://news.mongabay.com/2018/06/the-plastic-crisis-sinks-to-a-new-low-in-the-deep-sea/ https://www.nationalgeographic.com/news/2018/05/plastic-bag-mariana-trench-pollution-science-spd/

RESULTS: MARINE ENVIRONMENT

SAMPLE CODE	1st month	2nd month	3rd month	4th month	5th month	6th month
B1 Oxo-degradable bag						
F1 Oxo-degradable thinwall						
S1 Oxo-degradable straw						
C1 PLA cup						
S2 PLA straw						

RESULTS: MARINE ENVIRONMENT

SAMPLE CODE	1st month	2nd month	3rd month	4th month	5th month	6th month
F2 Bagasse food container	degraded					
B2 Cassava bag 1						
B3 Cassava bag 2						
F3 Cardboard box		degraded				
B4 Cassava bag 3						
B5 Recycled paper bag	degraded					

DESIGN: BURIED IN SOIL

Plastic packaging often ends up in the environment, buried in soil, entering farming systems through irrigation channels. In this component of the experiment we buried the packaging alternatives in soil (at a depth of 0.25m).

Sample preparation › Samples were buried in soil › Remove one set of samples each month › Visual degradation analysis

Six sets of samples are buried in farm land close to Kopernik's office at a depth of approximately 0.25 m.

Each month, one set of samples are dug up and removed to conduct analysis.

RESULTS: BURIED IN SOIL

SAMPLE CODE	1st month	2nd month	3rd month	4th month	5th month	6th month
B1 Oxo-degradable bag						
F1 Oxo-degradable thinwall						
S1 Oxo-degradable straw						
C1 PLA cup						
S2 PLA straw						

RESULTS: BURIED IN SOIL

SAMPLE CODE	1st month	2nd month	3rd month	4th month	5th month	6th month
F2 Bagasse food container		degraded				
B2 Cassava bag 1						
B3 Cassava bag 2						
F3 Cardboard box		degraded				
B5 Recycled paper bag	degraded					

DESIGN: OPEN AIR

In this component of the experiment we hung the packaging alternatives on bamboo racks to be exposed to the elements (rain, sun, wind) over a six-month period.

Sample preparation › Samples were hung and exposed to weather elements › Remove 1 set of samples each month › Visual degradation analysis

Samples were located at Kopernik's office and tied to a bamboo racks where they were exposed to typical weather conditions.

RESULTS: OPEN AIR

SAMPLE CODE	1st month	2nd month	3rd month	4th month	5th month	6th month
B1 Oxo-degradable bag						
F1 Oxo-degradable thinwall						
S1 Oxo-degradable straw						
C1 PLA cup						
S2 PLA straw						

RESULTS: OPEN AIR

SAMPLE CODE	1st month	2nd month	3rd month	4th month	5th month	6th month
F2 Bagasse food container						
B2 Cassava bag 1						
B3 Cassava bag 2						
F3 Cardboard box						
B5 Recycled paper bag						

SUMMARY OF RESULTS: VISUAL DEGRADATION AFTER 6 MONTHS

Visually not degraded
Visually degraded

Sample Code	Before	After 6 months					Overall degradability
		Home Composting	Quasi- Industrial Composting*	Marine Environment	Buried in soil	Open Air	
B1 Oxo-degradable bag							
F1 Oxo-degradable thinwall							
S1 Oxo-degradable straw							
C1 PLA Cup							
S2 PLA Straw							

* The quasi-industrial composting cycle at the facility is four months, thus photos in these columns represent the status after 4 months.

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SUMMARY OF RESULTS: VISUAL DEGRADATION AFTER 6 MONTHS

Visually not degraded
Visually degraded

Sample Code	Before	After 6 months					Overall degradability
		Home Composting	Quasi- Industrial Composting*	Marine Environment	Buried in soil	Open Air	
F2 Bagasse food container		Degraded	Degraded	Degraded	Degraded		
B2 Cassava starch bag							
B3 Cassava starch bag							
F3 Cardboard box		Degraded	Degraded	Degraded	Degraded		
B5 Paper bag		Degraded	Degraded	Degraded	Degraded		
B4 Cassava starch bag		N/A**	N/A**		N/A**	N/A**	

* The quasi-industrial composting cycle at the facility is four months, thus photos in these columns represent the status after 4 months.
** This product was not included in certain conditions due to limited availability at the time of experiment.

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CONCLUSION

The experiment found that the packaging alternatives (labeled as compostable, bio-degradable, oxo-biodegradable) did not degrade to a significant degree within the six-month experiment period in any of the test environments.[1] Because many of the packaging alternatives look like conventional plastic they are likely to be disposed off in a similar way to conventional plastic,[2] and they can also leak or be littered into the natural open environment in a similar way to conventional plastic. Therefore, we conclude that these packaging alternatives do not provide a solution for conventional plastic pollution in natural environments during the first six months after disposal.

The cardboard, paper and bagasse packaging did visually degrade during the experiment period, in all but the open air environment.

1. Because of the lack of an industrial composting facility in Bali, making industrial composting not possible in Bali at this time, we conducted the industrial composting environment component in a BSF facility.
2. During research conducted by Kopernik in Bali in 2019 with 72 respondents, we found that 58% of consumers would dispose of the items 'incorrectly' by either placing the items into mixed-waste or a recyclable bin.

ADDITIONAL CONSIDERATIONS, EXPERIMENT LIMITATIONS AND NEXT STEPS

This experiment recorded surface area loss degradation of the alternative packaging items using a small sample size over a six-month period. Further tests are necessary to assess the biodegradability and compostability of these items, that are becoming widely marketed and increasingly available as alternatives to conventional single use packaging.

The industrial composting component for the experiment had major limitations, due to the non-availability of an industrial composting facility in Bali. We therefore partnered with the BSF farm in Baturiti that produces compost, but we acknowledge that this is not an actual industrial composting facility.

We have been in discussions with Australia's CSIRO. CSIRO has designed and built test facilities which can determine the biodegradation, disintegration and compostability of materials. In order to verify biodegradation and compostability claims or earn certification by an independent 3rd party for biodegradation in a specific environment (soil, water or compost), standard requirements must be met. CSIRO will be able to determine compostability in accordance with the Australian national standard, AS 4736 for biodegradable plastics suitable for composting. The AS 4736 standard requires initial material characterisation and measurement of biodegradation (which must occur within 6 months), disintegration (which must occur within 12 weeks) and ecotoxicity, determined by testing plant growth and earthworms. We recommend that these tests be conducted in partnership with CSIRO on the packaging alternatives used in this experiment.

References: https://www.iso.org/obp/ui/#iso:std:iso:17088:ed-2:v1:en, Biodegradation Test Facilities at CSIRO Biodegradable Plastics - Testing according to Australian Standard AS 4736

ACKNOWLEDGEMENTS

We are extremely grateful for advice and written guidance on the experiment design received from:

Ms. Jane Fischer, Indonesian Waste Platform, Advisory Board Member, Material Innovations
Dr. Parveen Sangwan Senior Research Scientist Industrial Biotechnology, CSIRO Manufacturing
Dr. Mike Williams, Research Scientist, CSIRO
Dr. Johan Sebastian Basuki, Research Scientist, Polymeric Biomaterials, CSIRO Manufacturing
Mr. Alexandre Kremer, Associate at SYSTEMIQ

We are grateful to our partners Eco-Bali, MadeEfficient and Livingseas for providing their expertise and access to their facilities so that we could conduct this experiment.

Thank you to Amelia Fyfield, CSIRO for her support and connecting us to the CSIRO research team.

Any errors in the experiment design, implementation and analysis are our own.


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