



INNOVATING BIODEGRADABLE PRODUCTS, A CHALLENGING AND FAST-MOVING SCIENCE!

BESE aims to restore nature by using only biodegradable products. To ultimately leave only the natural system behind. Our goal: restored ecosystems and no pollution.

- How do we do this?
- What materials do we use?
- What is biodegradation?
- Answers to some frequently asked questions!

Biodegradability

***What do we mean with biodegradability exactly?
What is the expected time to fully degrade?***

Biodegradability is a complex phenomenon when you think about it. Let us give you an example: place a wooden table on a forest floor, out in the rain, and it will rot away in a couple of years. However, the same wooden table may sit in a castle for 1000 years and still be strong. There is the complexity of biodegradability.

The rate of biodegradation strongly depends on environmental conditions.

Some of our products degrade faster than others. We always provide our best estimate based on field experience in our product sheets. All of our products have the following in common: they can either dissolve over time into naturally occurring ingredients or can ultimately be digested by microorganisms and broken down to carbon and water.

Please note that for some of our products full degradation may take one to several decades. Other products will go in months.

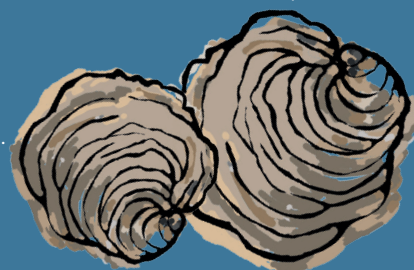
Certification

***What certification is applicable to our products? Are the products compostable?
Do the products contain harmful substances?***

The compounds in our biodegradable products have an OK compost industrial certificate/statement. This means that with certain temperatures, in a composting installation, the material will be eaten by microorganisms within six months and turned into natural harmless molecules. However, the required temperature for this type of biodegradation is generally much higher than you'll find in the natural world. Therefore, degradation in the real world will typically be slower.

In the certification we find proof that microorganisms can eat our products given certain environmental conditions. Additional to that, field tests are performed by scientists to show the actual process of degradation in field settings (e.g. Nitsch et al, 2021).

More specific information about biodegradability and non-toxicity is stated in a biodegradability statement of the compounds that we use. This can be provided upon request.





A fast moving science

Are all the products from the same material? What about developments in material science - biopolymers?

The field of compostable materials is moving fast. We started developing biodegradable products in 2012. Two years later, we engineered and produced the first **BESE-elements type 1**: The main ingredients are a starch-derived PLA combined with more raw forms of potato starch. This was cutting edge at the time, developed by material scientist and widely accepted as a biodegradable product.

Our experience, now after more than a decade?

We have several examples of BESE elements in the field that show good degradation. However, in colder temperatures degradation goes more slowly and we currently expect a lifespan of 10-20 years under natural temperate conditions.

In some tropical locations, we have seen strong degradation already occurring within 2-4 years (observation from Florida and Bonaire, Nitsch et al, 2021). In anoxic - or peaty - conditions, degradation will take considerably longer.

In the scientific world, especially in more recent years, faster degrading biopolymer blends are being developed and are slowly becoming available for large-scale use.

In 2018, we engineered a PBS-starch blend, which became available as **BESE-elements type 2**. It is still challenging to produce our products from this, but we are managing. To date, this is quite unique. Based on field conditions we now estimate this product will last for 2-4 years in temperate climates, although in saltwater degradation seems substantially slower than freshwater conditions.



Back to the future

So, are you done developing?

No! The R&D team are busy as ever.

Many people in this line of work for example know PHAs - a group of biopolymers produced by bacteria. Arguably the best marine-degradable biopolymers from which you could engineer some of the products that we use. Previously, it has been difficult to buy large enough quantities of good and stable quality PHA.

In addition, the molds that we use to injection-mold our BESE-products weren't suitable to process PHA blends.

But we are getting there!

We have invested in a new mold and in the development of a PHA-starch blend compound and we now have the first prototypes available for testing.



Site-considerations

Do you recommend using biodegradable products in all types of regions, systems and conditions?

For all of our products it is not a one size fits all: you should apply them correctly and with sense. In warmer climates, degradation goes faster. For instance, if you are restoring mangroves, you may need years of support from a structure. A fast degrading material will not be the right solution there, it will simply weaken too fast. BESE-elements type 1 may offer the best solution. As a **1st rule of thumb**: the lifespan of the BESE-product used should be long enough to allow ecosystem establishment, while being short enough to have fully degraded before the restored ecosystem may degrade again as part of its long-term ecosystem dynamics.

A second consideration is knowledge of the site conditions. BESE-elements are applicable in intermediate hydrodynamic conditions.

They will reduce currents and waves to some extent but are not suitable for coasts that suffer from constant high wave energy. So make sure you know your site and manage the risk of storm damage and washing up to the beach adequately. As a **2nd rule of thumb**: always start with a small pilot to see what happens during a year. If the BESE does not suffer, then try going larger. And if it fails before ecosystem establishment occurs, then clean up, despite it being a biodegradable product.

What happens if pieces of the product end up in the environment?

The material is heavier than water and won't float. There is some scientific evidence that they are not harmful to plankton life (Vasilakis, 2017). Finally, the certification shows that the materials are neither toxic nor otherwise chemically polluting. *But hey, let's do our best to not even pollute the environment with biodegradable materials!*



Wrapping up

Providing you with the current knowledge of biodegradable materials, should enable you to sensibly apply BESE-products, and of course we will be glad to help you with that.

We strive to use the best available materials and techniques. We adapt to changing scientific insights and improve continuously, to keep up with a fast-moving science. You can contact us any time for the latest updates and developments.

Do you think we can do better?

Please contact us and help us along! We are always open to improvement. Collaborations are key to speeding up knowledge for large scale ecosystem restoration techniques!

This Q&A and R&D are a produced by BESE in close collaboration with our partners from NIOZ, Utrecht University, Rodenburg Biopolymers, ENEXIO Water Technologies and Technical University of Delft.

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