Biodegradability of bioplastics: prenormative research, biorecycling and ecological impacts

Fact Sheet

Project Information

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Project closed

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€ 1 793 723,00

Coordinated by
UNIVERSITEIT VAN GENT
Belgium

Objective

The ecological impacts of production, biodegradation and biorecycling of bioplastics has been investigated. Extensive results were obtained and new methods and standards developed, some of which are detailed below.

The major objectives of the proposed project are:

- Development of methods for the assessment of biodegradability of bioplastics
- Development of standard test systems
- Evaluation of methods for the biorecycling of bioplastics
- Evaluation of the ecological impacts of production, biodegradation and biorecycling of bioplastics.

In the EC 5-10 million tons of plastic waste ends up in landfills or is incinerated. The application of biodegradable plastics and their disposal through composting and anaerobic digestion is now under debate. For the labelling of materials as biodegradable or compostable, reliable test methods are needed. Biological disposal methods enable the biorecycling of natural resources used for the production of these bioplastics.

In the project, standard test systems and methods for the assessment of the biodegradability of bioplastics were developed. Methods for the biorecycling of bioplastic waste, and to define ecological impacts of production, biodegradation and biorecycling of bioplastics were evaluated. A set of bioplastics (BIOPOL, BIONOLLE, MaterBi, polycaprolactone, cellulose acetate) that are credited to be biodegradable was used to reach these goals.

Several hundreds of microbial strains that degrade bioplastics in vitro were isolated and identified, revealing the biodiversity and biodegrading abilities of micro organisms that are able to degrade these materials in the environment.

A range of standardized biodegradation tests were developed and optimised. A battery of in vitro tests with defined cultures of biodegrading micro organisms allows rapid and reproducible preliminary assessment of biodegradability of bioplastics, and yields excellent material for further documentation of biodegradation. This approach can be followed by highly standardized bench scale simulation tests in aqueous and solid environments. In aerobic testing in aqueous conditions a respironmeter test was developed, and retrofitted with a conductivity equipment to measure CO2 production, to set up carbon balances. For anaerobic testing in aqueous conditions the use of an automated Methanomat equipment was shown to be promising. Two solid biodegradation tests were used: the controlled composting test for the determination of biodegradation under aerobic conditions, followed by a soil contact test, and the high-solids anaerobic digestion test for the determination of biodegradation under anaerobic conditions, followed by a compost stabilization test. The compostability can be determined by a new composting bin test, coupled with several ecotoxicity tests, that were adapted for application in compost. A compostability testing scheme is proposed.

Several analytical tools were evaluated for assessing the biodegradation bioplastics, and methods were optimised. These included chemical analysis, bulk morphological characterization, tensile characterization, surface characterization, analysis of intermediate degradation products.

The test systems were also applied to identify biorecycling methods, to upgrade biodegradable bioplastic waste to, e.g. fertilizer and biogas, animal feeds, or as novel carbon sources in waste water denitrification systems.

Several bioplastics proved to be appropriate for denitrification purposes. Experiments with polymer granules spiced with salts, led to promising results for use in water treatment.
Native bioplastics showed low digestibility in swine and sheep, but digestibility could be enhanced by more than 30% by pre-treatment, and seems to be a viable way of recycling the energy-rich bioplastic to food for animals.
A protocol for screening biopolymers for potential toxicity using cell culture tests was developed on the basis of ISO, EN, and ASTM standards for testing the in vitro cytotoxicity of medical devices and materials. Cell proliferation and cellular activities responded very sensitively to toxic agents, allowing a screening for acute toxicity of test samples under well-defined conditions in a relatively short time.
A number of new polymers were synthesized and tested. These included polyesters, i.e. poly(d-valerolactone), poly(e-caprolactone-co-d-valerolactone), and poly(e-caprolactone-co-ethylene oxide-co-e-caprolactone), and poly(ester-urethanes) based on poly(e-caprolactone) as a soft segment and methylene-bis-cyclohexyldiisocyanate and butanediol as a hard segment. These polymers were characterized and their biodegradability tested in some of the test systems.
Biodegradation and biorecycling data were entered into a life cycle analysis, following a "cradle to grave" approach, for a more rational comparison of the environmental impacts of different scenarios, such as "biodegradable plastics from renewable resources & biodegradation" versus "petrochemical plastics & incineration/land filling".
Life cycle analysis was performed for the model products "waste bag", "composting bag" and "shampoo bottle". These three model products were chosen because in such applications biodegradable materials have already proven their functional capability for realisation. On the basis of the required material functionality for such applications, a comparison with standard polymeric materials was obtained. It can be concluded that the biodegradable materials might be an ecologically better choice in the future only if material developments can be achieved to raise the material functionality.

Fields of science (EuroSciVoc)

engineering and technology > environmental engineering > water treatment processes > **wastewater treatment processes**

engineering and technology > environmental biotechnology > bioremediation > **bioreactors**

engineering and technology > environmental biotechnology > bioremediation > **compost**

engineering and technology > environmental engineering > waste management > **waste treatment processes** engineering and technology > industrial biotechnology > biomaterials > **bioplastics**

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