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BIOPLASTICS IN BIOWASTE AND DANUBE LITTERING

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ABSTRACT: In order to tackle plastic waste pollution, biodegradable plastics recently moved into focus and give hope to help solving terrestrial littering and marine plastic pollution problems. To date the share of biodegradable plastic among conventional plastic is low. Only in small market sectors, such as pre-collection bags for biowaste, biodegradable plastics are already widely applied in Austria and Europe. To investigate their degradation behavior and their impacts on the composting process, EN 13432 certified biowaste collection bags have been investigated during 12-weeks lasting lab-scale experiments and were found to fulfill requirements of the standard. For the composting process neither positive nor negative effects have been observed. Furthermore, only limited data about occurrence and characteristics of bioplastics in the open environment is currently available. First results from sampling campaigns in the National Park Danube within the INTERREG project “PlasticFreeDanube” indicate that the share of biodegradable bioplastic in the littering is currently neglectable.

1. INTRODUCTION

Problems of emerging plastic waste amounts in the environment are well known and a lot of measures have been set in Europe recently to tackle this problem. Ban of single-use plastic, recycling rates or use of biodegradable plastics are among them. Especially the latter is discussed controversially and is considered both an opportunity and a risk. Being biodegradable these types of plastics offer new ways of recovery and recycling (organic recycling) and give hope to help solving marine plastic pollution problem. But they also could increase misleading purchase decisions and littering potential. In some opinions they contradict principles of circular economy as they are not intended for material recycling and offer no corroborative value for compost during organic recycling. Currently less than 1% of overall plastic is biodegradable (Ashter, 2016).

With limited lifetime, biodegradable plastics are supposed to replace mainly single-use plastic products. In order to protect marine environment European Single Use Directive (Council of the European Union, 2019) bans plastic products with more sustainable alternatives by 2021, namely: cotton buds, plates, cutlery, straws and EPS food & beverage packaging. Products with no alternatives (cups and food packaging) should be reduced. Lightweight carrier bags are covered by extended producer responsibility and awareness raising measures, though not completely banned.

Products, labeled as biodegradable let consumers think that they simply disappear after a while. But we need clarity over how long the material will take to fully biodegrade and what environmental conditions are required therefore. To estimate the benefit of bioplastic in terms of cleaning up our rivers and oceans in future, there are three main issues to be kept in mind: (1) degradability of bioplastics on land, (2)

degradability of bioplastics in water and (3) relevance of existing and possible replacement of conventional plastic now and in future. Plastic can disintegrate to microplastic and is found in water, air, soils and also in marine regions far away from human civilization. In order to examine if biodegradable plastics are a solution to tackle plastic pollution two case studies have been conducted: 1) degradation of biodegradable plastic in compost and 2) screening of collected plastic samples in and along Danube river for biodegradable plastics

2. BIODEGRADABLE PLASTICS

Biodegradable plastics can be either bio-based or made (partly) from traditional petro-chemical non-renewable sources. Most biodegradables in Austria are not fully bio-based, but blends. The term bioplastic should not be mistaken with biodegradable. It is not uniformly defined and can either refer to (partly) bio-based plastics, to biodegradable plastics or to plastics which are both biodegradable and (partly) bio-based. In this study the focus lies on biodegradable plastics.

2.1 Occurrence of biodegradable plastics and their relevance for replacement of conventional plastics

In European Union 100,000 t biodegradable plastic products are set onto the market annually. Main field of applications are plastic carrier bags (67,000 t) and packaging materials (20,000 t). Of minor importance are foils for horticulture & agriculture, fibers and consumer goods (Frischenschlager et al., 2018). In Austria biodegradable plastic is mainly applied for medical uses, compostable biowaste & airtight bags, packaging materials & foils for short-lived consumer goods (food), filling & upholstering material, service packaging & catering products (drinking cups, dishes & cutlery), biodegradable products for agricultural & forestry applications, compostable horticulture items & textiles. The majority of these products are made of thermoplastic starch, cellulose acetate, polylactic acid (PLA) and polyhydroxy alcanoate (PHA) (BMNT, 2015).

The use of biodegradable biowaste pre-collection bags is steadily increasing. Households are supported with a convenient and easy way to dispose of their organic kitchen waste and so increase amount of separately collected biowaste. Compostable bags are widely spread for collection of biowaste in Austria. Already in the year 2008 up to 2.5% of Austrian bio-waste consists of biodegradable plastic bags (Amlinger and Fritz, 2008). If certified according EN 13432, bags are degradable in industrial composting plants, but they are not optimized for degradation in open environment conditions. Biowaste is collected separately in Austria since 1995 (Bioabfallverordnung, 1992) and treated aerobically or anaerobically. Besides standards for harmful substances and impurities, the quality of the compost is mainly determined by its input materials (= biowaste). Biodegradable and conventional plastics are not distinguishable for plant operators and therefore sorted out of biowaste in most Austrian composting plants, prior to rotting process. It can be expected, that with rising use of biodegradable plastic the share of biodegradable food packaging and coffee caps in biowaste is increasing.

Amounts of bioplastic in Austrian waste streams, Danube litter and the environment are unknown by the authors. The proportion of biodegradable plastics among conventional plastics in separate collected plastic waste streams is low to date and no pollution problems during recycling of conventional plastics occur.

2.2 Degradation of biodegradable plastics

Degradation is not uniformly defined and means either weakening of the material and disintegration into small pieces or complete chemical breakdown (mineralization). Biodegradation means that organic materials are broken down by microorganisms into water, gases (CO_2 under aerobic conditions, CH_4 under anaerobic conditions), mineral salts and biomass. Biodegradability strongly depends on milieu conditions (temperature, presence of oxygen, microorganisms, water content) and therefore may differ in soil, fresh water, seawater, composting plants or anaerobic digestion plants. Composting is a process where organic substance is biodegraded under aerobic conditions, while also new, stable organic substance (i.e. humic acids) is built. The property of biodegradation does not depend on the resource basis of a material but is linked to the chemical structure of the polymer.

For certification of biodegradability, standards for aerobic (compost, soils, freshwater, seawater) and anaerobic (sludge, digest) conditions are existing. But to our knowledge current standards are not able to realistically predict biodegradability of bioplastics within open environment including all possible milieu conditions on land, in inland water (e.g. Danube River) and in marine environments (e.g. Black Sea). Harrison, 2018 investigated biodegradability standards for carrier bags and plastic films in aquatic environments and stated that current international standards and regional test methods are insufficient in their ability to realistically predict the biodegradability of carrier bags within wastewater, inland waters (rivers, streams and lakes) and marine environments.

Most important standard for biodegradation in Austria is EN 13432:2000 – “Packaging: requirements for packaging recoverable through composting and biodegradation”. EN 13432 certified plastics degrade within 3 months during industrial compositing conditions and biodegrade within 6 months in standardized lab-scale conditions. If certified compostable according to international standards such as the EN 13432 (preferably by an independent third party), these plastics should be compostable in European industrial composting plants. To obtain certification according EN 13432 certain requirements need to be fulfilled. The assessment comprises a chemical characterization, determination of biodegradability, determination of disintegration and analysis of ecotoxicity of compost.

3. MATERIAL AND METHOD

3.1 Degradation of bioplastic during composting

Compostability of biodegradable biowaste bags and coffee caps was investigated within 12-weeks lasting lab-scale experiments at the Institute of Waste Management, following the specifications of EN 13432. Investigated bioplastics were either starch or PLA blends. Bioplastics and bio-waste were characterized both conventionally and by means of FTIR spectroscopy prior to the experiment, during rotting process and after finishing the experiment. Composting process was described by conventional parameters and by FTIR spectroscopy. FTIR spectroscopy was further used to collect spectra of the bioplastics itself and from grinded mixed samples (bio-waste + bioplastic). According to EN 13432, bioplastic must biodegrade within 6 months. This timeframe exceeds the usual duration of industrial composting and also experiment time of conducted study.

3.2 Biodegradable plastic in Danube river – first screening

Within the INTERREG project PlasticFreeDanube macro-plastics in and along the Danube river were collected and analyzed. About 820 kg of plastic waste was removed from 2017 to 2018 from the Donau-Auen Nationalpark within 13 collection activities. Collected samples were sorted into various categories (e.g. (food) packaging, non-packaging or foamed plastic materials) and analyzed to get an overview about

plastic item composition in and along Danube River.

4. RESULTS

4.1 Degradation of bioplastic during composting

Besides beginning biodegradation mainly physical degradation of bioplastics was observed. Biodegradation is strongly influenced by the chemical properties of plastic. Starch based bioplastic bags (trade mark Biomat and CleanPac) were degraded more obviously compared to PLA based bio-waste bags (trade mark dm Profissimo). Temperature and plastic layer thickness were also identified as critical characteristics for degradation. Sieving analysis (Figure 1) revealed that degradation within 12-weeks fulfilled specifications of EN 13432 (only 10% of original material > 2 mm). Plastic particles in the remaining fraction (< 2 mm) were barely visible by naked eye but FTIR spectra identified considerable amounts of plastics in compost (after 12-weeks rotting phase) which are supposed to biodegrade subsequently as biodegradation is confirmed by EN 13432 certification. When compost quality is assessed this should be considered. PLA based coffee caps did not fulfill requirements of degradation. Even after 24 weeks barely no degradation was observed (Figure 2). No evidence was found, that composting processes (mineralization, humification) was disturbed or enhanced by plastic admixtures. FTIR spectroscopy turned out to be suitable for monitoring biodegradation of bioplastics in lab-scale composting experiments.

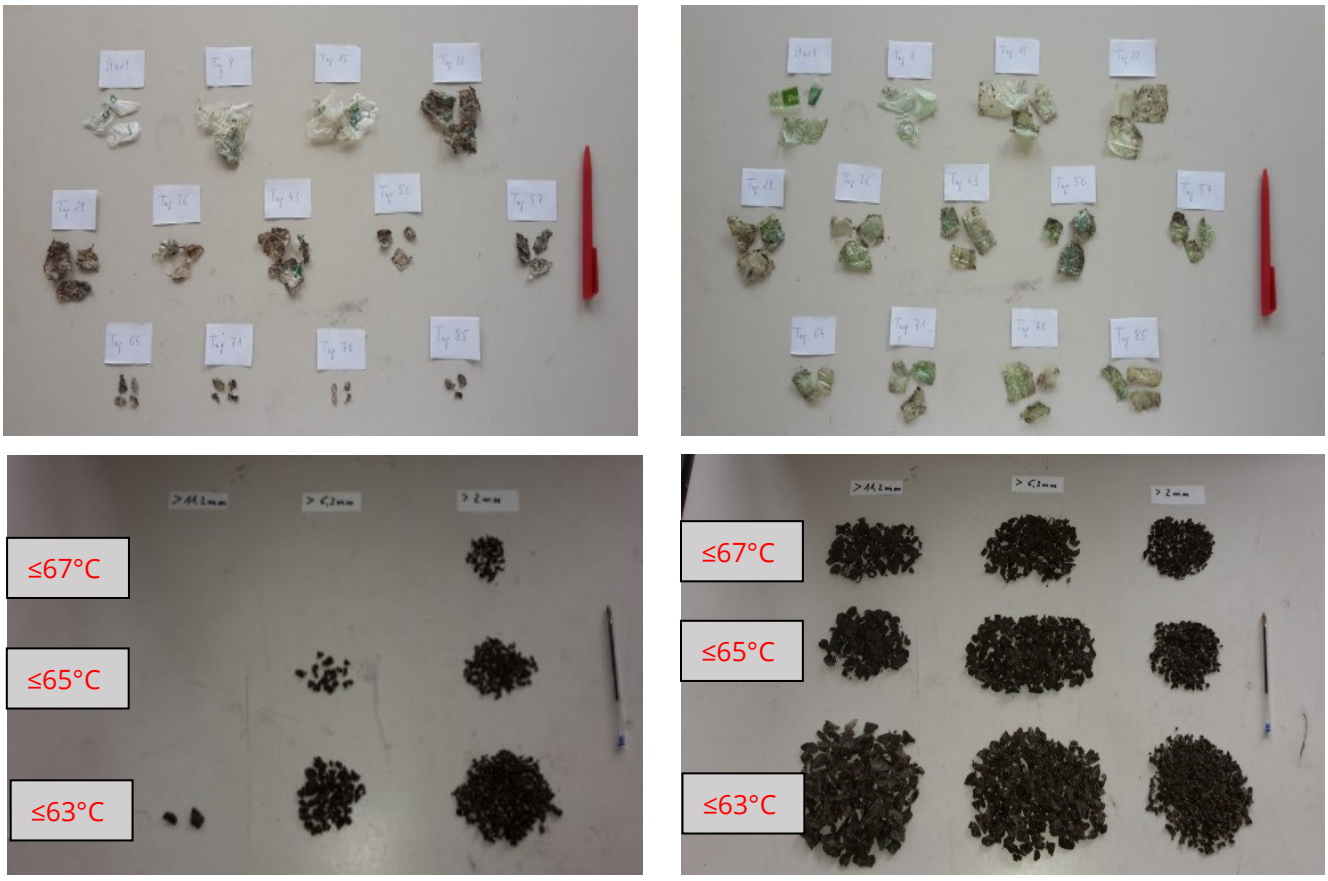

Figure 1. Temporal changes of bioplastic fragments during 12-weeks lasting lab-scale composting experiments (starch based Biomat-plastic (top left), PLA based dm Profissimo plastic (top right)). Sieving analysis of starch based Biomat-plastic (bottom left) and PLA based dm Profissimo-plastic (bottom right) at the end of composting experiment conducted in three different temperature ranges (maximum temperatures during composting experiment ranged from 63°C to 67°C)

Figure 2. Temporal changes of PLA based coffee caps during 24-weeks lasting lab-scale composting experiment

4.2 Degradation of bioplastic in aquatic systems

While investigating macro plastic litter in and along Danube river barely no (certified) biodegradable plastics were detected and investigated. Results of sorting analyses showed that a great share of collected macro-plastics are packaging materials. PET beverage bottles and foamed plastics account for over 30 % by weight in more than half of the samples. Actually, a potential field of application for degradable plastics, but during sorting no (certified) biodegradable plastics were detected visually. That might be because of the original low number of biodegradables among conventional plastic. Another hypothesis is, that biodegradable plastics disintegrate easily into tiny fragments, like we know from composting experiments, and were therefore not collected together with macro plastics samples along Danube River.

Literature research stated that only few investigations on biodegradation of bioplastics in fresh water were conducted (Burgstaller, et al. 2018). Several studies were concerned with investigations of (biodegradable) plastics in marine environments (e.g. a study of Napper and Thomson, 2019 were EN 13432 certified, starch based bags completely disappeared within 3 month while conventional and oxo-biodegradable did not) but due to various milieu conditions in marine environment (temperature, microorganisms, etc.) and plastic types no reliable general statement about biodegradability of bioplastics in unmanaged marine environmental conditions (freewater zones, sediment, etc.) can be made.

5. DISCUSSION AND CONCLUSIONS

Barely no biodegradable plastics were found during sampling and sorting activities within the PFD-project. To date in Austria, mainly biowaste bags are replaced through compostable plastic in notable amount. Biowaste bags support separate collection of biowaste. If certified according EN13432, they passed a four-step test procedure which guarantees the lack of harmful substances and biodegradation under standardized conditions. It should be noted that this knowledge could encourage consumers to negative waste managemental behavior. To avoid increased littering or low willingness for waste reduction approaches and recycling, plastic bags could be made of EN 13432 certified plastic without knowledge to customers. Totally transition to compostable plastic bags would raise acceptance of compost operators and allow them to treat biowaste without energy-intensive removing of plastic.

Time frame and level of biodegradation of bioplastics in specific surroundings are decisive factors to estimate their benefits to clean up our environment and oceans. From lab-scale composting experiments we know, that EN 13432 certified biowaste bags fulfill requirements concerning degradation during 12-weeks lab-scale composting experiment. But miss labeling and even false labels on products were observed during our research and it is assumed that this also applies to other biodegradable plastic products. Products not proper certified according EN13432 did not meet the demanded requirements.

If biodegradable plastic products should help cleaning our oceans in future, we would need compostable plastics which are guaranteed to biodegrade in various marine conditions within foreseeable timeframe. Further on, reliable labelling and clear specifications for certification are needed. Harmonized approaches in other environments than industrial composting, do not exist on European or international level. Therefore, we conclude that, compostable plastics are to date not the best solution for plastic littering problem.

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