DEGRADATION OF CERTIFIED COMPOSTABLE PLASTIC BAGS IN A COMPOSTING FACILITY – DETERMINATION OF MACRO, MESO AND MICRO PARTICLE SIZE FRACTIONS IN COMPOSTS

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1. Keywords
biowaste, biodegradable bags, composting, certification, bioplastic fragments, biodegradation

2. Highlights
- Test of four different types of compostable bio-based plastic bags in practice scale,
- Description of degradation by means of micro, meso and macro particle sizes,
- Macro particles after 6 weeks between 0 and 28% per initial bag weight, differing by charge,
- Meso and micro particles after 6 weeks approximately between 1 and 2 % per initial bag area.

3. Purpose
To dispose food waste, compostable bio-based plastics bags are increasingly used in households as an alternative to fossil-based plastic or paper bags. However, often German composting companies do not accept them and fear insufficient biodegradability during their operations [1]. Starch and poly lactic acid (PLA) based materials for bags are on the market. They are partly certified by DIN EN 13432 stating their compostability under laboratory conditions. A certificate is provided if, after a maximum of 12 weeks, less than 10% of the original material dry weight is to be found. Particles above 2 mm are concerned in this context. A further norm, DIN 13432 plus, is shortening the time to 6 weeks. To evaluate the degradation in practical scale, following questions shall be answered: Are certified bags degraded in an industrial composting plant? What are the sizes of the remaining bag fragments?

4. Materials and methods
The composting experiment was performed with commercially available compostable bio-based bags in the industrial composting plant of Neumünster, Germany. Specifically constructed sacks made of several layers of nets held the samples, which consisted of bags filled with a food waste rich biowaste, surrounded by green waste rich biowaste. The sacks were introduced into the industrial composting process and composting conditions were monitored [1, 2], for:
- 4 different types of certified bio-based plastics bags - 2 starch- (Mater-Bi), 2 PLA-based (ECOVIO)
- 20 bags from one material type included in one sack,
- 32 sacks in total, sampled after 2, 3, 4, 5, or 6 weeks,
- Composting for two weeks in a container system, followed by four weeks in a windrow.

After opening of the composted sacks, the fragments of the bio-based plastic bags were sampled. The macro particles were removed from complete sack content (64-80 kg). The meso and the micro particles were determined from representative samples (about 100 g), which were sieved. A share of each sieve fraction (about 5 g) was used to separate the particles using an illuminated magnifying glass and tweezers:
- Macro particles: easy visible fragments manually removed from the spread sack content,
- Meso particles: from the sieve fractions ≥16, ≥11.2-16, ≥8-11.2, ≥2-8mm,
- Micro particles: from the sieve fractions ≥1-2, <1mm.

The particles were dried and cleaned. From the macro particles the weight was determined, as well as the area sum displaying all particles close together in square form. The meso and micro particle number was counted. With an estimated area factor the area per particle fraction was calculated. The values were related to the initial weight respectively area sum of the bags.

5. Results and discussion

The methodology proved to be successful as a way to test bag degradability under real scale conditions. Temperature and water content measurements showed that composting proceeded as expected in industrial composting including a large inhomogeneity in material zones. The results from the fragment analytics showed that a degradation of the compostable bio-based plastic bags took place. The situation after six weeks of composting can be summarized as follows:

- Remaining macro particles from starch-based bags: 0-2 and 0-6 % of the initial weight,
- Remaining macro particles from PLA-based bags: 10-14 and 18-28 % of the initial weight,
- Remaining meso particles: mainly in the fraction ≥2-8 mm; with 0-1.4 % of the initial area,
- Remaining micro particles in the fraction ≥1-2 mm: 0.1 -1.6 % of the initial area,
- Remaining micro particles in the fraction <1mm: 0.1 -0.9 % of the initial area.

6. Conclusions and perspectives

The results were compared to the specifications of DIN 13432 plus. The starch-based bags kept the demands for the certificate, the PLA-based would need more composting time. However, a visibility of particles in compost might hinder compost marketing. If problematic values are reached would depend on the amount of bio-based plastic bags introduced. For continuation of research, following works are suggested:

- Differentiation studies between fossil based and bio-based plastic particles,
- Repetition in systems with more advanced processing including anaerobic pre-treatment,
- Modification of the method to less bags per sack, but at least three sacks per material,
- Inclusion of further materials and of nano particles,
- Investigation of influences from water content, temperature, and material thickness,
- Study on specific whereabouts of bio-based plastics ingredients,
- Study on behaviour of remaining particles after compost application in agriculture.

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