THE KASSEL PROJECT - USE AND RECOVERY OF BIODEGRADABLE POLYMER PACKAGING

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1. ABSTRACT

Biodegradable and compostable packaging materials made from biodegradable polymers (BDP) were introduced into the market to reduce the amounts of conventional packaging materials. Material recovery by the municipal organic waste collection system was examined by analysis campaigns of the waste streams organic residues, packing wastes and MSW. The processing of organic wastes mixed with biopolymeric packaging items has been tested in a commercial treatment facility. The safe use of the compost produced from these materials was demonstrated by regular compost analysis campaigns and in a full-scale agricultural application test. The collection via the municipal organic waste collection worked properly, no increased amount of impurities was detected. The processing of BDP in composting facilities is possible though it may require some adaptation measurements to provide optimal source separation. The use of produced composts for agricultural purposes has no negative effects on plant yields and soil.

KEYWORDS: biodegradable polymer packing, model project Kassel

2. INTRODUCTION

A model project with biodegradable polymers (BDP), i.e. plastic packaging items, was launched May 2001 in the German city of Kassel, that was prolonged until December 2002. The model project was conducted to promote and increase the use of biodegradable packing articles substituting conventional ones and to scrutinize the recycling paths of these explicitly labeled packing products via the municipal organic waste collection. The application of biodegradable materials for packaging purposes was considered to be the most practical area for their use (Tänzer 2000, Witt et al. 1998). Biologically degradable polymers based on renewable resources are considered in the German Packaging Ordinance (VerpackV, 1998), in the Biowaste Composting Ordinance (BioAbfV, 1998) and it is possible to carry out a biodegradability test according to a preliminary DIN standard (DIN V 54 900, 1998) to determine their compostability. A pilot experiment to introduce packaging made from biodegradable polymers into the market was carried out to demonstrate that whether or not it is possible to label biodegradable packaging products plainly and in a recognizable manner and to motivate consumers to properly segregate these materials after use and place them into the municipal organic waste bin.

The pilot-scale model project was made possible by a 50% sponsorship from the German Agency of Renewable Resources (FNR e.V.). The remaining 50% of the costs of the project were sponsored by producers of the raw material, processing industries and the retail trade. About 20 companies were involved in the project and actively supported it. Moreo-

ver, local and national retail traders (store chains) also participated in the model project. The kind co-operation and support of the composting facility Göttingen, the municipal waste management company “Die Stadtreiniger Kassel” and several public authorities were essential for the success of the project.

3. AIMS AND OBJECTIVES

The experiments should clarify if the consumer segregates such explicitly labeled BDP products in the adequate collection system without an increase of impurities, i.e. conventional plastic packaging, that complicates recycling processes. This topic was considered as an essential question, as separate collection systems for packaging and organic waste are existing in Germany as in most of the industrialized countries. Next emphasis was set on the recycling procedure, in that case a composting process. Examinations related to the processability of BDP packaging items in a technical composting process were carried out in a commercial, i.e. technical composting plant. The quality of produced composts made from organic waste containing BDP packaging was continuously monitored according to German standards (BioAbfV 1998, RAL-GZ 251). Last focal point was the possible and safe application of these composts in the agriculture. This topic was investigated with a full-scale agricultural application test. Fig 1 shows the life cycle of the BDP products and the special points of interests for the examinations as well as the compostability label.

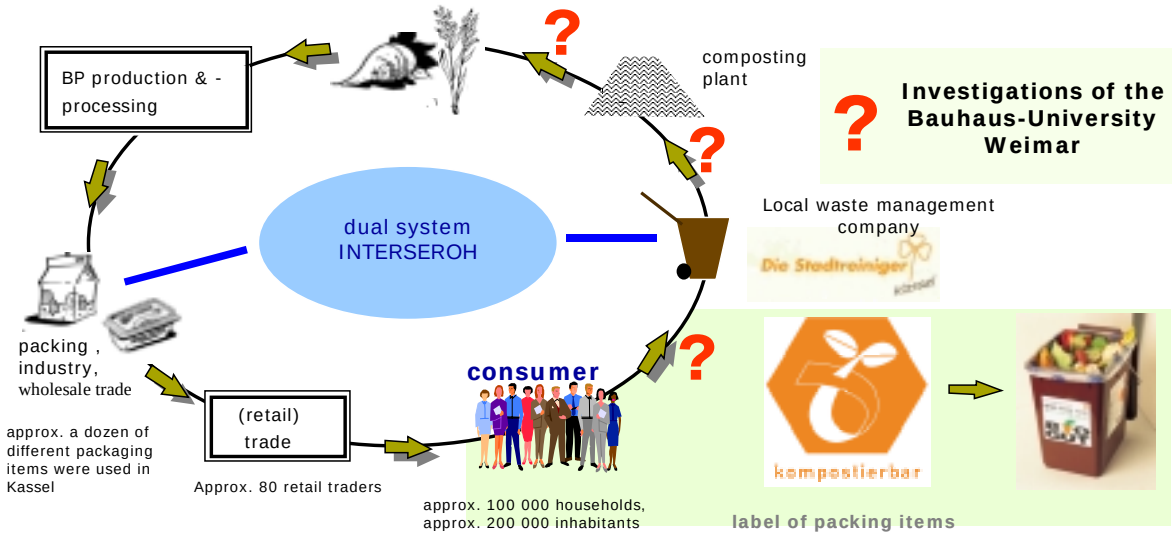

Fig. 3: Life circle of BP packing (adopted from IBAW e.V)

4. MATERIALS AND METHODS

The testing area is the city of Kassel with approximately 200 000 inhabitants in around 100 000 households. Kassel was chosen for several reasons: the social-economical structure of the city, the existence of the “biowaste bin”, which covers around 60% of the households, the multitude of retail trade shops and last but not least, the support of the authorities. The Hessian Ministry for Environment, Agriculture and Forests has approved

the collection of biologically degradable packing via the municipal organic waste collection as a dual system according to the German Packing Ordinance (BioAbfV, 1998)
Used BDP products were: packing as bags, trays, racks for fruits and vegetables, packing of dairy, bakery and butcher's products, bin liners and compostable foodware/catering products as cups, plates and cutlery. Samples are shown in Fig. 2. All these products have to pass a certification procedure according to the standard DIN V 54900 that proves their biodegradability before entering the market and all of them are marked identically with the label shown in Fig. 1. Biodegradable packing products are checked in a multi-stage examination, based on a complete chemical analysis concerning the biodegradability of all ingredients, complete biodegradability in lab scale testing rigs and compostability in a commercial composting plant. Produced composts are checked according to their quality and the maximum biodegradable diameter of the packing material is defined. DIN CERTCO as the body responsible is carrying out the certification of products.

Figure 2:. Examples of products sold (sources: Trespaphan, BASF, Moltex, natura)

The pilot experiment started in May 2001 with the sale of products in the retail trade in the City of Kassel, Germany. Once the products were introduced into the market, the materials were collected mixed with the organic waste and transported to a full-scale processing facility for composting. The finished compost was thoroughly evaluated to determine its quality. Furthermore, the composts produced were examined in an agricultural pilot scale application test.

4.1 Waste Analysis Campaigns

Main aim of the waste analysis campaigns consisted in a scrutiny of the collection of the BDP packaging items with municipal organic residues ("biowaste bin"). It was to clarify if the concentration of impurities (such as PE, PET, and others) in the organic waste changes due to improper identification as a conventional packaging by consumers. Seven waste analysis campaigns were executed. The campaigns were conducted in the selected, typical area structures of the city of Kassel as the composition of the waste differs considerably in these structures. Obtained results were compared with the results of a campaign conducted before the start of the pilot trial (August 2000) providing basic data. On the basis of these analysis campaigns, a simultaneous dimension check-up of the collecting system "biowaste bin" was executed. The dimension check-up was carried out because a higher volume de-

mand of the collection bins was assumed due to the low pouring density of biopolymers compared to organic waste. The determination of the waste composition of MSW, organic and the packing waste was done by the analysis of random samples in three different, representative urban area structures (AS) of the city (Gallenkemper et al. 1998, Barghoorn et al. 1986): AS 2 - multi-storey with more than 3 floors or more than 6 departments., AS 3 - multi-family houses with up to 3 floors or max. 6 departments and AS 4 - detached and two-family houses. The sample areas were chosen to examine three different urban structures, thus obtaining representative data of different structures that could be extrapolated to gain data about the entire city of Kassel (Intecus 1994).

4.2 Composting Plant

The main part is the complete check up of the existing treatment system, the process technology as the source separation of disturbing contents and the technical components concerning the processing of biopolymer packing materials with the source separated municipal organic waste. These investigations were conducted to test the system compatibility of the biopolymer products in a commercial composting system; i.e. whether these products have any influence on the process of the composting. The general compostability was not subject of these investigations, since exclusively products, which were certified by the DIN CERTCO as compostable were used in these trials. Fig. 3 provides information about the test system used. Samples to determine waste composition were taken at different phases of the process (1 to 4).

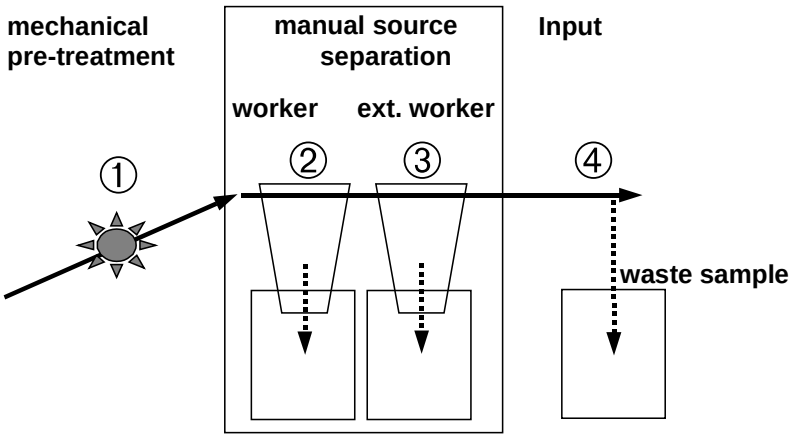

Figure 2:. Scheme of the test system in the composting plant

4.3 Compost Analysis

High quality compost has to be free of impurities and to meet the standards of the German Federal Compost Quality Assurance Organization (Bundesgütegemeinschaft Kompost e.V. - BGK 1994). The quality of the composts made from organic waste mixed with biopolymers was continuously monitored during the model test at a two-week interval according to the standards given in the German RAL-GZ 251 and in other federal law stan-

dards [BioAbfV 1998]. The matured compost produced in the plant was evaluated three months before the start of the project, in order to obtain base data to compare with the results of the examination during the pilot trial. The following parameters were analyzed: dry matter content, pH, organic matter content, self heating capacity (Rottegrad), mass of impurities, the degree of optical pollution, the concentration of zinc content as an indicator for heavy metal contamination and plant tolerance by using barley.

4.4 Agricultural Application Test

An agricultural application test was carried out to investigate the suitability of matured composts, which were made from organic waste that contained 1 % (w/w) of biologically degradable polymers. Accompanying tests were carried out without fertilization, with a mineral fertilizer and with normal compost. The compost addition to the soil corresponded to an amount of 30 tons dry mass per hectare, the maximum admissible load according the German Biowaste Ordinance (BioAbfV 1998) for quality composts. Fig. 3 provides a scheme of the test rig.

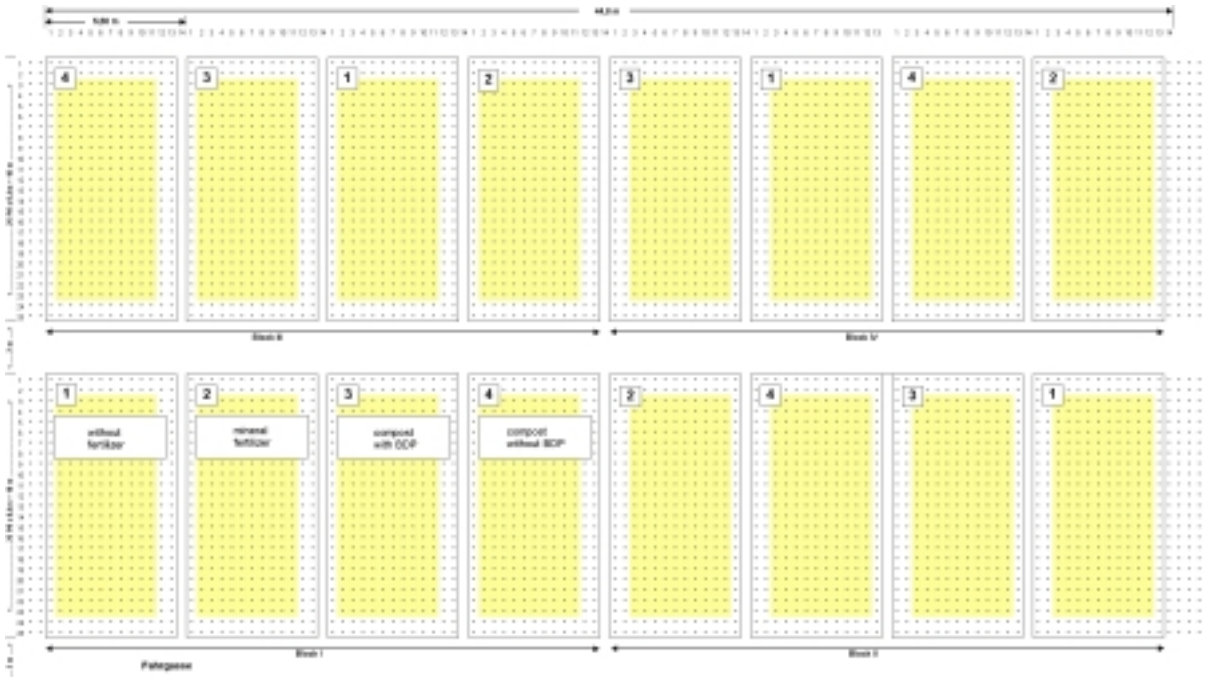

Figure 3: Scheme of the agricultural application test

Field 1 was tested without fertilization, field 2 was supplied with a mineral fertilizer, field 3 with compost made from organics including BDP and field 4 with a conventional compost. All tests were executed four times to obtain statistically secured results (Schuster et al. 1979) from June to August 2001 with Chinese leaves on a Loess soil.

5. RESULTS AND DISCUSSION

BDP product availability: General availability of BDP products in the trade varied strongly in assortment and quantity for different reasons, so that the Kassel citizen had in parts only limited access to BDP products. Offered packaging items were mainly bags (shopping bags, bags for fruits and vegetables etc.) that could be used as a collection bag in the household. The sorting of these bags filled with organic waste is relatively obvious and logical. Beside this BDP flowerpots with herbs were distributed within the scope of product promotion activities. A quantity of approx. 31 Mg (Mega gramme = tons) of biopolymer packaging (source DIN CERTCO) was delivered to the retail trade of Kassel within the testing time. The highest proportion of BDP in the organic waste, which was found during the analysis campaigns, was 0,47 % (w/w) of the examined organic waste. Related to a total amount of separately collected organic waste of approx. 6 million Mg in Germany this quantity is equivalent to 28 000 Mg of biopolymers in the organic waste. Since it was not possible to sell BDP packaging items only in the Kassel city area due to the structure of the involved retailers; a certain part of the BDP products were bought by citizens of surrounding towns and villages. This fact led to a lost of a certain part of the BDP products which was not found during the analysis campaigns in the city of Kassel

5.1 Waste Analysis Campaigns

Impurities in the collected organic waste: The amounts of impurities in the organic waste of the examined city structures did not change significantly compared with the results of the analysis campaign before the test (August 2000). Compared with the basic data a slight reduction of the impurity percentage was recognized. That can be caused by the intensive communication during the project phase thus causing a better sorting behavior. Data provided in Table 1 show the composition of the organic wastes in the area structures.

Table 1. Analysis results for organic wastes (biowaste bin)

Material group	**Average values from 7 analysis campaigns**		
	AS 2	**AS 3**	**AS 4**
organic waste	84,28 (95,00)	88,37 (94,25)	87,31 (96,18)
other organics	1,03	1,71	1,10
fraction < 8 mm	9,32	6,85	10,16
biopolymers	**0,15**	**0,16**	**0,01**
improperly sorted (papers, cardboard)	3,94 (3,09)	1,69 (4,38)	1,15 (3,22)
usable part	98,73 (98,09)	98,77 (98,63)	99,72 (99,40)
impurities	**1,27 (1.92)**	**1,22 (1,38)**	**0,28 (0,60)**
glass	0,15 (0,00)	0,10 (0,00)	0,00 (0,00)
metals	0,06 (0,04)	0,16 (0,00)	0,01 (0,00)
plastics	0,83 (1,69)	0,61 (1,38)	0,10 (0,60)
composite materials	0,10 (0,11)	0,13 (0,00)	0,01 (0,00)
others	0,13 (0,07)	0,22 (0,00)	0,17 (0,00)

The average values were obtained by 7 analysis campaigns conducted during the test. Values in brackets represent the results of the status quo analysis campaign conducted before the start of the project. "Other organics" includes materials as kitchen papers etc. consisting of paper and organic sticking, the fraction smaller than 8 mm consists mainly of organic wastes thus counting it as biowaste. Papers and cardboard are listed as "improperly sorted" because in Kassel exists a separate collection system for these materials. Despite of this, papers and cardboard are counted as usable, because they don't disturb the composting process and are compostable. Average amounts of impurities decreased slightly in all area structures examined.

Conventional plastics form the main part in terms of a mass based consideration, of the impurities. Average percentages of BDP products in the collected organic residues were determined with 0.15 to 0.16 % (w/w). Almost no BDP were detected in AS 4. This was partially caused by the lack of availability of products for the consumer in this structures as it was situated on the outskirts of the city. It is assumed that by the availability of gardens and the explicit labeling as "compostable" the BDP items were deposed on backyard or home composting sites. This was confirmed by a market research with personal interviews. 25 % of the interviewees declared that they are running a private home composting site. Another reason was the fact, that the density of biopolymer packaging selling retailers was very low thus causing a bad access of the citizens living in the examined area.

Volume demand for the collection containers: No significant changes of volume demand of the collection bins were detected due to the simultaneous collection of BDP packing items since seasonally influences possess substantially larger effects on this demand.

Recovery of BDP products in the biowaste collection system "biowaste bin": The recovery rate is the part of the total organic waste in all collection systems that is collected via the appropriate collection system ("biowaste bin"). To calculate the recovery rates for the entire city the produced amounts of organic waste per person in each waste fraction were determined. The city was divided in area structures with assigned number of inhabitants. With these figures it was possible to calculate the to determinate the total amount of the organic waste in all fractions of the entire city. The recovery rate of BDP items projected on the entire city of Kassel differed considerably in the three urban areas. The highest recovery rates were achieved in AS 3. They started with 95 to 90 % (w/w) and decreased to values of approx. 80% (w/w) of the total amount of BP items in the tree analyzed waste streams (packing wastes, MSW, and biowaste) in the course of the project. In AS 2 the recovery rates were lower, approx. 60% (w/w) of the total amount. Almost no BDP items were found in the waste streams of areas with detached and two-family houses (AS 4) thus preventing the calculation of a recovery rate.
Only small amounts of biodegradable polymers were found in the MSW; however, the quantity collected biopolymer packaging via this collection system was considerable. Even a small percentage of biopolymers in the MSW implies a relatively high amount due to the higher total mass and the more frequent collection compared with the biowaste. Very small quantities of biopolymer products. were regained in the packaging fraction ("yellow bag").

5.2 Composting Plant

No direct influences on the composting process and technical components of the composting plant were detected by the treatment of organic waste mixed with BDP. Manual source separation is affected by higher amounts of BDP items at simultaneously high amounts of conventional disturbing contents. The efficiency of the manual source separation decreased with increasing BP content in the organic waste during the executed experiments. The quality of the manual source separation was not impaired in tests with organic waste including a small proportion of BDP products (0,125 % (w/w)). However, organic wastes with a content of 0,25% (w/w) caused already a clear quantity reduction of the separated impurities. Already small BDP additions to strongly contaminated organic waste (more than 5% (w/w)) deteriorated considerably the manual source separation performance. Samples without BDP addition were cleared of impurities most effectively in both investigation campaigns although they possessed the highest pollution rate from all used organic waste samples. These facts indicate that the process of source separation is affected negatively with that type of source separation practiced in this composting plant. However, no general predicates can be derived because the source separation is carried out in other compost plants with differing methods, e.g. an input stream sieving without manual sorting process or without any pre-treatment with a subsequent sieving of the composts. Tests proved that systems with a manual source separation achieve better performance of the source separation by simple measurement. One tested possibility is including the conventional packing residues in the organic waste in the composting process and eliminate impurities afterwards by sieving or similar methods. These pre-treatment process makes sure, that BDP products get into the composting matrix and avoids that the BDP product are sorted out in relevant amounts in the course eof the source separation. Personnel interviews resulted in the finding that BDP products with used process of source separation in that composting plant were only very heavily distinguishable from "normal" impurities. This was caused by a frequently only one-side and small formatted labeling. That leads to the conclusion that it must be guaranteed that the BDP products are labeled on both sides and generally as big as possible.

5.3 Compost Analysis

The results of compost quality analysis campaigns were compared with the data of a analysis campaigns of the compost made from biowaste without BDP that were conducted before the start of the experiment. During the testing phase monthly conducted campaigns observed the quality parameters of produces composts. No changes in compost quality parameters were detected. All parameters measured remained in the same range indicating that the co-composting of BDP had no influence on the composting process and its products. Composts made from biowaste mixed with certified biopolymers had the same quality as conventional composts. The limits given in several standards (RAL GZ 251, Bio-AbfV 1998) were met. Only very low heavy metal contents were detected.

5.4 Agricultural Application Test

Chinese leaves, which were fertilized with matured compost made from biowaste containing BDP had fresh mass yields of 1.3 tons per hectare (total product) or 0.83 tons per hectare marketable product, that is considered as a normal yield level (Fig 3). Same results were obtained comparing dry mass yields and single fruit masses.

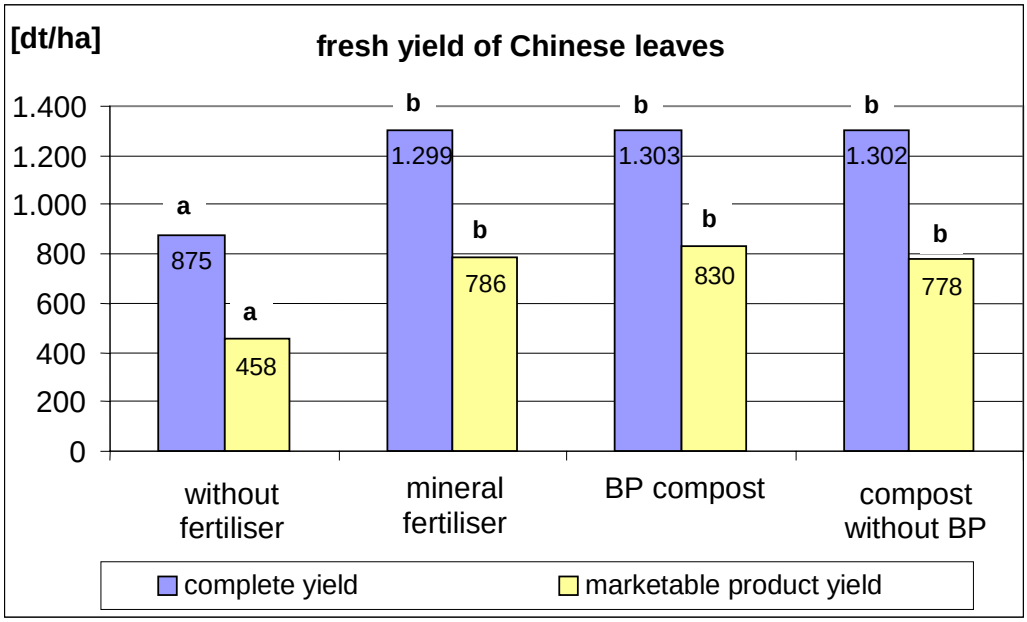

Figure 3:. Fresh yield (mass) of Chinese leaves

The obtained yields corresponded to the yields obtained from fertilization with conventional matured compost as well as with mineral fertilizer. Vitamin and nitrite contents as well as the plant quality were identical in all fertilized versions. Soil parameter were tested before and after the end of the trials. No modification of soil characteristics could be determined due to the use of compost made from BP containing biowaste. The test demonstrated convincingly that an utilization of BP by municipal organic waste collection with the following composting is possible in the agriculture without problems.

6. CONCLUSION

The pilot project showed clearly that it is possible to collect BDP products with the organic waste in a common collection system, i.e. the “biowaste bin”. Consumers can distinguish between conventional plastic packing and their substitutes made from biopolymers. Essential is one remarkable and identical label for this new class of products. The treatment in technical composting facilities is possible though it may require slight adaptations in case of a manual source separation of impurities. Compost made from organic residues mixed with BDP have no negative effects on plants and soil.

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