Additional note on PLA in comparative mLCA on waste treatment of diaper and incontinence material

Colophon

Research data

Name research	Comparative mLCA on waste treatment of absorbing hygienic products
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General

In the study 'Comparative mLCA on waste treatment of absorbing hygienic products' a comparison was made of three waste treatment options for used absorbing hygienic products (AHP), by applying an mLCA method. The three options were: incineration in a waste incineration plant, the FaterSMART treatment option by Fater, and a Thermal Pressure Hydrolysis (TPH) process by Elsinga.

During the study Elsinga noted that they have been in contact with a diaper manufacturer to discuss the option of replacing the plastics in diapers with polylactic acid (PLA), and if their process would be capable of retrieving PLA in any form. Elsinga has tested their process with PLA and proved that their process transforms PLA back to its monomeric (liquid) form: lactic acid.

Polylactic acid (PLA) is a thermoplastic polyester like PE and PP. PLA can be produced from renewable resources, and perhaps more interesting, it is economically viable to do so. Moreover, PLA is biodegradable. PLA's monomer is lactic acid, a weak acid widely used in industries as as the food, cosmetic, pharmaceutical and chemical industries.

Considering this development and general interest in PLA, we have studied the effects of PLA in the comparative mLCA on waste treatment options for AHP. This document should be seen as an addition to this previous study. However, because of the change in scope, handling PLA in a separate document was viewed as the best course of action.

Functional unit

The functional unit is unchanged: one (1) ton of used Adsorbent Hygienic Products (AHP), meaning a combination of diapers and incontinence material.

However, the composition of diapers was changed. The new composition is depicted in Table 1. Here, PE and PE in the diaper itself was changed to PLA. Actual weight percentages were not changed. The plastic bags, in which AHP is collected also remains PP. Of the 102 kg plastics per ton AHP, 62 kg (60,8%) is PLA, 40 kg (39,2%) remains PP.

Table 1 Composition of the PLA-diaper and incontinence material (input material)

Material	Diapers (wt%)	Incontinence material (wt%)	Average composition (wt%)
SAP	9,7%	3,9%	6,8%
Fluff-pulp	7,1%	17,9%	12,5%
Non-woven plastic (PLA)	6,2%	3,2%	4,7%
Elastic and self-adhesive tape	3,8%	0,2%	2,0%
PLA film	1,5%	1,5%	1,5%
Glue	0,9%	0,8%	0,9%
Others	0,3%	0,0%	0,2%
Liquid biowaste	67,5%	67,5%	67,5%
Plastic bags (PP)	3,0%	5,0%	4,0%

Life cycle inventory

While Elsinga has tested their process with PLA to see what would happen to PLA, accurate and robust data is not available. Therefore, in this study we assume all other material is unaffected, and that losses of plastics are similar. The only change in the calculation are therefore the choice background database processes. Table 2 shows SimaPro input of plastics for cycles 1, 2, and 3 of the mLCA. The rest of the recovered materials is assumed to be unchanged.

Table 2 Avoided primary raw materials - plastics

Process step	Material or energy-use	Database process	Amount	Unit
Cycle 1	Polypropylene	Polypropylene, granulate {RER}| production | Cut-off, U	93 * 0,392	kg
Cycle 1	PLA	Lactic acid {RER}| production | Cut-off, U	93 * 0,608	kg
Cycle 2	Polypropylene	Polypropylene, granulate {RER}| production | Cut-off, U	84,8 * 0,392	kg
Cycle 2	PLA	Lactic acid {RER}| production | Cut-off, U	84,8 * 0,608	kg
Cycle 3	Polypropylene	Polypropylene, granulate {RER}| production | Cut-off, U	73,3 * 0,392	kg
Cycle 3	PLA	Lactic acid {RER}| production | Cut-off, U	73,3 * 0,608	kg

In order to make the comparison with diapers as they currently are, we also need to consider that the production of PLA-containing diapers might have a different environmental impact compared to PP/PE-diapers. Therefore, we also made a comparison of PLA granulate and PP/PE granulates in their respective amounts they were used in diapers. With this comparison we make the assumption that the process of production of diapers is further unchanged, only the raw materials (plastic granulate) is different. Relevant database processes and amounts can be seen in Table 3.

Table 3 Production of PLA versus PP/PE

Process step	Material or energy-use	Database process	Amount	Unit
PLA production				
Production PLA	PLA	Polylactide, granulate {GLO}| market for | Cut-off, U	62	kg
Original diaper plastics production				
Production PE	PE	Polyethylene, high density, granulate {GLO}| market for | Cut-off, U	47	kg
Production PP	PP	Polypropylene, granulate {GLO}| market for | Cut-off, U	15	kg

Results

In Table 4 results of the PLA calculation compared to the original plastics calculated ‘Comparative mLCA on waste treatment of absorbing hygienic products’. Note that this entails the entire process, as described in that document, whilst only the changes compared to the previous study were noted here. The results include endpoint of the ReCiPe method and the global warming potential. Included in the TPH – PLA results is the production of PLA-granulate, while production of PE and PP granulates was subtracted according to the amounts given in Table 3. Detailed results can be seen in the next section, where we dissect the differences with a contribution analysis.

Table 4 Results ReCiPe Endpoint (H) and global warming potential

Category		TPH - PLA	TPH - Original
Total	Pt	**-27,68**	**-20,40**
Human health	Pt	-24,48	-17,60
Ecosystems	Pt	-1,77	-1,50
Resources	Pt	-1,43	-1,30
Global warming	kg CO_2-eq	-994,53	-722,12

Contribution

Figure 1 and Figure 2 depict the contribution analysis by ReCiPe score and global warming potential respectively. The figures are a more refined version of the numbers given in Table 4; the stacked bars together add up to the value in Table 4.

Notable is that the production of PLA is more environmentally impactful than PP and PE are. In these graphs, the impact of production of PP and PE was subtracted from the impact of production of PLA, to show the extra impact that comes with PLA-diaper production. The extra loads of production are however met with larger benefits from recovering lactic acid. With the mLCA method, the benefits of recovering materials (in this case lactic acid) are weighed more heavily, which leads to a significantly better score compared to the original diaper.

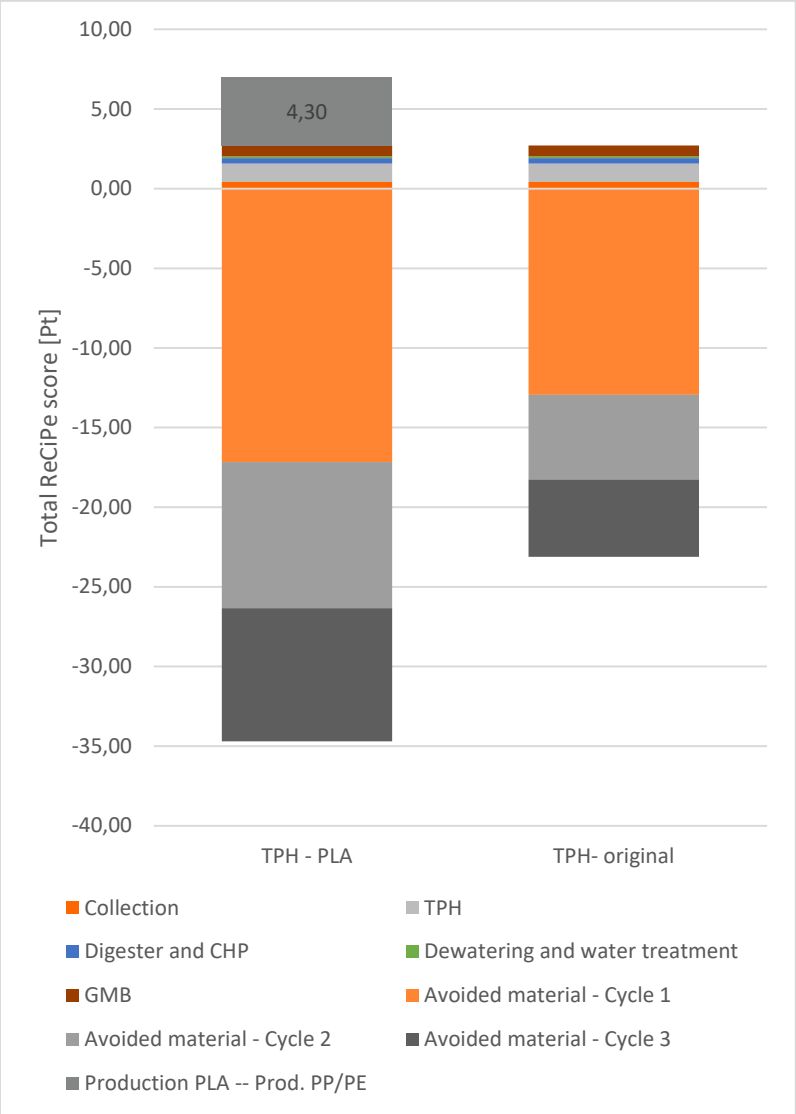

Figure 1 Contribution analysis by process steps in ReCiPe score

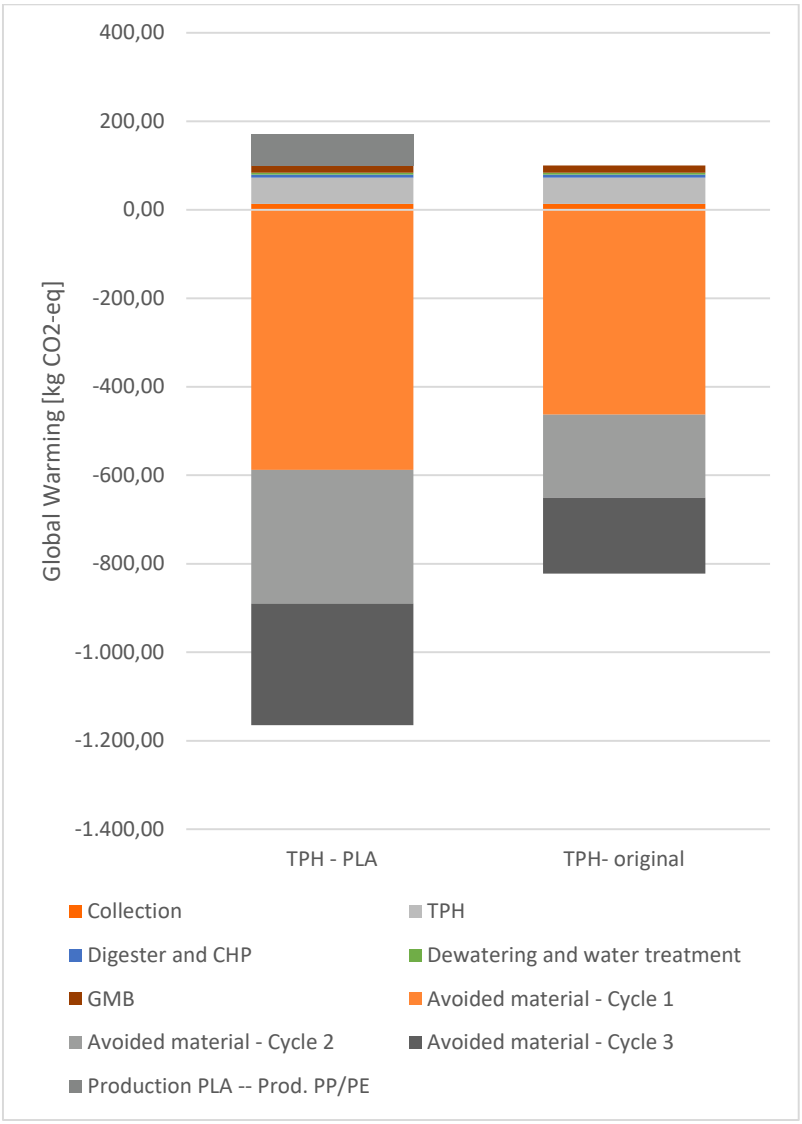

Figure 2 Contribution analysis by process steps in Global warming potential

In Figure 3 we show the avoided impact per material for every mLCA cycle. From this figure we can deduce that recovered lactic acid is responsible for most of the avoided impact, much like plastics were in the original scenario. In Figure 4, avoided impacts from plastics from the original scenario is compared to the PLA-diaper scenario. This figure makes it clear that recovering lactic acid avoids more impact than the replaced PP and PE would have otherwise.

In the second paragraph of the contribution analysis it was noted that recovering of materials is weighed more heavily in the mLCA method. Labels were added in Figure 1 and Figure 4, to aid with a comparison for just the first cycle. The ReCiPe score increased by 4,30 points due to production of PLA compared to PP/PE. The impact avoided by recovery of plastics in the first cycle increased by (9,82 – 5,59 =) 4,23 points in the PLA scenario. In other words, if we were to compare the two scenarios with only one recovery cycle, the results would be near identical. It is due to the mLCA method, weighing recovery more strongly, that the PLA scenario results in a better score.

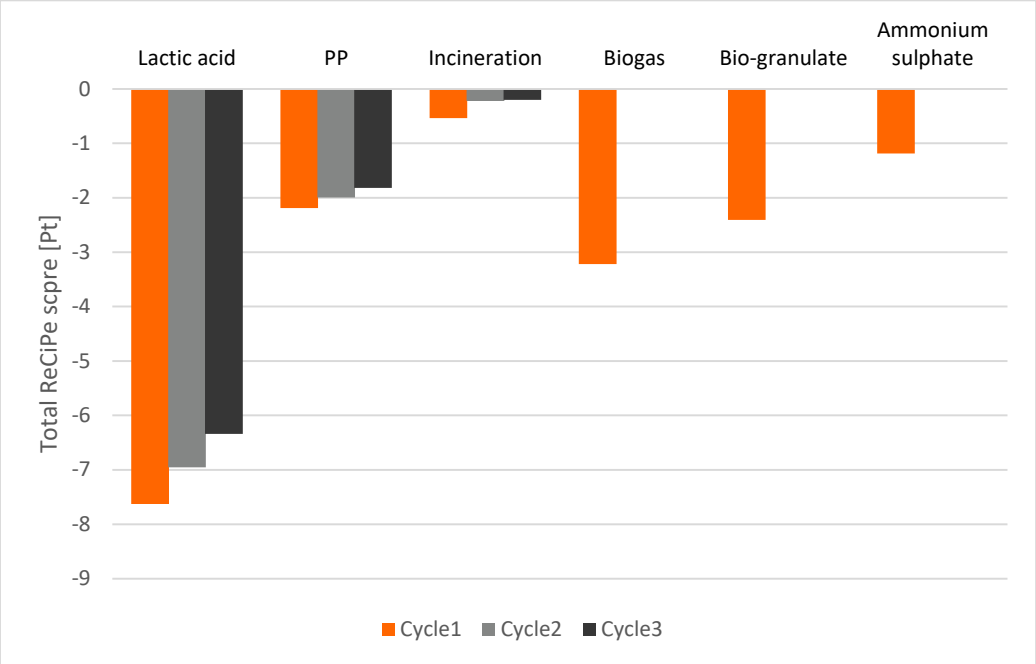

Figure 3 Avoided impact per product and cycle

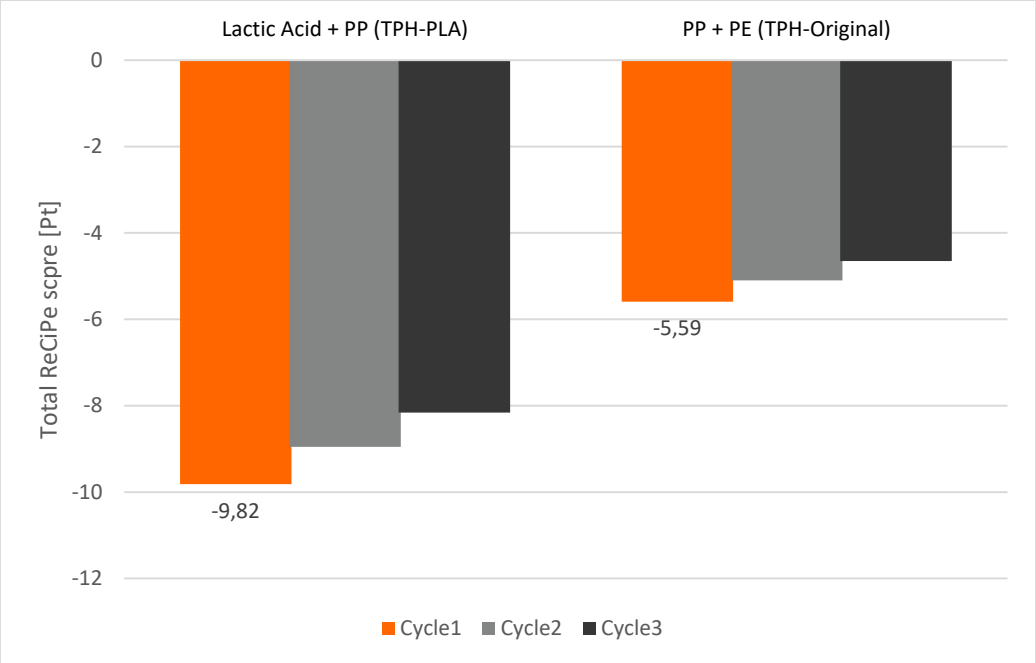

Figure 4 Comparison of PLA and original scenario - Avoided impact plastics per cycle

Concluding remarks

Compared to the original scenario (PP/PE diapers), waste treatment of diapers made with poly lactic acid (PLA) leads to a significantly larger avoidance of environmental impact. It should be noted however that, although we have not done research the production of diapers, the production of PLA-diapers is likely to have a larger environmental impact. We have shown this extra impact is almost entirely alleviated with the extra benefits due to recovered lactic acid in the first cycle. Heavier weighing of recovery of materials in the mLCA method is a decisive factor, in the comparison with regular diapers.

Nevertheless, if a new diaper design could not have been recycled as is possible with the current design, the mLCA result would have been worse. Exploring waste treatment of a new product whilst still in the design phase is an important step to achieving a more circular society. And PLA certainly is an interesting option for a circular plastic due to its biobased, and thereby renewable characteristic. Therefore, it is encouraged to explore this design option in more detail, as this quick study is an assumption loaded quick mLCA of a potential situation.

Other remarks

Because no incineration process of PLA is available in background databases, we could not make a decent comparison with incineration of PLA-diapers. Nevertheless, given the results of incineration of standard AHP, and the fact that PLA has a lower heating value of 17,9 MJ/kg (under half of PP or PE), it is safe to assume incineration would show positive ReCiPe scores (i.e. higher environmental impact).