PLEX v3 documentation

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Table of contents

1 Introduction

The PLEX v3 database is an add-on to ecoinvent 3.10 APOS unit database. The first update was done by Ciroth & Kuoame (2019)[1] and the latest update came about in July 2023[2], for ecoinvent v3.9.1. The idea presented by Ciroth & Kuoame is that the plastic litter of a certain (unit) process is calculated by multiplying the total amount of expected plastic inflow to that process (by adding the plastic content of flows entering that process) with the littering probability (the expected amount of litter) of that process, see equation below:

$$PL_j = P_{litter} * \sum_{i=1}^{n} PC_i$$

Where:

- PL_j = plastic litter from process j [kg]
- P_{litter} = expected probability of litter from process j [%]
- PC_i = plastic content of flow i [kg]
- n = number of incoming flows for process j

In the appendices one can find weight estimations of flows (Appendix A), plastic content estimations of flows (Appendix B) and littering per process (Appendix C). For more on methodology, check last year's report: https://www.openlca.org/wp-content/uploads/2024/08/PLEX_Plastic_litter_extension_for_ecoinvent.pdf.

This new version of the database aims to update the background database to the latest version provided by ecoinvent, whilst also revising and improving the current methodology.

This document will guide you through the improvements made for this update and in the appendix you will see a granular disclosure of the estimations and assumptions made to make v3 of the database.

[1] Ciroth, A., Kouame, N.: Elementary litter in life cycle inventories, approach and application , presentation, LCM, Poznan, 2019.

[2] https://www.openlca.org/wp-content/uploads/2024/08/PLEX_Plastic_litter_extension_for_ecoinvent.pdf

2 Change log – updates and improvements from the previous implementation

The following changes and improvements were made in this version update:

2.1 Updated background database

The background data was updated to ecoinvent 3.10 APOS unit database in the background.

2.2 Flows with units "items" were improved

In comparison to the previous, generic definition of mass per unit, see Annex A., this update counts with a more precise estimation of the mass of flows that have units as "number of items".

2.3 Tyre, break and road wear now included as direct littering

Tyre, break and road wear flows in the output are direct emissions, and were previously not taken into account. For tyre wear, it is 95% plastic content being directly littered, for the others, it is 95% probability of littering but <100% plastic content. Wear in transportation processes is now taken into account by the database as direct litter.

Additionally, it was spotted that some transportation processes from ecoinvent didn't have tyre wear. Tyre wear was therefore added for those passenger car, lorry, bus and scooter processes that didn't have it, following:

PROCESS_NAME	tyre wear (kg)	/unit
transport, passenger, motor scooter | transport, passenger, motor scooter | APOS, U	6.99E-06	p*km
transport, passenger coach | transport, passenger coach | APOS, U	1.84E-05	p*km
transport, regular bus | transport, regular bus | APOS, U	1.84E-05	p*km
transport, trolleybus | transport, trolleybus | APOS, U	1.84E-05	p*km
transport, passenger car | transport, passenger car | APOS, U	9.51E-05	km
transport, passenger car with internal combustion engine | transport, passenger car with internal combustion engine | APOS, U	9.51E-05	km
transport, passenger car, EURO 3 | transport, passenger car, EURO 3 | APOS, U	9.51E-05	km
transport, passenger car, EURO 4 | transport, passenger car, EURO 4 | APOS, U	9.51E-05	km
transport, passenger car, EURO 5 | transport, passenger car, EURO 5 | APOS, U	9.51E-05	km
transport, freight, light commercial vehicle | transport, freight, light commercial vehicle | APOS, U	2.46E-04	t*km
transport, freight, lorry 28 metric ton, fatty acid methyl ester 100% | transport, freight, lorry 28 metric ton, fatty acid methyl ester 100% | APOS, U	2.46E-04	t*km
transport, freight, lorry with reefer, cooling | transport, freight, lorry with reefer, cooling | APOS, U	2.46E-04	t*km

transport, freight, lorry with reefer, freezing | transport, freight, lorry with reefer, freezing | APOS, U	2.46E-04	t*km

The tyre wear was calculated with an average of the already available ecoinvent processes with tyre wear. It was assumed that buses and lorries had the same tyre wear. Furthermore, bicycle tyre wear was considered as negligible, and aircraft tyre wear was not included as no available data was found by the time of making the update.

2.4 New leachate water (SLF) flows

These flows were a completely new set of flows introduced in ecoinvent v3.10. The flows were assumed to have 0.0001 plastic content for plastic related Leachates, and the rest = 0.

3 Future work

This update improves the estimation of weights of flows with units "items". Further work could go in the direction of:

- Varying littering probability per process depending on region,
- Distinguishing where littering goes. E.g. soils vs marine waters,
- Differentiation of plastic type (PET, PP, PE, PVS, etc) and size (macro, micro, or even specified sizes),
- Supposedly, many flows of plastic litter are disregarded in the currently available databases, e.g. cigarette butts (Ciroth & Kuoame, 2019) or aspects of human behaviour.

4 Contact

The database extension can be found in openLCA Nexus, https://nexus.openlca.org/database/PLEX.

For any feedback about use, bugs and implementation in openLCA as well as questions or other comments, please contact us: gd@greendelta.com

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Appendix

A. Weight estimations

Estimate weight for all flows that doesn't have mass as property, directly in excel. Was done according to weight classes:

a) very large > 100 000 000 kg, all objects in this category have the weight 5 000 000 000 (example: airport or reservoir for hydropower plant)
b) large > 1 000 000 kg, = 50 000 000 kg (example: factories or smaller infrastructures, e.g. mining infrastructures)
c) medium > 10 000 kg, = 500 000 kg (example: most buildings, airplanes, ships)
d) small > 100 kg, = 5000 kg (example: vehicles and larger machines)
e) very small < 100 kg, = 50 kg (example: domestic goods and everything smaller than that)

Further work was done on this update to dig deeper into the weight by processes with units "items". The table is available upon request.

B. Plastic content estimations

Estimate/guess plastic content of all flows, also according to classes:

a) all plastic 100% (example: primary plastic flows, e.g. polyethylene)
b) very high 95% (example: plastic products, waste plastics)
c) high 50% (example: paints)
d) medium 10% (example: vehicles)
e) low 0.1% (example: fibreboards, soaps)
f) very low 0.0001% (example: most waste flows with no obvious plastic content)
g) none 0% (example: metals, electricity)

The above criteria was applied to product and waste flows:

Product flows

A. Agriculture, forestry and fishing

Within this category, most flows were set to be zero, as the outgoing flows of crops, meat, wood and fish were assumed to be mainly plastic free. Exceptions:

- In the sub-category *0164: seed processing and propagation,* all non-organic seed has a component called chemical dressing, which is assumed to be a plastic cover of the seed.

This component is also mentioned in (CIEL, 2022) as an important contributor to plastic litter, along with plastic microcontainers of fertilizers and pesticides. Because of this, these seeds are assumed to have a low (0.1%) plastic content.

- Within the category *03: Fishing and aquaculture*, equipment is assumed to have an overall plastic content of 10% (Richardson, Hardesty, Wilcox, 2019). The assumption differs from the reference as it was put in between the mentioned losses of different types of equipment (5.7% of fishing nets, 8.6% of traps and 29% of lines). Also, only cages are accounted for in the database, neither nets nor lines or traps are mentioned, but are accounted for as a part of the weight of fishing vessels.

B. Mining and quarrying

All flows in this category are assumed to be plastic free, as they are mainly metals, stones, petroleum and gas.

C. Manufacturing

10: Manufacture of food products all flows are assumed to be plastic free.

13: Manufacture of textiles all textiles are assumed to have zero plastic content except polyester, polypropylene, and fleece, which are assumed to have a 100% plastic content.

16: Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials . All flows within this category are assumed to have a zero plastic content except those involving glue or adhesives that are assumed to have a low-medium (0.1%-10%) plastic content.

- 1621: manufacture of veneer sheets and wood based panels = 0.1%
- 1622:Manufacture of builders' carpentry and joinery = 1%

17: Manufacture of paper and paper products all flows are assumed to have no plastic content except for beverage packaging that are assumed to have a plastic content of 20% (Schlecht & Wellenreuther, 2020)

18: Printing and recording of media were all assumed to have zero plastic content.

19: Manufacture of coke and refined petroleum products were also assumed to have zero plastic content.

20: Manufacture of chemicals and chemical products flows in this category had different values for different sub-groups. In the sub-group

- *2013: Manufacture of plastics and synthetic rubber in primary forms,* all flows were assumed to have 100% plastic content.

- 2022: *Manufacture of paints, varnishes and similar coatings, printing ink...,* all flows were assumed to have a high (50%) plastic content. Magnetite, ink, solvent and toner were assumed to be non-plastic.
- 2023: *Manufacture of soap and detergents, cleaning and polishing preparations...,* all flows were assumed to have a low (0.1%) plastic content.
- 2029: Adhesives and seal were assumed to have a very high (95%) plastic content.
- 2030: Man-made fibres such as polyester were also assumed to have 100% plastic content.

Rest were assumed to be 0.

21:Manufacture of basic pharmaceutical products and pharmaceutical preparations, all (one) flows were assumed to have no plastic content.

22:Manufacture of rubber and plastics products, all flows within *Manufacture of plastics products* were assumed to have a very high (95%) plastic content

23:Manufacture of other non-metallic mineral products, *24:Manufacture of basic metals* and *25:Manufacture of fabricated metal products, except machinery and equipment* were assumed to be zero in terms of plastic content.

26:Manufacture of computer, electronic and optical products were assumed to have 20% plastic content, based on the amount of plastic in e-waste (Sahajwalla & Gaikwad, 2018).

28:Manufacture of machinery and equipment n.e.c. are assumed to have a low plastic content of 0.1%

29:Manufacture of motor vehicles, trailers and semi-trailers and *30:Manufacture of other transport equipment* are assumed to have a medium plastic content of 10%.

D. Electricity, gas, steam and air conditioning supply

All flows were assumed to have no plastic content.

E. Water supply; sewerage, waste management and remediation activities

36: Water flows were assumed to have no plastic content, however the ultrafiltration model contained in this group was assumed to have a high plastic content.

37: 0

38:Waste collection, treatment and disposal activities; materials recovery, all obvious plastic flows were set to 100% plastic, unsorted scrap to 0.1%, rest to 0.

39: all remediation activities were set to 0

F. Construction

All flows within both *41: Construction of buildings, 42: Civil engineering* and *43:Specialized construction activities* were assumed to have a plastic content of 1%. The only exception were the activities in category 4312: site preparation that were set to 0 as they mainly concerned service activities such as machine operation.
All flows in categories G, H, I, J, M, N and S are assumed to be 0.

Waste flows

Waste flows are in general assumed to be less certain than product flows, and are hence more seldom 0% or 100%.
Gas: 0
Waste flows corresponding to a product flow has the same plastic content as that product.
Gas and heat etc. are assumed to have 0 plastic content.
E-waste is, as for products, assumed to have a 20% plastic content.
MSW: 0.1
Dried Sludge: 0.0001
Sewage sludge (70-97% water): 0.000001, plastic weight is assumed to be low related to the weight of the water.
Sludge: 0.000001
Waste water: 0.000001, plastic weight low related to the weight of the water
NEW: Leachate water (SLF): assumed to be 0.0001 plastic content for plastic related Leachates, rest = 0.
Residues from various sources: 0.1% plastic
Explicitly unsorted waste. 0.001, i.e. 0.1%
Bottom ash: 0.000001, plastic assumed to be condensed when burning
Hazardous waste without precision: 1%

C. Probability of littering per process

In order to come up with these probabilities, the following are considered:

- Open/close – is the process opened or closed? In an open process the plastic can reach nature, but in a closed one (e.g. airplane), plastic inadequately disposed would not reach nature whilst in the closed environment.
- Use/unforeseen disposal/accident – the process can further be categorised like this.

Then, a probability of littering is given per process, based (in the majority) on ecoinvent categories:

a) None 0
b) Very low 0.000001
c) Low 0.001
d) Medium 0.1
e) High 0.5
f) Very high 0.95

A. Agriculture, forestry and fishing

01: Crop and animal production, hunting and related activities: These processes are defined as open, and the type as use. Plastic use is assumed to include for example the adding of plastic-coated fertilizers and pesticides, which are assumed to become litter to a very high extent.

02: Forestry and logging

This category is assumed to be the same as 01.

Alternative interpretation: no obvious plastic flows identified and hence the littering probability is set to be very low.

03: Fishing and aquaculture

The process type here is assumed to be open, and the use type as "unforeseen". The littering probability is set to 10%, with the idea of referring to an estimated amount of lost fishing gear.

B. Mining and quarrying

Mining and quarrying are processes assumed to take place in the open. Since there is no obvious identified plastic flows in these processes, the probability for littering to occur is set to very low. However, there could be release of plastic related to, for example, accidents where gear or equipment is lost, or where infrastructure is harmed or weared off.

C. Manufacturing

All manufacturing processes are assumed to be closed activities, apart from that repair and installation activities could potentially be open.

10: Manufacture of food products

In the processes for manufacturing of food products, there are no obvious flows of plastic litter identified. The littering risk is therefore set to very low. There could potentially be some littering risk in case of accidents, or if there is any plastic equipment used in the manufacturing that gets lost.

13: Manufacture of textiles

When manufacturing textiles, it is assumed to be some plastic litter from the treatment of synthetic textiles or unforeseen waste flows. The overall amount is expected to be low.

16: Manufacture of wood etc.

17: Manufacture of paper and paper products

18: Printing and reproduction of recorded media

19: Manufacture of coke and refined petroleum products

For both 16, 17, 18 and 19, there are no obvious flows of plastic pollution identified, hence the risk is set to be very low.

20: Manufacture of chemicals and chemical products

In the sub-group of chemicals and chemical products, the amount of litter is assumed to be very low for products that are non-plastic (basic chemicals, fertilizers, nitrogen compounds, pesticides and agrochemicals, and "other" chemical products). For the manufacture of plastics and synthetic rubber, paint and varnishes, soaps and detergent, and man-made fibres, the litter is assumed to be higher, i.e. "low" instead of "very low" because these processes are assumed to involve more flows of plastics and hence potential flows of litter.

21: Manufacture of basic pharmaceutical products and pharmaceutical preparations

No obvious flows of plastic pollution identified; hence the risk is set to be very low.

22: Manufacture of rubber and plastics products

For the manufacturing of rubber and plastic products, the assumption is similar as for primary plastics, i.e. that there is a higher amount of different plastic flows hence higher risk and amount of litter. Still, of the total amount, only a low amount is expected to become litter.

23: Manufacture of other non-metallic mineral products

24: manufacture of basic metals

25: Manufacture of fabricated metal products, except machinery and equipment

For both 23, 24 and 25, there are no obvious flows of plastic pollution identified, hence the risk is set to be very low.

26: Manufacture of computer, electronic and optical products

27: Manufacture of electrical equipment

28: Manufacture of machinery and equipment n.e.c.

For the manufacture of computers, electronics and electrical equipment, there is a higher number of plastic flows expected, hence the risk/amount of expected litter is low instead of very low.

29: Manufacture of motor vehicles, trailers and semi-trailers

30: Manufacture of other transport equipment

For the manufacture of vehicles, trailers and transport equipment, there is a higher number of plastic flows expected than for e.g. basic metals or mineral products, hence the risk/amount of expected litter is low instead of very low.

31: Manufacture of furniture

Same assumptions as for 13: Manufacture of textiles.

D. Electricity, gas, steam and air conditioning supply

As there are no assumed plastic flows in these processes, the probability that litter would occur is also set to none.

E. Water supply; sewerage, waste management and remediation activities

36: Water collection, treatment and supply

No obvious use of plastics in the collection and treatment of water, except for filters, which might generate a very low amount of litter (in terms of microplastics).

37: Sewerage

For WW treatment processes, some litter is expected because of assumed inflow of plastics and microplastics that are not removed, as well as treatment that might add microplastics to

released water. The probable amount is hence estimated to be low instead of very low. The majority of plastic entering wastewater treatment is still expected to be collected.

38: Waste collection, treatment and disposal activities; materials recovery.

Collection and sorting of non-hazardous waste: 0.1

Processes that are furnace related, such as furnace slag, are assumed to be very low as there are no expected plastic flows (plastic is assumed to be consumed if present): 0.000001

Heat and power co-generation: 0

Landfill (sanitary and unsanitary): 0.95

- Landfarming: 0.95
- Open dump/burning: 0.95
- Underground deposit is assumed to have very low littering rates: 0.000001
- Industrial composting: 0.000001
- Incineration and anaerobic digestion: 0.000001
- Treatment of bottom ash: 0.000001
- Impoundment: 0.001
- Material recovery: 0.1
- 39: Recultivation is assumed to generate very low litter

F. Construction

Construction activities are assumed to have different plastic flows, for example materials used for construction or equipment. It is assumed that some get lost, mainly due to unforeseen disposal such as wear or components lost, as well as waste from demolition not taken care of properly, or e.g. pipes left in the ground after serving their purpose. The overall amount is estimated to 0.001.

G. Wholesale and retail trade

Estimated to be 0 as none of the flows are expected to have any plastic content (services)

H. Transportation and storage

Very low (0.000001) as there is a possibility that the mode of transport gets littered itself due to an accident (e.g. sea, road accident).

However, transform P_littering for tyre, break and road wear to 1, as these flows in ecoinvent are literally showing direct littering onto an open space.

I. Accommodation and food service activities

Estimated to be 0 as none of the flows are expected to have any plastic content (services)

J. Information and communication

Estimated to be 0 as none of the flows are expected to have any plastic content (services)

K. –

L. –

M. Professional, scientific and technical activities

Estimated to be 0 as none of the flows are expected to have any plastic content (services)

N. Administrative and support service activities

Estimated to be 0 as none of the flows are expected to have any plastic content (services)

S. Other service activities

Estimated to be 0 as none of the flows are expected to have any plastic content (services)