New database exchanges for characterisation factors of the Swiss method of environmental scarcity

Memorandum
Zürich, June 2020

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Comsissioned by
Federal Office for the Environment (FOEN)
represented by Peter Gerber

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Suggested citation: Doka G. (2020) New database exchanges for characterisation factors of the Swiss method of environmental scarcity. Memorandum. Doka Ökobilanzen, Zürich, Switzerland.

Contents

1 Introduction

The method of environmental scarcity (synonyms: ecoscarcity, UBP, MOeK) is currently (March '20) being updated. It will contain new characterisation factors that will require new exchanges in LCI databases.

1.a New characterisation factors in environmental scarcity

Two new characterisation factors (or eco-factors) are planned in the updated method of environmental scarcity. Their magnitude is not definitive yet, but they will be added to the new method.

Characterised Flow	Physical Unit	Characterisation Factor (tentative) *
Waste mass placed in landfill	kg [wet]	18 UBP /kg
Organic carbon placed in landfill	kg [C]	5500 UBP/kg C

* The amounts listed here are provisional. The definite figures will be published in the updated ecoscarcity methodology report in 2020.

The meaning of the ecofactor for waste mass in landfill is to depict the scarcity of suitable landfill sites and a desire to preserve Swiss land areas. The meaning of the ecofactor for carbon in landfill is to include the risk of possible unwanted and detrimental developments of landfills and this risk of possible problems is attached to the content of organic carbon (fossil and biogenic).

2 Required new exchanges

The new characterisation factors refer to flows which are not located at the technosphere/biosphere, but refer to **flows in the technosphere**. In LCA, the landfill body is commonly considered a man-made artefact within the technosphere. The new characterisation factors refer to mass flows *going into* a landfill body, which are therefore technosphere flows.

Together with the method developers Fredy Dinkel and Thomas Kägi at Carbotech Basel, Gabor Doka has established how to implement the new characterisation factors, in order to allow databases to calculate complete results for the new environmental scarcity method. The chosen approach is the **creation of new exchanges**. As explained above these exchanges refer to technosphere flows, but in the logic of the database calculation procedures and LCIA result generation they are equal to other biosphere exchanges.

The following two new exchanges need to be created in databases and assigned in LCIA calculation of ecoscarcity results.

Name English	Name German	Category	Subcategory	Unit	Characterisation Factor (tentative)
Waste mass, total, placed in landfill	Abfallmasse, gesamt, einer Deponie zugeführt	natural resource	in ground	kg [wet]	18 UBP / kg
Organic carbon, placed in landfill	Organischer Kohlenstoff, einer Deponie zugeführt	natural resource	in ground	kg [C]	5500 UBP / kg C (2011/13)

The advantage of this is that precise results are obtained for any landfilling process. The ecofactors are not differentiated according to landfill type and neither do the new exchanges need to be differentiated further.

Conventionally, characterised exchanges are at the technosphere/biosphere boundary. In the case of landfills, the already inventoried exchanges *out of* the landfill body are conventional emissions to air and water, which are characterised by LCIA methods. The new characterisation factors are not referring to such emissions, but to *inputs* into the landfill body, and therefore still within the technosphere.

2.a Conceptually similar exchanges

Using biosphere exchanges to inventory what are in reality technosphere flows is not unprecedented. the following titular biosphere exchanges are actually technosphere exchanges, of which the first three are characterised by at least one LCIA method:

Volume occupied, final repository for low-active radioactive waste, m^3: Volume of the repository facility
Volume occupied, final repository for radioactive waste, m^3: Volume of the repository facility
Volume occupied, underground deposit, m^3: Volume of the deposited waste
Volume occupied, reservoir, m^3: Water volume in a hydro power plant reservoir
Water, turbine use, unspecified natural origin, m^3: Water volume going through a hydro power plant
Vehicle kilometres travelled, km: Vehicle-kilometres travelled, for traffic noise assessment

2.b Categories and Subcategories of the new exchanges

The new exchanges are put in the already existing category **raw/in ground**. It would be maybe more appropriate to create an entirely new category and subcategory (e.g. technosphere exchange/landfill), but for reasons of practicability it seemed easier and less disruptive to use already existing categories. The waste-related exchanges like "Volume occupied, final repository…" and "Volume occupied, underground deposit…" are already in this same category.

2.c UUIDs of the new exchanges

For inventories in the EcoSpold2 XML file format, the ecoinvent association has issued following UUIDs for the new exchanges in April 2020:

Exchange name	UUID
Waste mass, total, placed in landfill	6bc06a91-ae35-4a2b-ab39-da4dd36b621a
Organic carbon, placed in landfill	4044e84c-26c5-4cef-b76c-8c660d60bcfe

3 How to use the new exchanges

The two new exchanges are only intended to properly accommodate the characterisation factors of the new ecological scarcity method.

In *existing process inventories* relating to landfilling processes, the two new exchanges shall be added to the inventory with their accurate, waste-specific amounts.

An Excel table listing the required figures for disposal processes in ecoinvent v2.2 and 3.6 is available at http://www.doka.ch/publications.htm under the heading "New inventory exchanges for characterisation factors of the Swiss method of environmental scarcity".

The new exchanges are introduced in the updated Excel waste disposal calculation tools (version June 2020, available for free at http://www.doka.ch/publications.htm. So for any *new* disposal activity datasets created with those tools, the exchanges will already be included.

In *new disposal process inventories* created after June 2020, the new exchanges will be part of the created inventories.

3.a Waste mass placed in landfill

Often the waste mass will be 1 kg, if the process inventory is a landfilling process. But exceptions exist:

Sanitary landfill: In sanitary landfills with leachate treatment some sludge can be produced, which can go to incineration producing incineration residues, which are landfilled, and this producing additional landfilled mass beyond the 1kg initially landfilled. The waste-specific amount of mass going to landfill is equal to the amounts of the exchanges for the technosphere activities "process-specific burdens, slag compartment" (landfilled bottom ash) and "process-specific burdens, residual material landfill" (landfilled ashes and flue gas scrubber residues, solidified); both already in the required unit of kilogram.

Incineration: In municipal and hazardous incineration inventories, waste-specific amounts of residues are landfilled, and this landfilling is integrated into the incineration inventory. So although the process is initially an incineration (waste mass to incineration in *not* counted in ecoscarcity) due to the landfilling of secondary wastes some waste-specific amounts to landfill are invoked. As already explained above, the waste-specific amount of mass going to landfill is equal to the amounts of the exchanges "process-specific burdens, slag compartment" and "process-specific burdens, residual material landfill".

3.b Organic carbon placed in landfill

Also for the exchange "organic carbon placed in landfill" process inventories involving landfilling shall be expanded with the waste specific amount of carbon in the waste originally placed in the landfill.

For foreground landfilling processes (sanitary landfill, residual material landfill, tailings, unsanitary landfills, open dumps) the organic carbon content of the landfilled waste can be found in the

GeneralComment of the process inventory.[1] Also accompanying reports reference the inventoried waste compositions.

In the case of sanitary landfills a small portion of the carbon originally placed in the landfill can be landfilled again via the process chain (which is already included directly in the process inventory of the sanitary landfill process):

Waste → leachate → Wastewater treatment → digester sludge → Incineration → landfilled residues

So here the total carbon placed in landfill can slightly exceed the carbon of the originally landfilled waste. But this does not constitute incorrect double counting, since the carbon in landfilled incineration residues is effectively an additionally required process as opposed to the initial sanitary landfill. Please note that the ecoscarcity method counts organic carbon placed in a landfill regardless of its further fate. In this example the further fate of carbon involves an additional landfilling process via generated higher order wastes.

For incineration processes some landfilling occurs via disposal of secondary waste (solid incineration residues). The carbon in those landfilled wastes need to be determined using the waste composition and employed transfer coefficient models. Since the disposal models are designed to be waste-specific throughout, also for secondary or higher order wastes, this is easily feasible.

Open burning can take place in landfills or dumps, but also anywhere else and any unrecycled solid residues are left on the ground. It is assumed that those leftover solid residues qualify in either situation for being included as undesirable flows in the sense of the ecoscarcity method.

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1 The general comment contains a section starting with "waste composition (wet, in ppm): …" and the subsequent entry for C (carbon) refers to the organic carbon content in ppm = mg/kg. The functional unit of all disposal processes is per kilogram wet waste composition. So the carbon content given here is the one needed for the amount of organic carbon placed in landfill (convert mg to kg though). Please note that in Ecospold2 the waste composition might be given additionally as *exchange properties* of the treated waste, but those are per kilogram dry waste, i.e. do not correspond with the functional unit of the disposal process.

Process	f.u.	Waste mass placed in landfill	Organic carbon in landfill
Residual material landfill	1 kg	1kg [1]	Waste-specific amount
Sanitary landfill	1 kg	1kg and possible additional amounts from secondary waste treatment via leachate treatment	Waste-specific amount and possible additional amounts from secondary waste treatment via leachate treatment
Unsanitary landfill	1 kg	1 kg	Waste-specific amount
Open Dump	1 kg	1 kg	Waste-specific amount
Municipal incineration	1 kg	Waste-specific amounts from incineration residues (slag compartment + residual material landfill) [1]	Waste-specific amounts from incineration residues (slag compartment + residual material landfill)
Hazardous waste incineration	1 kg	Waste-specific amounts from incineration residues (in residual material landfill only) [2]	Waste-specific amounts from incineration residues (in residual material landfill only)
Open Burning	1 kg	Waste-specific amounts from incineration residues [3]	Waste-specific amounts from incineration residues
Wastewater treatment	1 m^3	Waste-specific amounts from incineration of generated digester sludge (slag compartment + residual material landfill)	Waste-specific amounts from incineration of generated digester sludge (slag compartment + residual material landfill)

1 Some residual waste materials are solidified with cement. This additional waste mass is heeded in a separate dataset "disposal, cement, hydrated, 0% water, to residual material landfill".

2 The landfilled amounts are usually <1kg, but they can exceed 1kg, because the solid remains of incineration can be oxidised during incineration and mass form air oxygen is added to the solid outputs.

3 Open burning can take place in landfills or dumps, but also anywhere else and any unrecycled solid residues are left on the ground. It is assumed that those leftover solid residues qualify in either situation for being included as undesirable flows in the sense of the ecoscarcity method.

3.c Remarks regarding the augmentation of existing datasets

For consistency, *already existing* datasets with landfilling activities in them should additionally be augmented to include in their process inventories the two new exchanges for waste mass and organic carbon placed in landfill.

The new exchanges shall be added where the actual waste-specific landfilling process is inventoried with its emissions and process expenditures. This is not always crystal clear from process names alone, as there have been instances, where authors made inventories consisting only of a call to existing landfilling processes, but using the naming conventions of a landfill inventory.[2] To avoid double counting, exchanges shall only be added in the "final sink" landfill processes, but not in processes merely *requesting* those processes.

In 2003 for several landfills, datasets containing constant, process-specific expenditures independent of waste composition were created and requested in the landfilling processes proper. It is not advisable to adding the waste mass exchange in those process-specific datasets. As not all landfilling processes refer to the old "process-specific burdens", e.g. unsanitary landfill, it is advisable to have the augmentation in a uniform pattern in the process that includes the waste-specific landfilling expenditures.

2 For instance in the KBOB database contains a process called "disposal, render carrier board, resin bound, to inert material landfill". The name of this process has the exact structure of a inert landfilling process, but this is misleading. Its inventory contains merely links to other processes, like inert waste to landfill, plastic plaster to landfill, and glass to landfill.

3.d LCIA implementation ecoscarcity

As of this writing (June 2020) the magnitudes for characterisation factors of the ecoscarcity update are not known yet.

In addition to the new ecoscarcity version, the ecofactors could also be used with advantage in *older ecoscarcity versions*. Versions 2008 and 2013 had already ecofactors for valuation of organic carbon in landfills (15 and 5.5 UBP per gram C, respectively). The new exchange for organic carbon placed in landfill allows a much more accurate assessment of this burden than the previously used solution of characterising long-term TOC emissions. The latter factor needs to be removed from ecoscarcity calculation, when the new exchanges are employed in LCIA.

Valuation of total mass in landfills was already employed in the (leagacy) ecoscarcity versions of 1990 and 1997 (220 and 500 UBP per kilogram waste, repectively). The solution employed previously for these factors was a valuation via the landfill surface area, which was available from the inventories. If still needed, the new exchange for waste mass placed in landfill allows an alternative and more flexible implementation of those ecofactors.

3.e Other usages

Other usages of the new exchanges for LCIA other than the intended application are not endorsed.

The organic carbon to landfill exchange must for instance not falsely receive a negative GWP for "carbon not released". This is not carbon sequestered and stored in perpetuity. A considerable amount of carbon in landfills can yet be released, either as CO_2, CH_4, or TOC emissions. Also in the case of biogenic materials, the carbon in a waste has already been heeded with a negative GWP via CO_2 uptake during biomass growth. Counting the same carbon again with a negative GWP constitutes double counting.

Also, on a more conceptual level, one should not value *non-emissions* in LCIA. LCA looks at actually *occurring* emissions, which does not mean that a non-emission deserves a benefit of some sort. In all processes a lot of the involved materials are usually *not* emitted. This is very normal and no precedent should be created to make this into something that deserves a reward or benefit. Otherwise massive double counting problems are introduced, making LCA results useless.

4 Why previous solutions do not work

4.a Waste mass placed in landfill

Already in previous versions of the method of environmental scarcity (1990 and 1997) a valuation of waste mass in landfills was defined. In order to be able to assess those masses in LCIA, Doka (2003-III, p.41) proposed in the ecoinvent 2000 project to calculate deposited waste mass from the *occupied landfill surface area*. Assuming a certain landfill body height and a waste density the surface area can be converted to the waste mass deposited. The eco-factors for waste can then be attached to the direct landfill land occupation using a conversion factor. For this purpose six different landfill land use types were defined that allowed to differentiate between the different landfills.

This approach works fine, since the different landfill models of ecoinvent 2000 had *constant height*, and therefore constant ratios of deposited mass per square meters of landfill surface area.

In 2017 the landfill models of ecoinvent were regionalised (Doka 2017b). The models were made more flexible to allow for different local climates and also the landfill height was made into an user-adjustable parameter. Therefore, the modelled landfill height is not constant for each landfill type anymore and the LCIA characterisation via the landfill surface area fails.

> The new exchange "Technosphere exchange, total waste mass placed in landfill" allows a precise characterisation of deposited waste mass in LCIA. **For this reason the past implementation via surface area occupation by (Doka 2003) is obsolete and must not be used anymore.**

4.b Organic carbon placed in landfill

An ecofactor for organic carbon in landfill was already derived in previous versions of the environmental scarcity method (2008, 2013).

This ecofactor could be applied by inventory authors directly in the creation of foreground landfill process calculation, i.e. adding 18 UBP in the results for each kilogram of landfilled waste.

But this flow could not be characterised in the background landfill processes of a database, i.e. any *indirect* landfilled waste would not be assessed. To circumvent this problem, the ecoscarcity authors proposed a proxy solution: instead of characterising the carbon put *into* the landfill, the carbon emissions *from* the landfill should be characterised, but only the long-term TOC emissions (LT TOC), as those originate exclusively from landfill processes in the ecoinvent database. The authors used a generic, constant carbon transfer coefficient (TK) to calculate back from LT TOC emission to carbon content of the waste. They have done this only for two types of landfills (sanitary + residual material). In implementation of LCIA factors merely a single factor derived for sanitary landfill is used to characterise LT TOC emission.

This proxy approach errs by using a *constant* transfer coefficient. In the sanitary landfill model of ecoinvent the transfer coefficient is *waste-specific*, i.e. depends on the waste characteristics and is not simply a constant factor for all waste materials. So for each sanitary landfill process a different carbon transfer coefficient is correct. The proxy approach introduces unnecessary distortions, which in the present ecoinvent disposal processes can exceed a factor 2. Furthermore the transfer coefficient the authors do use, is not even the one appropriate for average waste in a sanitary landfill.

The proxy approach also dismisses ultimately other landfill types, that also emit LT TOC (residual material waste, bottom ash landfills, hard coal tailings, lignite tailings). Depending on the process those neglected landfills could be much more relevant contributors to LT TOC. For other landfill types the transfer coefficients differ amongst each other and the lack of granularity introduces additional distortions.

The questionable nature of the proxy solution has already lead to authors skipping this ecofactor altogether even in a BAFU study (see page A6 in Dinkel et al. 2012).

> The new exchange "Technosphere exchange, organic carbon placed in landfill" allows a precise characterisation of organic carbon placed in landfills in LCIA. **The approximation for valuing carbon placed in landfills via LT TOC emissions must not be used anymore.**

5 References

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