From Global Material Footprint to Product Material Footprints

Challenges of Sustainability Research

Auftaktkonferenz

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Content

Relevance of the material footprint within the sustainable development goals (SDGs)

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Material footprint for SDG monitoring

The material footprint is used as indicator for SDG 8 and SDG 12.

**Target 8.4:** Improve progressively, through 2030, global resource efficiency in consumption and production and endeavor to decouple economic growth from environmental degradation.

**Indicator 8.4.1:** Material footprint, material footprint per capita, and material footprint per GDP

**Target 12.2:** By 2030, achieve the sustainable management and efficient use of natural resources.

**Indicator 12.2.1:** Material footprint, material footprint per capita, and material footprint per GDP

However, up to now there is no target level of sustainable material footprint defined.
The material footprint in 2010 and 2017

From 2010 to 2017 the global material footprint grew from 73 to 86 billion tons a 17.5 % increase.
Material footprint per capita and per unit GDP from 2000 to 2019

The material footprint per capita grew from 9.3 to 12.4 tons a 34% increase.

The material footprint per unit GDP dropped from 1.19 kg/US$ to 1.14 kg/US$ a 4% decrease.

https://sdg-tracker.org/economic-growth
Future projections of raw material consumption

Current raw material consumption could double by 2060.

The growth is dominated by material use for production of goods and energy. Main consumer is the construction and building industry.
DPSI framework

Socio-economic system

Nature

Impacts
landscape changes
hydrological changes
biodiversity loss
soil loss

State Change

Pressures

Drivers

Pressures

State Change

Impacts

raw material extraction

production and consumption

abiotic raw material

waste

emission discharge

biotic raw material

waste and emission

global warming
eutrophication
acidification
water quality
soil degradation
The Product Material Footprint (PMF) was developed to assess the environmental impacts of material use for a product or service.
The indicators of the Product Material Footprint (PMF) are used to track the biotic and abiotic material used in production. Production involves the use of primary abiotic material and used abiotic material. Inputs to production include biotic raw material and used biotic material. Outputs from production include waste and products. The RMI (Recovery, Management, and Integration) system manages unused extraction and separation of primary material. The TMR (Transfer, Management, and Recovery) system involves the use of unused extraction to manage the stock of abiotic material resources in the biosphere. The socio-economic system includes the harvest of primary biotic material, and the fund of cultivated biotic material resources. The economy includes the stock of abiotic material resources, the fund of natural biotic material resources, and the fund of cultivated biotic material resources.
PMF as Life Cycle Impact Assessment Method

Article
Measuring Product Material Footprint as New Life Cycle Impact Assessment Method: Indicators and Abiotic Characterization Factors

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Abstract: The global economy is using growing amounts of natural resources such as raw materials, water, and land by making and using goods, services, and infrastructure. Aspirations on international, regional, and national levels e.g., the Sustainable Development Goals, the EU flagship initiative Roadmap to a Resource Efficient Europe or the German Program for Resource Efficiency are showing an urgent need to bring the global raw material use down to sustainable levels. An essential prerequisite to identify resource efficient options and to implement resource efficiency measures and solutions is the ability to compare different products or services regarding their raw material use. Until today, there is no internationally standardized approach defined and no software supported calculation method including the necessary data basis available to measure the raw material intensity of products. A new life cycle impact assessment (LCIA) method Product Material Footprint PMF is described. Two indicators are used to quantify the PMF: the Raw Material Input RMI and the Total Material Requirement TMR. The calculation of global median values for the characterization factors $C_{PMF}$ and $C_{RFM}$ of abiotic materials was done based on different databases. This article presents the methodological approach of the PMF; the calculation results for $C_{RFM}$ of 42 abiotic materials and $C_{PMF}$ of 36 abiotic materials, and the implementation of the LCIA method into the software openLCA for use with the ecoinvent database.

Keywords: product material footprint; new life cycle impact assessment method; abiotic materials; raw material input; total material requirement; characterization factors

Article
Biotic Part of the Product Material Footprint: Comparison of Indicators Regarding Their Interpretation and Applicability

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Abstract: The product material footprint (PMF) represents a central instrument to assess the potential environmental impacts of products and services based on their life-cycle-wide material use. Within the life-cycle impact assessment framework, the indicators raw material input (RMI) and total material requirement (TMR) have been used for its calculation, but so far, only abiotic materials have been considered. This research analyses the requirements and indicators for the assessment of the biotic part of the PMF. The central question is whether the indicators RMI BIOTIC and TMR BIOTIC are suitable for this purpose or if they need to be adapted. For comparison, the indicator cumulative raw material demand (CRD) is applied. The indicator concepts of RMI, TMR, and CRD are compared by defining the system boundaries for determining the biotic parts of the footprint. To test the applicability, the production of wheat bread is assessed as a case study. The characterization factors of wheat grains are determined and each of the three indicators is implemented in the software openLCA for use with the ecoinvent database. The results show that RMI BIOTIC and TMR BIOTIC are suitable indicators for the quantification and assessment of the biotic part of the PMF. While CRD BIOTIC provides the same information as RMI BIOTIC, both indicators differ regarding the biotic part. The CRD per definition does not consider biotic inputs from agriculture and forestry and thus conveys insufficient information on the used and unused biomass extraction for the product LCA. The ratio of RMI BIOTIC to the net annual increment and TMR BIOTIC to the net primary production could be used for absolute sustainability assessment.

Keywords: resource use; material flows; life cycle impact assessment; system boundary; agriculture

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Four steps to calculate the PMF

1. Determination of characterization factors

2. Implementation in LCA Software

3. Modelling of product system

4. RMI and TMR as material footprint results
Sustainable Resource Application (SURAP)

Software solution for real time calculation and visualization of the material footprint of design options based on digital planning information.
Future research outlook

**Update data:** Most of the data used to calculate the characterization factors are based on the year 2014 or later. Therefore, a regular update of the material footprint data needs to be implemented.

**Increase precision:** Currently, the calculation is based only on the content of the material in the raw material. In the future, the process efficiency and dissipation should be included.

**Include regionalization:** The current results represent global averages values based on international markets and supply chains. The accuracy of the material footprint could be further improved by a spatially-explicit assessment.

**Evaluation of results:** The material footprint indicators could be used for absolute sustainability assessments. $\text{RMI}_{\text{biotic}}$, e.g. to assess primary biomass used in production in terms of net annual increment.
Thank you very much for your kind attention!

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