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THE IMPORTANCE OF PRIMARY DATA FOR LIFE CYCLE ASSESSMENT OF CONSTRUCTION PRODUCTS IN BRAZIL

A IMPORTÂNCIA DE DADOS PRIMÁRIOS PARA A AVALIAÇÃO DO CICLO DE VIDA DE PRODUTOS DE CONSTRUÇÃO NO BRASIL

LA IMPORTANCIA DE LOS DATOS PRIMARIOS PARA LA EVALUACIÓN DEL CICLO DE VIDA DE LOS PRODUCTOS DE CONSTRUCCIÓN EN BRASIL

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ABSTRACT:

This work presents a study of six construction products: sand, gravel, clay block, concrete block, ready-mix concrete and mortar. National LCIs were developed using primary data collected at manufacturers located in the State of São Paulo, and upstream and downstream processes were based on the ecoinvent database. Datasets available in ecoinvent deemed representative of these six construction products were chosen for comparison. Four impact indicators were calculated: Global Warming Potential, Water Depletion, Cumulative Energy Demand and Resource Depletion. The differences between the national and the international impact results range from 10% to 255%, with an overall average difference of 69%. GWP was the indicator with the least average difference (53%); while Water Depletion had the highest (101%). Regarding the products, the differences considering all impact indicators range from 42% (gravel) to 109% (clay block). The results indicate the importance of national LCIs based on primary data in order to ensure reliable construction LCA studies in Brazil.

Keywords:
Life Cycle Inventory, primary data, construction.

1| INTRODUCTION

Life cycle assessment (LCA) is considered a suitable tool for evaluating the environmental performance of construction products (CBCS et al. 2014). Usually this application of LCA implies limiting its scope to a cradle-to-gate analysis, because a specific construction product may have multiple options of use. However, even cradle-to-gate LCA studies require a significant amount of data in order to develop the life cycle inventory (LCI) of a product.

In Brazil, the national life cycle inventory database is still under development and secondary data sources are not uniform and consensual (Oliveira et al. 2013). As a result, it is common to use LCA data from other locations. However, these data might not be representative of the system product being modelled, due to differences in product composition, manufacturing technology, energy sources, etc. (Colodel 2008; Soust-Verdaguer et al. 2016).

To overcome this problem, some methods were developed to adapt existing life cycle data to local conditions, with varying degrees of complexity (Colodel 2008; Oliveira et al. 2013). The main approach though is the adaptation of macro parameters, such as energy mix (Oliveira et al. 2013; Saade et al. 2014). However, previous research has shown the importance of collecting primary data, at least for the foreground process (Castro et al. 2015; Silva et al. 2015).

The aim of this work is to discuss the importance of primary data for life cycle assessment of construction products in Brazil, based on a study comprising six construction products commonly used in traditional construction.

2| METHODOLOGY

Primary data of the manufacturing processes of six construction products – sand, gravel, clay block, concrete block, ready-mix concrete and mortar – were collected via questionnaires applied during site visits in manufacturers (one for each product) located in the State of São Paulo, Brazil, between the years of 2014 and 2015. When necessary, allocation by mass was applied. In order to develop the Life Cycle Inventories (LCIs) for these construction products, upstream and downstream processes were modelled using the ecoinvent database (version 3.2) (Wernet et al. 2016), considering a cradle-to-gate system boundary.

To assess the importance of primary data, impact results calculated for the national LCIs (Table 1) were compared to the results obtained from similar LCIs available in the ecoinvent database ("Rest of the World" datasets), as shown in Table 2. The analysis was also supported by the examination of ecoinvent metadata (Kellenberger et al. 2007).

Table 1 – Life cycle Assessment impact categories and methods.

Impact category	LCIA Method
Global Warming Potential (GWP)	IPCC 2013, 100 years' timeframe (IPCC 2013)
Water Depletion (WD)	ReCiPe Midpoint H (Goedkoop et al. 2009)
Cumulative Energy Demand (CED)	Cumulative Energy Demand (Frischknecht et al. 2007)
Abiotic Depletion Potential (ADP), reserve base	ILCD Midpoint (European Commission & Joint Research Centre 2012)

Table 2 – Ecoinvent datasets chosen for comparison with Brazilian datasets.

Product	Corresponding ecoinvent dataset	Reference product
Sand	Gravel and sand quarry operation	Sand
Gravel	Gravel production, crushed	Gravel, crushed
Clay block	Clay brick production	Clay brick
Concrete block	Concrete block production	Concrete block
Ready mix concrete	Unreinforced concrete production, with cement CEM II/A	Concrete, normal
Mortar	Cement mortar production	Cement mortar

The impact results were calculated using Simapro (version 8.2.0.0). The relative difference between the LCIA results obtained from the LCIs developed by IPT based on primary data gathered in Brazil and from the ecoinvent datasets was calculated according to the following equation:
relative difference = (result IPT – result ecoinvent) / result ecoinvent (%)

3| RESULTS AND DISCUSSION

Table 3 presents the relative differences between the impact assessment results calculated for the LCIs developed in this research and for ecoinvent LCIs, by product. It must be highlighted that gravel and sand (aggregates) are used in the manufacturing of concrete block, ready-mix concrete and mortar. Since we opted to use the Brazilian datasets when developing the LCIs of these products, they also contribute to part of the differences observed in their results.

Table 3 – Relative differences between impact assessment results of IPT and ecoinvent datasets.

Product	Impact category				Average absolute difference (by product)
	GWP	WD	CED	ADP	
Sand	+ 50%	- 99%	+ 85%	- 16%	63%
Gravel	- 67%	- 39%	- 50%	- 12%	42%
Clay block	- 90%	+ 255%	- 49%	- 40%	109%
Concrete block	+ 10%	+ 121%	+ 112%	- 44%	72%
Ready-mix concrete	+ 72%	- 64%	+ 58%	+ 55%	62%
Mortar	- 28%	- 29%	- 20%	+ 197%	69%
Average absolute difference (by impact category)	53%	101%	62%	61%	69%

A high correlation was observed between GWP and CED results, and therefore their discussion will be presented together. For sand, diesel and energy consumption determined by IPT were higher than in ecoinvent and that explains the higher GWP and CED result for Brazil. Regarding gravel, diesel and energy consumption determined by IPT were lower and consequently the results for GWP and CED. Besides the differences between the gravel extraction processes – in Brazil quarrying is done by explosion while in Europe it is an open pit excavation – there might be though an underestimation of diesel consumption by the Brazilian manufacturer who delivered primary data.

For the clay block, the main difference regarding GWP and CED is the use of saw dust as fuel for the tunnel kiln in the factory visited in Brazil – the CO2 generated in the combustion is biogenic – whereas in the ecoinvent dataset the main fuels are natural gas, heavy fuel oil and light fuel oil. For the concrete block: although GWP is highly influenced by cement type and content in cementitious products, in this case, the higher GWP (and also CED) of the IPT dataset is explained by the electricity consumption, that contributes with 30% of the final result. The electricity consumption in ecoinvent was extrapolated from cement cast plaster floor production, which is quite lower.

The cement content of the ready-mix concrete assessed by IPT is 363 kg cement/m^3 concrete, while that of the ecoinvent dataset is 200 kg/m^3 - the dosage considered by IPT is of a concrete for cast-in-place walls that needs formwork to be disassembled in 48 hours. This explains the difference observed in the GWP and CED. Regarding the mortar dataset, IPT found a lower GWP mainly due to the cement content (0,12 kg/kg versus 0,2 kg/kg of ecoinvent) and cement type (IPT considers a cement type with 6-20% alternative constituents while ecoinvent uses “cement, Portland”). On the other hand, IPT considers the use of quicklime in the composition of mortar (0,037 kg/kg), which explains why the GWP result is only 28% lower than in ecoinvent.

For WD indicator, the average difference between IPT and ecoinvent results is 101%. For clay and concrete block, the IPT results are superior due to electricity consumption, once the main source of electrical energy in Brazil is hydroelectric power and the evaporation of water in hydro reservoirs is considered. Brazilian aggregates have a lower WD, explained by differences in the excavation processes, that also entails a lower WD for the ready-mix concrete. The difference between WD results for mortar is related to the silica sand content inventoried by IPT (0,21 kg/kg), which is lower than in the ecoinvent dataset; however, there might be an underestimation of this indicator because drying of artificial sand (crushed gravel) was not considered.

The average difference between IPT and ecoinvent results for ADP is 61%. Sand, clay block and gravel available in Ecoinvent present a higher ADP result due to the energy mix (mainly related to nuclear energy share). For concrete block (and also gravel) the higher results for Ecoinvent processes are due to a higher consumption of rubber and steel for equipment maintenance. Ready-mix concrete assessed by IPT presents a higher ADP due to cement content as previously mentioned. The higher ADP value found by IPT for mortar is associated with kraft paper production used for packing (it accounts for 95% of the final ADP indicator).

4| CONCLUSIONS

Overall relative difference of LCIA results of Brazilian and ecoinvent datasets was high – results range from 10% to 255%, and the average absolute difference is 69%. The main reasons for this finding were differences in process parameters such as energy consumption levels, fuel types and product composition.

The results of this study demonstrate the importance of primary data collection in order to have reliable life cycle assessment of construction products. However, reliability also requires extending data collection, not only because of data representativeness, but also for having reference values of LCI flows and LCIA results to which specific product data can be compared, aiming at a better analysis.

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