LCA as comparison tool for environmental evaluation of recycled aggregate production from CDW and natural aggregates

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Introduction

The present study deepens the knowledge of the environmental aspects that prove the benefit of using AR instead of natural aggregates. The present work quantifies not only the environmental impact, but also the effect of introducing possible improvements in the productive system, and what effect they cause in the reduction of impacts.

The Life Cycle Analysis (LCA) methodology is applied to quantify and compare the environmental impacts generated in the production of a ton of mixed recycled aggregates from Construction and Demolition Wastes (CDW) according to the data provided by the plant managers and those generated in the production of a ton of natural aggregates extracted from a quarry. The results revealed that the production of mixed recycled aggregate is more beneficial for the environment since the LCA confirms that the average reduction of impacts generated during the production of mixed recycled aggregates with respect to the extraction of natural aggregate.

The main goal of the present work is to quantify not only the environmental impact, but also the effect of introducing possible improvements in the productive system of aggregates production, and what effect they cause in the reduction of impacts. The LCA methodology is applied to compare the environmental impacts generated in the production of mixed recycled aggregates from CDW according to the data provided by the studied CDW plant and those generated in the production of natural aggregates extracted from a quarry sited in Province of Córdoba (Andalusia).

Experimental methodology

A comparative study will be carried out on the environmental impacts produced by the production of 1 t of natural aggregate (NA) in comparison to the production of 1 t of recycled aggregate (RA) from CDW through the application of LCA. The methodology applied is the same as for any production process, but with a different objective and scope of study in each case which allows establishing the comparison between different products or systems (Suárez *et al,* 2016).

The life cycle considered for both materials: NA from a quarry and RA from a treatment plant is the production process that includes: (1) the necessary raw materials, (2) the transport to the production plant, (3) processing treatment and (4) final production of the material.

In the present work, transport to the site has not been considered, considering that the production of both types of materials (quarry for NA and the recycling plant for RA) have the same radius of action and both the same operating system and type of transport.

Thus Likewise, the implementation of the materials, their conservation and maintenance, as well as the management of waste at the end of the useful life of the materials have not been considered, since it has been considered that both materials cause similar impacts. a general scheme of the limits of the system considered for the realization of the LCA of both materials.

The method for the evaluation of the impacts has been IMPACT 2002+, developed by the Polytechnic University of Lausanne (Switzerland), since it is the one that best adapts to all the chosen impact categories (Collangelo *et al*, 2020) applying the impact categories showed in Table 1.

Table 1. Environmental impact assessment categories in IMPACT 2002+.

Impact categories	Funcional unit
Global warming	kg CO2 eq
Ozone layer depletion (ODP)	kg CFC-11 eq
Aquatic acidification	kg SO2 eq
Aquatic eutrophication	kg PO4 eq
Eutrophication of marine water	kg N eq
Terrestrial eutrophication	mol N eq
Photochemical ozone formation	kg NMVOC eq
Depletion of abiotic resources – minerals and metals	kg Sb eq
Depletion of abiotic resources – fossil fuels	MJ, net calorific value
Water consumption	World m^3eq. private

The selected impact categories are based on the recommendations for the performance of LCA in buildings according to CEN/TC350 of Sustainability in the building, to assess sustainability assessment frameworks, building and civil works.

Results and discussion

For this the present study, the free and open source software for modeling the life cycle of products and systems: the OpenLCA program has been used in order to establish the comparative between the environmental impact of both products (NA and RA in Fig. 1).

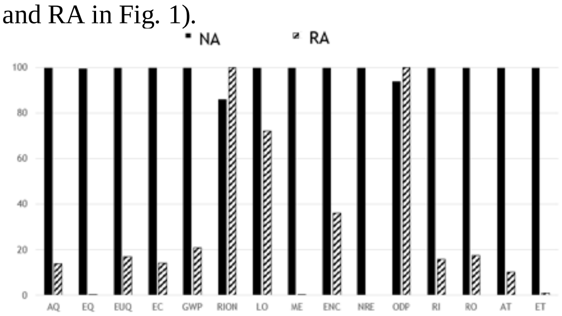

Figure 1. Relative results by impact categories for both construction materials.

In most of the impact categories it is observed that the greatest impact is generated in the production of 1 t of NA, except in the categories of ionizing radiation and depletion of the ozone layer. In the categories of aquatic ecotoxicity, mineral extraction, non-renewable energy and terrestrial ecotoxicity, it is observed that the impact produced in the production of RA is negligible compared to that generated in the artificial aggregate production process.

Conclusions

The construction industry is responsible for many of today's environmental problems. Most of the impacts are due to the phase of acquisition of raw materials (explosions in the case of artificial aggregate), the transport of these and the products generated, as well as the diesel used in the treatment plants.

Based on the fact that the economic environment is increasingly competitive and also that responsibility in construction works is growing more and more due to a greater demand for environmental legislation, the need for a tool that allows evaluate and compare different alternatives for the production of construction materials from raw material from natural resources and recycled material, thanks to which, in addition to the technical criterion that has already been widely studied, the environmental criterion could be taken into account.

References

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