LCA applied to comparative environmental evaluation of aggregate production from recycled waste materials and virgin sources

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INTRODUCTION

Numerous studies are focused on technical and environmental feasibility of recycled aggregates based on laboratory control parameters. However, it is necessary to quantify impacts of the overall process by applying Life Cycle Assessment (LCA) methodology. LCA helps ensure the sustainability of a sector that requires a high consumption of resources, materials and energy, generating large amounts of gaseous, liquid or solid emissions. The present work quantifies the environmental impacts generated during the production of 1 ton of mixed recycled aggregates (MRA) from CDW and those generated during the production of 1 ton of natural aggregates (NA) extracted from a quarry.

Source: https://www.gecorsa.es/

The results revealed that the production of 1 ton of MRA from CDW produces a lower environmental impact than 1 ton of NA extracted from a quarry.

EXPERIMENTAL METHODS

Functional Unit → the basis parameter of calculation on which the balances must be referred. In the present study, the functional unit is 1 tonne of aggregate.
System Boundaries → the study covers the product stage information modules A1, A2 and A3 (raw material supply, transport, manufacturing of products).

Table 1: Environmental impact assessment categories in IMPACT 2002+

Impact categories	Midpoint reference substance	Impact categories	Midpoint reference substance
Aquatic acidification, AQ	kg SO2 eq	Mineral Extraction, ME	MJ surplus
Aquatic ecotoxicity, EQ	kg TEG water	Non-carcinogenic effects, ENC	kg C2H3Cl eq
Aquatic eutrophication, EUQ	kg PO4 eq	Non-renewable energy, NRE	MJ primary
Carcinogenic effects, EC	kg C2H3Cl eq	Ozone layer depletion, ODP	kg CFC-11 eq
Global Warming Potential, GWP	kg CO2 eq	Respiratory inorganics, RI	kgeq PM2.5 into air
Ionising radiation, RION	Bq C-14 eq	Respiratory organics, RO	kg C2H4 eq
Land Occupation, LO	m2org	Terrestrial acidification, AT	kg SO2 eq
		Terrestrial ecotoxicity, ET	mol N eq

RESULTS & DISCUSSION

To analyse the LCA results and establish the differences between both production processes, Fig. 1 and 2 shows the impact contribution during the production of 1 ton of MRA and 1 ton of NA respectively on a relative scale from 0% to 100%.

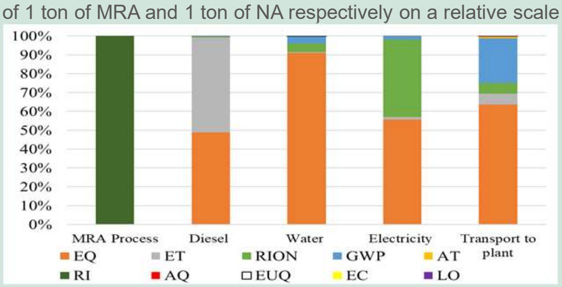


Figure 1. Impact contribution of processes during the production of 1 ton of MRA.

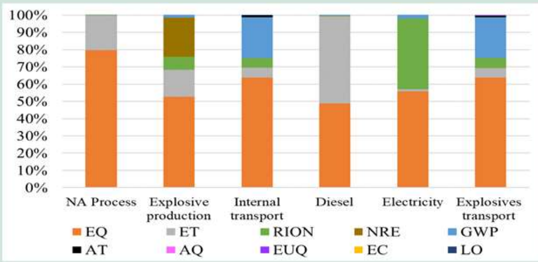
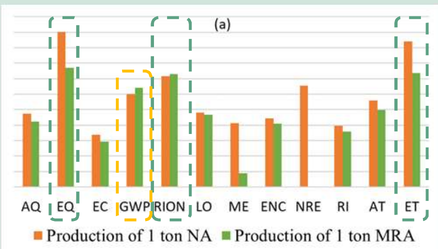


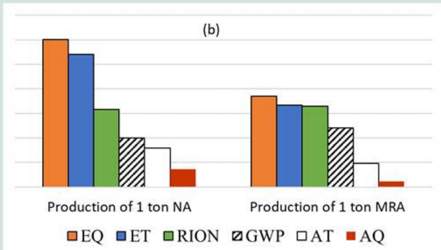
Figure 2. Impact contribution of processes during the production of 1 ton of NA.

To establish the comparison between both production processes, Fig. 3 compare the total impact produced by the production of each material.
The total accumulated impact value of MRA and NA processes corresponds to the sum of the individual values of the total process of MRA (composed by five processes: MRA Process, Diesel, Water, Electricity, Transport to plant) and NA (composed by six processes: NA Process, Explosive production, Internal transport, Diesel, Electricity, Explosives transport) according to the system boundaries and processing characteristics.

Figure 3. Comparative of Impacts generated in the production of 1 ton of NA and 1 ton of MRA.

Most impacted categories
Categories Aquatic ecotoxicity, EQ
Terrestrial ecotoxicity, ET
Ionising radiation, RION
Global Warming Potential, GWP





CONCLUSIONS

It can be deduced that the accumulated impact values generated during the manufacturing of 1 ton of NA is much greater than the produced during the production of 1 ton of MRA, which confirms the environmental benefit of this recycled material compared to the extraction of natural materials.
MRA caused a lower impact in most of the impact categories evaluated, and specially in aquatic acidification, aquatic ecotoxicity, ionizing radiation and global warming. The present study contributes to quantifying the environmental benefit of promoting a circular economy in the construction sector by maximizing recycling ratios, which guarantees the sustainability of a sector that is currently in the spotlight worldwide.