Evaluating Environmental Sustainability in Concrete Mix Design using Non-Conventional Fine Aggregates: River Sand vs Manufactured Sand Scenarios

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The construction industry heavily relies on materials, mainly concrete, posing environmental challenges. To address this, 'greener' concrete options have emerged, aiming to reduce reliance on new materials. Concrete grades are pivotal, determined by mix designs based on compressive strength. Cement, fine and coarse aggregates, water, and sometimes admixtures constitute concrete. Incorporating non-conventional materials, like quarry dust, seeks to create more eco-friendly concrete but lacks comprehensive life cycle inventory (LCI) data for ready-mix concrete. This study conducts a 'cradle-to-use' life cycle assessment (LCA) of two concrete types: one with conventional river sand and another blending river sand with quarry dust, both meeting the 30 MPa strength standard. Data from a quarry and batching plant are collected for environmental impact assessment, considering material, water, electricity consumption, and waste generated over two months. SimaPro Faculty version models the environmental impact per m^3 for both concrete types using ReCiPe 2016 v1.1 mid-point and end-point characterization models. End-point analysis reveals lower human health impact for the non-conventional concrete (0.0538 Pt) compared to conventional (0.0762 Pt). Among 18 mid-point categories, "human carcinogenic impact" ranks the highest for both concrete types, with the non-conventional showing reduced impact (0.938 Pt) compared to conventional (1.27 Pt). Notably, clinker production remains the primary source of environmental impact for both, followed by electricity consumption during cement production. Replacement of fine aggregate shows a modest reduction in environmental impact.

The study underscores the significantly lower environmental impact of non-conventional fine aggregates, particularly quarry dust. This establishes the non-conventional mix as a more environmentally friendly choice among the two concrete scenarios.

Keywords: *Greener concrete, Life cycle assessment, Fine aggregate, Quarry dust, River sand*