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An assessment on the sustainable production of construction clay bricks with spent shea waste as renewable ecological material.

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Abstract

The primary objective of this research is to ascertain the potential utilization of spent shea waste as renewable ecological material in sustainable clay brick manufacturing. In this regard, the particle sizes, mineralogical, thermal properties of the brick raw materials were extensively characterized from physical, spectroscopic and thermal analytical methods, respectively. Proportionate amounts of clay materials were replacement with 0%, 5%, 10%, 15% and 20 wt.% of spent shea waste to prepare modeled brick samples via manual pressing, which were fired at 900-1200 °C temperatures. Technological properties including green density, linear fired shrinkage, fired density, water absorption, apparent porosity and compressive strengths of the modeled bricks were investigated. The nature of pores and thermal conductivity of the modelled bricks were also ascertained. The various test results indicate that use of shea waste in construction could contribute to economic firing, improve the fluxing properties of raw materials, and beneficially lighten brick weights as well as enhancing their thermal insulation properties.

In recent times, the rapid pace of brick construction due to technological advancement , dwindling reserves of non-renewable natural resources , legislative enactments of sovereign states , declining development in energy/ electricity , and climate change concerns , have cumulatively obsoleted convectional overreliance on clay resources and provided great impetus for use of various abundant materials as additives for construction. Other fundamental concerns creating this radical paradigm shift could conceivably be linked to population increase , increasing relevance of sustainability, economic production procedures , energy-savings , environmental conservation and environmental protection issues . Thus, the increasing popularity of replacing clay resources with often abundant and low cost materials for tailoring the properties of construction bricks into desired forms is a need-of-the-hour in the brick construction industry. In particular, use of renewable ecological materials as essential additives to construction materials, is gaining momentum among researchers around the globe nowadays. Raut et al from India presented a review on sustainable construction materials using industrial and agricultural solid waste towards highlighting the need to harness the often-unmanaged organic residue in the design of green buildings . Mucahit and Sedat from Turkey replaced up to 30 wt.% of clay materials with recycled paper processing residue, a mainly organic materials, in developing lightweight bricks with beneficial reduced thermal conductivity properties at acceptable compressive strengths. Muñoz et al from Chile and Spain used waste pomace generated from the winery industry to develop fired clay bricks with improved thermal insulation characteristics. Bories from France, and Muñoz et al from Chile and Spain provided a comprehensive list of organic residue used as renewable ecological construction materials globally . Thus, the issues of reusing renewable ecological materials are an evolving field of current interest. One such renewable ecological material that is hugely generated from the shea butter/oil industry is Spent Shea Waste (SSW). The shea (Vitellaria paradoxa, C.F. Gaertn) butter industry is increasingly catching major international attention because of its significant multifunctional butter use in the pharmaceuticals, detergent and cosmetics industries . Shea butter is also often use as cooking oil and an essential butter formulation in traditional medicines . Moreover, recent revision of European Commission regulations consenting to use of substitutes for cocoa butter coupled with a number confectionery recoveries in the former soviet states have mutually occasioned an up thrust in demand for the shea butter product . These developments have compelled most governments in the shea belt parklands to commercialize the shea butter agro-industry mainly as a viable means of reducing poverty, ensuring food security, creating job opportunities and most of all, improving their non-traditional export base. Thus, the frequent generation of unprecedented levels of corollary SSW products is assuming alarming proportions. It is evident that SSW is being exported to United Kingdom for co-combustion in coal power plants conceivably because of its excellent biofuel value and relative low carbon content . Nevertheless, the quantities involve are far less that generation capacities. Innovative ways of utilizing SSW profitably are currently limited to field trials in Africa. Taking into account the substantial generation of SSW, its renewable source, the natural widespread availability of the shea tree across the African sub-Saharan regions, its comparative low cost and the beneficial influence of ecological materials on brick technological properties, SSW could be excellent target materials of choice for reuse in the construction industry advantageously. However, until now limited information exist in published literature on the reuse of SSW in the clay industries although its good calorific value is well known . At present, the increasing volumes of SSW are indiscriminately damp on idle lands as a major disposal method with dire consequence to the environment. Considering the good biofuel value of SSW, its current indiscriminate damping constitutes a major loss of valuable energy; besides, this disposal method is at variance with best environmental management practices.

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Therefore, the present research primarily seeks to leverage on the huge abundance of SSW for reuse as ecological construction materials towards improving the technological properties of fired clay bricks sustainably. Hence, the focus of this research is to provide baseline data on reuse of SSW as renewable ecological materials to improve the technological properties of clay bricks into various superior performing products. Therefore, it is hope that this research would create a new path of possibility on the viable synergistic reuse of SSW as indispensable construction materials towards adding value to the shea butter industry.

Use of spent shea waste as renewable ecological construction material for sustainable production of construction clay bricks has been extensively examined in relation to their elemental, mineralogical, thermal, technological as well as morphological characteristics. The high content of Al2 O3 and SiO2 , low amount of Fe2 O3 and CaCO3 , good variety of inorganic oxides such as K2 O, NiO, MnO, MgO, ZnO, Cr2 O3 , TiO2 and V2 O5 , and the excellent diversity of spent shea waste inorganic oxides mostly found in traces showed the suitability of the brick raw materials for use in structural construction works. The mineralogical characterization of the raw materials support the substitution of significant amounts of clay material for spent shea waste in forming brick units because of their inert nature. Thermal analysis of the raw material indicated the preferential transformation of the clay material into beneficial polyphases and the potential of gaining about 3,283.06 kcal/kg environmentally safe heating energy from spent shea waste. Replacing clay materials with spent shea waste showed overall improved technological performance of brick specimens in terms of reduction in weights, increase in compressive strengths and better thermal insulation properties at acceptable structural enclosure buildings standard requirements. Morphological studies provided photographic clues on the preferential transformation of the clay materials, decomposition of spent shea waste and the nature of the pore structures within the improved performing brick matrices. Overall, convincing baseline data on use of spent shea waste as renewable ecological material for sustainable production of construction clay bricks has been provided.

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