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Unlocking Health Benefits: A Comparative Analysis of CSEB and Traditional Burnt Bricks in Bangladesh's Sustainable Building Practices

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Abstract:

The study conducted a comprehensive analysis comparing the health impacts of traditional burnt clay bricks to Compressed Stabilized Earth Blocks (CSEB) in Bangladesh. Utilizing SimaPro software and the ReCiPe method, researchers evaluated the human health implications of both building materials. Results revealed that CSEB production significantly reduces environmental burdens and costs compared to conventional bricks. The study underscores the potential of CSEB as a green building material, offering tangible benefits for both environmental sustainability and economic viability. By utilizing dredged river sand mixed with cement, CSEB not only minimizes greenhouse gas emissions but also mitigates the depletion of agricultural land. These findings highlight the importance of transitioning towards sustainable building materials like CSEB to alleviate the adverse health impacts associated with conventional construction practices.

KEYWORDS: Green building material, health impact, earth block(CSEB), Traditional burnt brick.

1. Introduction

The built environment includes different organic compounds that affect the quality of the indoor and outdoor environment and greatly impact human health. So, any development projects should be concerned about environmental, social, and health consequences. Health determinants are the direct or indirect causes of a disease, condition, or injury [1].

The impact of the built environment is related to building materials. The building industry is one of the biggest sources of energy use and greenhouse gas emissions. The most widely used construction material in Bangladesh is fire brick, also known as burned clay brick. Every year, a considerable amount of burnt clay brick is used for construction purposes, and a massive amount of agricultural land is lost due to the production of the firebrick. So, initiatives have been taken by the Bangladesh House Building Research Institute (HBRI) researcher to find alternative green building materials that use less energy and have less impact on the environment during their lifetime. They have produced CSEB (Compressed Stabilized Earth Block) from the dredged soil of the river mixed with proportionate cement. Research suggests CSEB could be an alternative green building material toward sustainable development by saving natural resources, using less energy, and minimizing production costs.

The present study wants to know the health impact of this alternative building material compared to the traditional burnt brick. A proper health impact assessment requires a wide range of impact assessments, including socio-demographic, environmental health, epidemiological, and health systems data[2]. Due to limitations on time and resources, the present research considers only some specific health determinants, such as health impact analysis of building material using SimaPro software modeling following the Life Cycle Assessment (LCA).

2. RESEARCH BACKGROUND

2.1 Building Materials and Health

Numerous building materials could include questionable chemicals that have both immediate and long-term health effects. Skin allergies, eye irritation, throat irritation, and sneezing are possible short-term effects. Long-term effects could include infertility, asthma, and cancer, among others. Endocrine disorders, obesity, and autism are among the health issues that the next generation can inherit. Many of the ingredients in building materials can be Persistent Bio Bioaccumulative toxins (PDTs) and Persistent Organic Pollutants (POPs), which can severely damage the environment and have lasting impacts on human health. Diminishing various aspects of construction materials, like embodied energy, energy usage, carbon dioxide emissions, and recyclable nature, can have a dual impact on human and environmental well-being.[3].

2.2 Green Building Material

In industrialized nations, Buildings significantly impact the environment, using about 40% of natural resources[4]. Green building (GB) has emerged as a new building philosophy in an effort to lessen the impact. It aims to improve indoor environmental quality, use more ecologically friendly materials, and implement resource-saving and waste-reduction techniques. [5].

Using green building materials and products represents a critical strategy in designing a green building. An environmentally friendly, healthful, recyclable, or high-performing material that minimizes its effects on the environment and human health over the course of its life cycle(LC) is referred to as a green building material (GBM) [6]. It is specially made from non-toxic, natural, and organic substances and can reduce indoor air contaminants as well as health impacts [7].

2.3 Alternative Green Building Material in Bangladesh

Bangladesh is one of the most densely populated countries in the world. Bangladesh produces 17.2 billion bricks for residential use each year[8]. A million bricks are produced using about 240 tons of coal [9]. About 23,300 tons of particulate matter, 1.8 million tons of carbon dioxide, 302,000 tons of carbon monoxide, and other chemicals released annually from brick kilns are extremely harmful to human health, and this harm only occurs in the Dhaka region[10].

Bangladesh is now working to implement sustainable development targets. The Bangladeshi Housing and Building Research Institute has launched a study project to address the issue. The study looks for alternative building materials using readily available local resources. The study uses soil from river dredging instead of agricultural topsoil to create blocks that are sold in Bangladesh. Housing and Building Research Institute has produced CSEB from the dredged soil of the river mixing with proportionate cement. Using alternative green building materials minimizes transportation costs associated with carbon dioxide emissions, lowers the cost of building materials, creates opportunities for employment and skill development, and preserves our agricultural land[11].

2.4. CSEB (Compressed Stabilized Earth Block)

Early in the 19th century, Europeans first attempted compressed earth blocks. François Cointereaux, the architect, utilized hand rammers to compact the damp soil into a tiny wooden mold that he held in place with his feet after precasting little blocks of beaten earth. In 1950, Cinvaram, the first steel manual press, was produced. This method is used in South Asia, Africa, and India. Over the past three decades, compressed earth blocks have gained widespread usage across the globe, not only in developing nations but also in developed nations such as the United States, the United Kingdom, and Canada[12].

2.4 Health Impact Assessment

Environmental impact assessment (EIA) is an integral part of the development, and EIA methodology has been refined to examine potential social and health impacts[13]. Environmental impact assessment (EIA) often addresses this concern by considering little input from the health sector[1]. Sustainable development promotes comprehensive impact assessment is required to integrate health and ecological risk measurement with meaningful community consultation[14].

Often, it is difficult to prescribe a specific research method for Health Impact Assessment (HIA) because of a lack of resources, time, and available data. Research suggests some inferences about health impact, and the research components can be divided into four assessments, i.e.

_socio- demographic,
_health determinants,
_health status and
_health systems. [1].

Health determinants are the direct or indirect causes of a disease, condition, or injury. A health determinants assessment aims to measure the factors that affect people's health, such as waste management, public infrastructure, pollution, housing, food and fuel security, and access to and quality of water and sanitation. The present research considers only some specific health determinants.

2.5 Life Cycle Assessment (LCA): Software and Human Health

The impacts of building materials on human health have been compassed the emission of harmful substances through their life cycle, including raw materials during construction, maintenance, and renovation[15]. The LCA method quantifies the potential impacts of the product system throughout its lifetime. This approach is the only appropriate method for comparing materials and human health impact from the construction industry since 1990[7, 16]. The advancement of LCA software helps to resolve the complexity of this method and the Pact of the materials and products, despite the fact that LCA is an expensive and complex methodology. There are different methods for life cycle impact assessment (LCIA), such as CML 2000, ReCiPe, and EPS 2000, to determine the impact on human health, which are considered only for outdoor sources of pollution, not indoor ones[7].

3 Materials and methods

The present research is followed by previously published research on CSEB in Bangladesh. Recently in Bangladesh, research on CSEB, experimented with different ratios (1:4, 1:5, and 1:6) of cement mix with dredged sand (Table 1). Their experiment shows that all cement-sand ratios give satisfactory results when comparing compressive strength and water absorption capacity, which is very low compared to clay brick[17]. Following this experiment, the present research uses the same cement-sand ratio (1:4, 1:5, and 1:6) to investigate the health impact using SimaPro software within the LCA method.

3.1 Materials

Premier Ordinary Portland Cement (OPC) CEM-I 42.5N and 52.5N Grade was the cement manufacturer used in all the mixes. The soil used in that study was brought from the Turag River. The city's Dhaka water supply system supplied fresh tap water, free from all forms of organic water. An earthen block preparation machine, Cinvaram, was used to produce CSEB (Figure 1).

Table 1:Mixing Proportion of cement, sand, and water (Hasan 2020).

Series	Cement-Sand ratio	Cement	Sand	water
1st series	1:4	20%	80%	12.5%
2nd series	1:5	16.66%	83.33%	12.5%
3rd series	1:6	15.28%	85.71%	12.5%

Figure 1: Compressed Stabilized Earth Block (CSEB) production [17].

3.2 Methods

The present research has been designed in two parts: a theoretical part based on a literature review of relevant theories and research on the health impact of building materials and software modeling. The methodology employed in these two parts is explained below, focusing on the three interrelated phases.

1st phase_Literature Survey: The research will start with a literature survey on published knowledge (e.g., research papers, books, standards, codes, and websites) to understand the impacts of building materials on human health.

2nd phase_Data collection: The research is collecting data from published research on CSEB to follow the mixing proportion of cement, sand, and water.

3rd phase_SimaPro software modeling: The research is prepared CSEB model (Table 2) in SimaPro software by following the same mixing proportion (Table 1) of CSEB conducted by Hasan et al. 2020. ReCiPe method is used to evaluate human health impacts based on the LCIA (Life Cycle Impact Assessment) methodology.

Table 2: Mixing proportion and weight of the different samples.

Sample	Ratio	Cement	Sand	Water
CSEB-1	1:4	1 kg	4kg	12.5%
CSEB-2	1:5	0.83 kg	4.17 kg	12.5%
CSEB-3	1:6	0.7 kg	4.3 kg	12.5%
Traditional brick	5 kg			

3.3 Assumption and Limitations

For this section of the methodology, the following are the main presumptions and limitations:

- An essential consideration when comparing products is the functional unit. In this research, the functional unit is set to be five kilograms of output.
- The ReCiPe method is considered the only outdoor source of pollution, not indoor ones.

3.4 Grounding of SimaPro Software

The outcomes of SimaPro for LCIA encompass two levels of impact categories: midpoint and endpoint level. The ultimate damage assessment results from converting midpoint indicators with different units into endpoint levels. The Area of Protection (AoP) includes the ecosystem, human health, and resources, and these are the three categories of damage assessment. Furthermore, there are three different indicators at the endpoint level:

- Damage assessment,
- Normalization, and
- Weighting

In the ReCiPe method, 'damage to human health' combines mortality and morbidity represented by endpoint level. The loss of species represented the AoP of the natural environment, and the increased set of future extractions represented the AoP of natural resources[18].

4 RESULT AND DISCUSSION

The research focuses on human health by comparing the LCIA (Life Cycle Impact Assessment) of CSEB (three samples) and traditional brick. The damage assessment indicator result from the endpoint level utilized in the ReCiPe method is shown in Figure 2. A scale of 100% is used to display them. The term "disability-adjusted life years," or "DALYs," refers to the measurement of harm to human health. The number of years lost and the number of years lived with disability are used to quantify damage to human health[18]. Figure 2 shows the impact of the decline in human health on the three sample CSEB types compared to traditional brick.

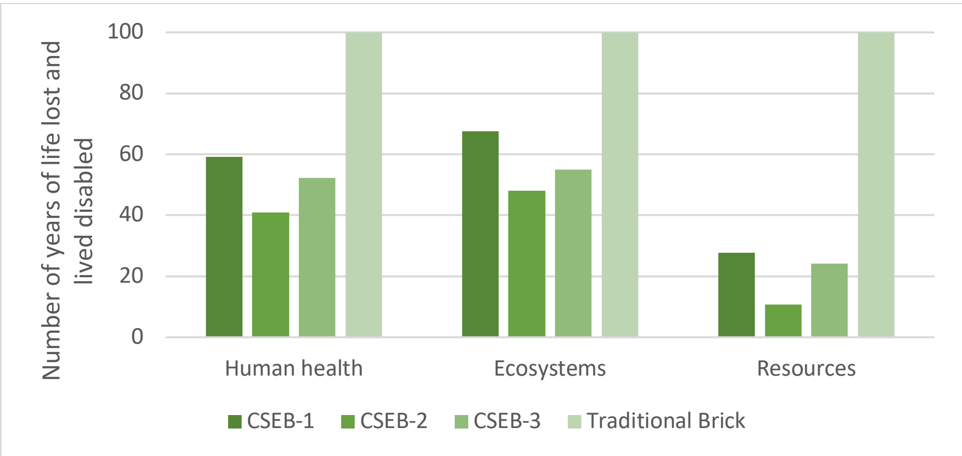

Figure 2: Damage Assessment Indicator at the Endpoint level.

Table 3 focuses on the impact categories on human health at the midpoint level. The values are shown in Figure 3, which indicate that the group with the most significant impact is human carcinogenic toxicity. Research also found a substantially reduced impact for three CSEB types compared to traditional brick.

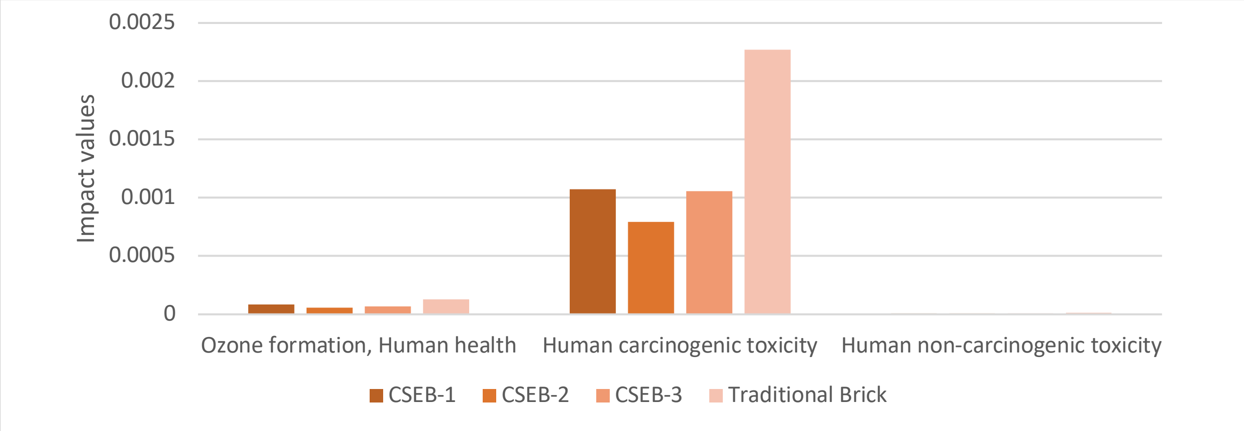

Figure 3: Normalization indicator at the Midpoint level.

Table 3: Damage Assessment Normalization indicator at Midpoint level.

Impact category	CSEB-1	CSEB-2	CSEB-3	Traditional Brick
Ozone formation, Human health	8.52E-05	5.7E-05	6.894E-05	0.000126229
Human carcinogenic toxicity	0.001075	0.000795	0.0010578	0.002268463
Human non-carcinogenic toxicity	8.98E-06	6.62E-06	8.426E-06	1.07837E-05

Further impact assessment indicators are normalization and weighting, which simplify the complex interpretation of the results at the midpoint level.

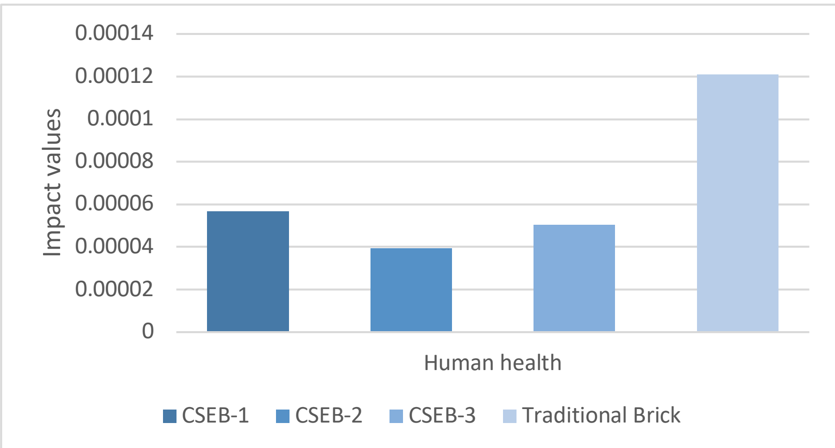

Figure 4: Normalization indicator at the Endpoint level.

Determining the extent to which an impact category adds to the overall issues related to human health and the environment is known as normalization. The incompatibility of units is also resolved by normalization. When comparing the effects of two products using the same unit, the normalization produces results that are easy to understand. When using emissions per year in the normalization process, a year is the precise unit of a normalized value[18].

The impact category on human health decreased significantly when the traditional brick was replaced with CSEB, from 0.0012 to 0.00004, according to normalization results (Figure 4).

Regarding midpoint approaches, which are heavily utilized for internal decision-making, weighting is the most robust and thought-provoking step in life cycle impact assessment. For weighting, mPt is the value. One mPt (mili point) is equivalent to 1/1000 Pt, and one point is equivalent to 1/1000 of Europe's average annual environmental impact. Complete weighting summarizes life cycle assessment (LCA) data into a single score that simplifies comparing the effects of two products on human health [18].

The weighting indicator, which establishes the research strategy's significant impact on the human health measure, is shown in Figure 5. The impacts on human health were reduced from 38 mPt to 16 mPt due to using CSEB-2.

Therefore, the SimaPro analysis shows that the total impact on human health declined by around half using CSEB rather than traditional brick.

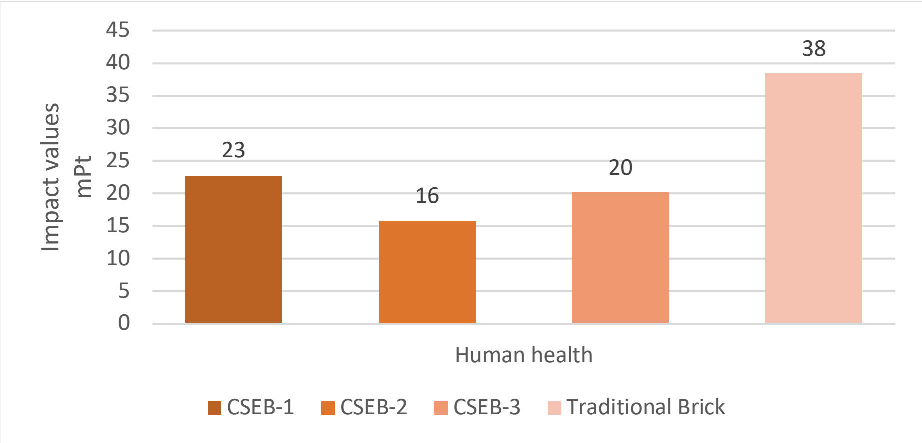

Figure 5: Weighting Indicator at the endpoint Level.

5. Conclusion

The present research analyzes three samples of the same building material's impact on human health. The result shows the effect of building materials on human health is unavoidable, but we can reduce the impact considerably. Previous research showed that CSEB has the potential to be a sustainable green building material in the context of Bangladesh. The present research focused on the health impact of CSEB compared to traditional brick, and the result shows the health impact of CSEB is substantially lower than brick. So it can be said that a green building material has the potential to minimize health impact.Furthermore, the result indicates that the raw material composition is also considered. The present research uses three different ratios of cement and sand for CSEB samples. The result shows in all three categories of damage assessment, CSEB-2 has the minimum health impact, followed by CSEB-3, CSEB-1, and traditional brick. Considering the different ratios of cement and sand (1:4, 1:5, 1:6), it has been shown the proportion of cement is maximum in CSEB-1 and minimum in CSEB-3, but CSEB-2 has the lowest health impact. So, it can be said a reasonable composition of raw materials of building materials can reduce human health impact. Considering the limitations of time and resources, the data is only software-based and follows only some specific damage assessment types. Further research is concerned with other impact assessment components such as socio-demographics, health determinants, health status, and health systems.

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