Exploring the Ecological and Public Health Implications of Brick Manufacturing in a Suburban Municipality of Bangladesh: A Comprehensive Case Study

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Article

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Abstract: The brick manufacturing sector in Bangladesh is experiencing rapid growth, leading to notable environmental and health concerns. The primary objective of this research is to examine the Savar Upazila, a region of significant economic significance owing to its favorable brick manufacturing conditions and proximity to Dhaka city. Brick kilns, among other sources, constitute significant contributors to air pollution. The study utilized primary and secondary data to examine brick kiln emissions' effects on the surrounding area's environment and public health. The collection of primary data was conducted in multiple zones within Savar Upazila, which is home to a significant number of brick kilns. The utilization of secondary data provided valuable insights regarding the toxic pollutants discharged by these kilns and the corresponding health risks they pose. The participants provided accounts of various health ailments, such as dermatological conditions, optical difficulty, and respiratory complications, further aggravated by brick kilns' incidents. The prevalence of crop losses, soil degradation, and reduced agricultural yields was confirmed by 74% of the respondents. The trees and crops in the surrounding area experienced adverse effects due to the deposition of dust particles. During periods of inactivity, the concentrations of sulfur oxide (SOx) were between 6 and 9 times lower compared to periods of operation. Similarly, nitrogen oxide (NOx) levels were observed to be 4 to 6 times lower during non-operational phases. The degradation of water quality in adjacent bodies has been attributed to the deposition of dust and ash originating from brickfields, resulting in substantial repercussions on aquaculture. A significant proportion of participants indicated experiencing diverse health issues, notwithstanding the employment prospects generated by brick kilns, thereby underscoring the adverse consequences on both the environment and the local economy.

Keywords: brick kiln emission; ecological & environmental impacts; human health impacts; socio-economic consequences

1. Introduction

The study of brick manufacturing has often been regarded as an exploration of civilization, as brick, crafted from mud and straw, has been a fundamental building material for millennia [1–3]. The art and science of brick production have been an integral part of architectural heritage, and in Bangladesh, brick-making dates to its earliest days [4,5]. Due to the influx of people into urban areas, Bangladesh's rapid urbanization has resulted in a boom in the brick industry, increasing demand for bricks [6,7]. Consequently, an ever-growing number of brick kilns have been established. More than 400,000 individuals are employed within the brick industry in Bangladesh [8,9]. Regrettably, brick kilns are the second primary source of air pollution, following closely behind vehicular emissions and urban settlements [10–12]. Brick burning exacerbates environmental pollution, disrupts ecosystems, and significantly contributes to the absorption of greenhouse gases into the atmosphere [13]. Unfortunately, brickfield laborers are compelled to lead substandard lives due to the polluted

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air and deteriorating water quality [14–16]. Long-term exposure to high pollution levels is awful for people's health [14]. Respiratory diseases like lung cancer, asthma, chronic bronchitis, and emphysema can happen [13,17]. This is primarily because of particles more significant than 10 microns, standard in brick kilns [18,19]. Brick kilns exhibit both short-term and long-term consequences on the environment [20]. Long-term effects include the depletion of the ozone layer, global warming, photochemical smog production, less fertile land, and the long process of topsoil regeneration after excavation for brick production [20]. Short-term effects include the disruption of natural vegetation processes, lower crop yields, and deforestation [21,22]. Each brick kiln consumes a substantial 350 tons of wood annually, further fuelling deforestation [23]. Moreover, the emission of black smoke from brick kilns adversely affects pollinators and agricultural production, causing a decline in crop yields [24,25]. Regrettably, in Bangladesh, approximately 8,000 brickfields operate without clear environmental regulations [15,26]. Traditionally, brick manufacturing has remained a small-scale, unregulated industry, primarily concentrated in rural and peri-urban areas of developing countries. This has led to the annual utilization of 25 to 26 percent of the country's wood for brick burning, significantly contributing to deforestation [5,27,28]. Typically, brickfields are established near towns and major construction sites, exacerbating environmental concerns.

In the context of the challenges posed by environmental pollution, particularly in regions with a growing brick manufacturing industry, such as Bangladesh, sustainable waste management practices have become paramount [29–35]. One of the ways to address this issue is by converting organic solid waste, such as agricultural residues or waste materials from brick production, into bioenergy [36–41]. This not only offers an eco-friendly solution for waste disposal but also contributes to reducing the demand for non-renewable energy sources, potentially mitigating the adverse environmental impacts associated with their extraction and use [42–45]. Moreover, the by-products of waste-to-bioenergy processes can be utilized in the brick manufacturing industry, enhancing its ecological sustainability [46,47]. As part of a holistic approach to environmental management, the challenges presented by air pollution from brick kilns should be considered alongside other environmental concerns [10,48,49]. Adequate wastewater treatment and management play a crucial role in safeguarding local water bodies and aquatic ecosystems from the harmful effects of industrial discharges [50–52]. Proper wastewater treatment can alleviate water pollution, ensuring that the by-products of brick manufacturing, including suspended solids and pollutants, do not compromise water quality. Furthermore, the proficient administration of landfill leachate is imperative in order to avert its pollution of water sources, thereby augmenting the capacity to maintain water quality near brick field areas [53–55]. In the context of Bangladesh, where brick kilns are often situated near towns and construction sites, it becomes essential to address both air and water pollution challenges concurrently, as they are interrelated and share common sources [27,48,56]. Integrating solid waste management, waste-to-bioenergy production, and wastewater treatment and management aligns with the overarching objective of reducing the environmental and health impacts associated with brick manufacturing, as discussed in the previous paragraph. By adopting these comprehensive measures, it becomes possible to mitigate the adverse effects on human health, ecosystems, and the environment, thereby fostering more sustainable and responsible industrial practices within the brick manufacturing sector. High chloride content in water not only poses a threat to living beings and construction material but also results in the degradation of mild steel reinforcing bars, underscoring the interconnected challenges that effective environmental management in brick manufacturing regions, such as Bangladesh, seeks to address [57].

Where brick manufacturing has rapidly expanded, ensuring a reliable water supply and efficient sanitation system has become increasingly vital [58–60]. As mentioned earlier, the elevated chloride content in water sources not only endangers the environment and construction materials but also affects the overall quality of the water supply [57,60,61]. Such contamination can lead to increased health risks for the population dependent on these water sources, exacerbating the need for improved sanitation and access to safe drinking water [61–65]. To deal with these problems, we must include complete environmental management plans that handle bioenergy production, wastewater

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treatment, and waste management. As industries grow, these steps are essential for protecting the environment and people's health.

Despite its economic significance, Bangladesh's brick industry remains resource-intensive and environmentally detrimental, resulting in considerable social and ecological implications [5,66–71]. This sector relies on outdated technologies, exhibits high emissions, and heavily depends on a single raw material, clay, to produce solid clay bricks [72,73]. Bangladesh currently manufactures approximately 150 billion bricks annually [5,7,19], consuming a substantial 45 million tons of fertile soil, equivalent to about 2,600 hectares of agricultural land [7]. This unsustainable rate of soil usage poses a looming threat of severe food shortages in the near future. Furthermore, brick kilns consume nearly 3.5 million tons of coal and 1.9 million tons of wood annually, using outdated designs that significantly contribute to air pollution [24,74]. Research indicates that almost 38 percent of particulate matter pollution near Dhaka can be attributed to brick kilns [70,75–77].

The study sought to unveil alterations in the socio-economic, environmental, and health aspects as perceived by the respondents both before and following the establishment of brickfields in their vicinity. The gathered data was anticipated to shed light on the potential positive or negative influences of these brickfields on agriculture, aquaculture, and the overall socio-economic status of the study area.

2. Methodology

The research aims to consolidate and analyze current evidence regarding the level of exposure to risk factors and health issues among brickfield workers. This comprehensive assessment involves the examination of various research sources, including published research articles, unpublished studies, reports from organizations and corporations, and theses, all of which delve into the environmental conditions, occupational pollutants, and their impact on the health of individuals.

2.1. Present Scenario of the Study Area

Savar is situated at coordinates 23.8583°N 90.2667°E, encompassing a total area of 280.13 square kilometers (108.16 sq mi) and housing 66,956 household units [78,79]. It shares boundaries with Kaliakair and Gazipur Sadar Upazilas to the north, Keraniganj Upazila to the south, and Dhaka City's Mirpur, Mohammadpur, Pallabi, and Uttara thanas to the east, while the western borders are with Dhamrai and Singair Upazilas. The southern region of the Upazila is characterized by alluvium soil from the Bangshi and Dhalashwari rivers. Major water bodies in the area include the Bangshi, Turag, Buriganga, and Karnatali rivers. The total cultivable land spans 16,745.71 hectares, with an additional 10,551.18 hectares designated as fallow land. According to the 2011 Bangladesh census, the population of Savar Upazila was 1,387,426, with males comprising 54.20% and females 45.80% of the total population [80]. Figure 1 provides a visual representation of the study area, Savar Upazila.

The Savar Upazila hosts over 200 brick kilns, with approximately 30 to 35 located in Amin Bazar and 10 to 15 in the Genda area, as reported by local sources. The assessment of the socio-economic impact of brickfields on individuals considered their occupation, income, health, and housing conditions. Figure 2 illustrates the socio-economic status of the study area, with the primary sources of income being agriculture and agricultural labor, followed by commercial activities.

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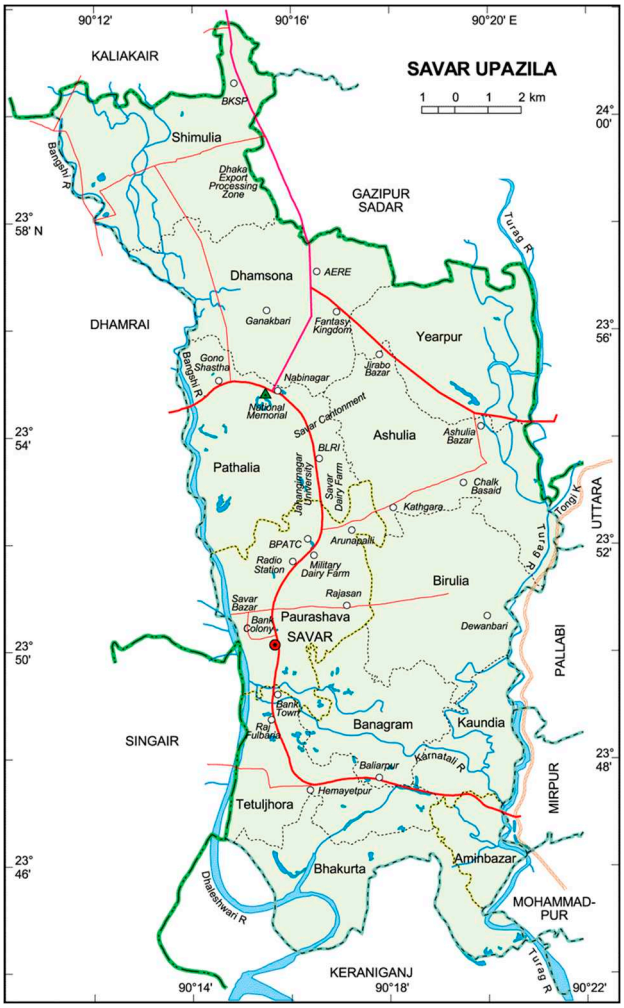

Figure 1. Location of the study area (Savar Upazila)(Source: Google Map).

2.2. Data collection

A comprehensive research endeavor was undertaken, encompassing field investigations and a questionnaire survey, with the objective of substantiating existing evidence and acquiring empirical data concerning the environmental and health impacts associated with brick fields within the Savar Upazila region of Dhaka. The questionnaire survey, designed to gauge the perceptions and experiences of individuals closely linked to brick field operations, was administered to a total of 560 respondents, who could be categorized into two distinct groups: Category-1 comprised 160 workers directly engaged in brick field activities. At the same time, Category-2 included 400 individuals residing in the vicinity of brickfields. The study's findings revealed that both groups, Category-1 workers and Category-2 residents, experienced adverse consequences arising from the operations of brickfields, indicating the significant and detrimental effects of this industry on the affected population.

3. Results and Discussions

3.1. Socio-economic status of Savar upazila

The predominant economic activities in the region primarily revolve around agriculture and agricultural labour, with a substantial portion (24 and 13%, respectively) of the population engaged in these pursuits. This is closely followed by employment in the service sector, which constitutes a significant source of livelihood for a noteworthy proportion of the population. The service holders consist of 21% of the population. Notably, commerce plays a vital role in the economic landscape of Savar Upazila, sustaining the livelihoods of approximately 17% of its residents. A minimal fraction,

 doi:10.20944/preprints202311.0263.v1

specifically 1% of the population, was identified as individuals who possess direct ownership or involvement with industrial activities within the surveyed area. A graphical representation of the socio-economic status within the study area can be observed in Figure 2.

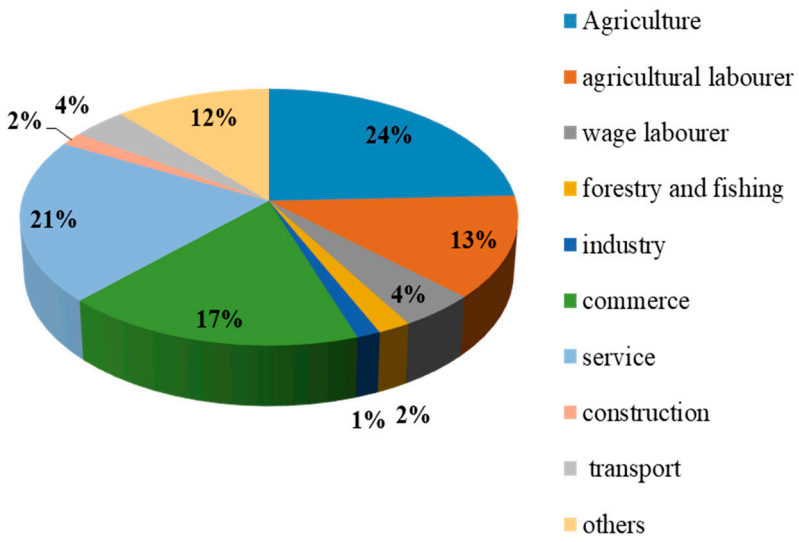

Figure 2. Socio-economic status of Savar upazila.

3.2. Income level of respondents

Category-1 participants were predominantly involved in various aspects of the brick manufacturing process, encompassing molding, burning, and transportation, rendering them more susceptible to health-related risks. Their primary motivation for engaging in these activities was economic, frequently without giving the potential negative effects due consideration. In contrast, Category-2 respondents pursued various careers, including farming, aquaculture, and household duties, but their proximity to the brickfields continued to have a negative impact. Examining respondents engaged in brickfield work revealed that they garnered economic benefits from their employment. A significant portion of this group, 47%, fell within a medium-income range, earning between 8000 and 12,000 (Bangladeshi Taka) BDT, although this wage level was considered insufficient for maintaining a standard of living. Nevertheless, they regarded brickfield employment as an opportunity to improve their quality of life, as it presented the availability of locally-based permanent job prospects that were previously scarce. For 37% of the respondents involved in other occupations, their income levels were within the lower range, averaging 5000–8000 BDT.

3.3. Effect on agricultural production

Approximately 26% of the respondents expressed the view that brickfields had no discernible impact on agricultural production. Conversely, a substantial majority, accounting for 74% of respondents, attributed the reduction in agricultural productivity to the emission of black smoke from these brickfields. Over a period of a decade following the establishment of brick kilns near crop fields, the production of crops experienced a significant decline, amounting to approximately 78%. Furthermore, a notable portion of agricultural land was rendered unsuitable for crop cultivation, as observed during the field investigation. This was attributed to factors such as the excessive exploitation of topsoil, the depletion of water sources, the inadequate water retention capacity of soils, reduced crop stability, and diminished crop yields [81,82]. In addition to these detrimental effects, emissions originating from brickfields were found to have adverse consequences on coconut trees, mango trees, and mustard seed crops. Moreover, contemporary agricultural practices involve the application of high doses of chemical fertilizers, raising concerns about the potential for ecological imbalances to arise from their utilization.

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3.4. Air pollution of brickfields

The emissions produced by brickfields have a discernible impact on the atmospheric composition, primarily by elevating the concentration of carbon dioxide in the air at the expense of oxygen. This alteration in air quality becomes manifest through observable air pollution characterized by emissions and dust particles discharged from the brickfields. The consequences of such pollution are notably detrimental to the respiratory health of individuals residing in these areas, leading to a higher incidence of respiratory diseases attributed to acute air pollution. In accordance with the International Ambient Air Quality Standards (IAAQS), the research findings indicated substantial disparities in air quality between operational and non-operational phases of brick kilns. The average concentrations of sulfur oxides (SOx) during non-operational phases were approximately 6 to 9 times lower than during operational phases, with a similar pattern observed in nitrogen oxides (NOx) concentrations, which were 4 to 6 times lower during non-operational phases.

3.5. Health effects of brickfields

The emissions of black smoke from brick kilns have resulted in a significant health burden for the affected population, leading to the emergence of various diseases. Health assessments conducted among individuals residing in close proximity to brick kilns demonstrated notable disparities in hygiene conditions between those directly exposed to the emissions (the exposed group) and those not directly exposed (the non-exposed group). This divergence in conditions can be attributed to the distinct chemical composition and optical properties of the black smoke, which contribute to its unique impact on visibility and climate, setting it apart from other particulate matter. These factors collectively account for the release of toxic gases into the environment. The study findings indicate that among Category-1 respondents, 64% reported suffering from severe health problems, 27% experienced minor health issues, and 9% reported no health problems. In Category-2, respondents predominantly presented with respiratory diseases (36%), followed by eye irritation (34%) and skin conditions (12%). Notably, 18% of Category-2 respondents remained unaffected by any of these health issues, as summarized in Table 1.

Table 1. Types of disease found in category-2 respondents.

Types of Diseases	Percentages of Affected Respondents (%)
Skin disease	12
Eye irritation	14
Respiratory problems	13
Skin disease and Eye irritation	15
Skin disease and respiratory diseases	14
Eye Irritation and respiratory diseases	14
No problem	18
Total	100

3.6. Effect on aquaculture

A significant majority, approximately 59% of the respondents, asserted that brickfields exert a substantial impact on fish production and the growth of aquatic plants. The remaining respondents indicated only minor effects on aquaculture. Notably, respondents who owned ponds in close proximity to brickfields reported a notable decline in fish production, amounting to approximately 80-85% following the establishment of brickfields in the vicinity. The detrimental effects on aquaculture can be attributed to the multifaceted consequences of brickfields, including waterlogging and water pollution, which in turn contribute to a variety of diseases among aquatic life, directly or indirectly implicating brickfields in these ecological disruptions.

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3.7. Effect on vegetation

A majority of respondents, constituting 83% of the sample, expressed a shared concern regarding the ongoing decline in agricultural production, attributing this trend to the significant adverse effects of brickfields on vegetation. These effects encompassed diminished production, stunted growth, and the emergence of various plant diseases, collectively contributing to a challenging agricultural environment. In contrast, a smaller segment of respondents, comprising 10%, ascribed only minor effects to brickfields, while an additional 7% professed a lack of awareness regarding any detrimental consequences on vegetation. Notably, a distinct group of respondents, specifically the 43% who owned brickfields, were less inclined to acknowledge the adverse impacts on vegetation reported by the farmers. However, a noteworthy subset within this category, encompassing 28% of brickfield owners, conceded to experiencing substantial effects, particularly in terms of impaired flowering and fruiting of trees. These varying perspectives underline the complex and multifaceted interactions between brickfield operations and agricultural outcomes.

3.8. Effect on soil fertility

A substantial portion of the respondents, accounting for approximately 440 individuals, expressed a consensus regarding the profound impact of brickfields on both soil fertility and agricultural production. Those who owned agricultural lands in proximity to brickfields reported adverse effects stemming from the dispersal of black smoke and ash over their crops. In contrast, 15% of respondents cited minor impacts, and 7% asserted that they perceived no discernible influence on soil fertility. Corroborating these observations, the Upazila Agricultural Office reported a notable reduction in crop production, estimated at around 75-80%, in areas adjacent to brickfields over recent years. This decline is attributed to the incineration of the soil, which results in a decrease in soil pH, an increase in sand content, and a reduction in clay content [83–85]. These alterations exert profound and multifaceted effects on the physical, biological, and chemical properties of the soil, ultimately leading to a pronounced decrease in soil fertility and overall agricultural productivity. The interplay of these factors underscores the intricate relationship between brickfield operations and soil quality.

4. Conclusion

In light of the comprehensive investigation conducted in this study, it becomes evident that a significant proportion of brickfields within the study area are closely situated to agricultural lands and residential areas, contributing to substantial losses in agricultural production and impeding fish cultivation. Moreover, these brickfields have emerged as a primary driver of topsoil degradation and pervasive environmental pollution throughout the study area. The repercussions of these environmental factors extend to the community's health, manifesting as a spectrum of issues including skin diseases, eye irritation, respiratory ailments, gastrointestinal complications, injuries, reproductive health challenges, and mental health concerns.

Of particular note, gastrointestinal health problems have surfaced as a pronounced concern among brick kiln workers due to the lack of access to sufficient and clean water supplies within their working environment. Additionally, the mental well-being of brick kiln workers is another pressing issue, given the low remuneration and the demanding nature of their work in exceedingly polluted conditions. These findings collectively underscore the multifaceted challenges associated with brickfield operations, emphasizing the imperative need for comprehensive and sustainable solutions to mitigate their adverse impacts on both the environment and public health.

References

1. E. Nodarou, C. Frederick, and A. Hein, "Another (mud) brick in the wall: scientific analysis of Bronze Age earthen construction materials from East Crete," *Journal of Archaeological Science*, vol. 35, no. 11, pp. 2997–3015, 2008.
2. D. Rosenberg, S. Love, E. Hubbard, and F. Klimscha, "7,200 years old constructions and mudbrick technology: The evidence from Tel Tsaf, Jordan Valley, Israel," *PLoS One*, vol. 15, no. 1, p. e0227288, 2020.

3. G. W. Van Beek and O. Van Beek, *Glorious Mud!: Ancient and Contemporary Earthen Design and Construction in North Africa, Western Europe, the Near East, and Southwest Asia*. Smithsonian Institution, 2013.
4. R. Saha and M. Rahman, "Green Brick Revolution in Bangladesh," in *International Conference on Climate Change Impact and Adaptation. DUET, Gazipur*, 2013, pp. 1–10.
5. K. M. ud Darain *et al.*, "Energy efficient brick kilns for sustainable environment," *Desalination and Water Treatment*, vol. 57, no. 1, pp. 105–114, 2016.
6. M. M. Hassan, L. Juhász, and J. Southworth, "Mapping time-space brickfield development dynamics in Peri-Urban Area of Dhaka, Bangladesh," *ISPRS International Journal of Geo-Information*, vol. 8, no. 10, p. 447, 2019.
7. M. A. Hossain, A. M. Zahid, M. Arifunnahar, and M. N. A. Siddique, "Effect of brick kiln on arable land degradation, environmental pollution and consequences on livelihood of Bangladesh," *Journal of Science, Technology and Environment Informatics*, vol. 6, no. 02, pp. 474–488, 2019.
8. S. F. Rashid, "Strategies to reduce exclusion among populations living in urban slum settlements in Bangladesh," *Journal of health, population, and nutrition*, vol. 27, no. 4, p. 574, 2009.
9. M. A. Mohit, "Bastee settlements of Dhaka City, Bangladesh: A review of policy approaches and challenges ahead," *Procedia-Social and Behavioral Sciences*, vol. 36, pp. 611–622, 2012.
10. M. A. Bhat and E. O. Gaga, "Air pollutant emissions in the pristine Kashmir valley from the Brick Kilns," in *Biodiversity, Conservation and Sustainability in Asia: Volume 2: Prospects and Challenges in South and Middle Asia*, Springer, 2022, pp. 959–979.
11. M. A. Pramanik, M. J. I. J. Prothan, and M. M. Munir, "Challenges of low carbon city planning due to emissions from brick kilns: a case study on Dhaka City of Bangladesh," *Journal of Bangladesh Institute of Planners ISSN*, vol. 2075, p. 9363, 2018.
12. E. Saikawa *et al.*, "Air pollution in the hindu kush Himalaya," *The Hindu Kush Himalaya assessment: Mountains, climate change, sustainability and people*, pp. 339–387, 2019.
13. J. A. Saju, M. M. Rahman, P. K. Debnath, and S. B. Nayan, "IMPACTS OF AIR POLLUTION ON HUMAN HEALTH AND ENVIRONMENT DUE TO BRICK KILNS EMISSION: A REVIEW".
14. M. K. Saha, R. Ara, S. D. Kadir, and M. G. Mostafa, "Environmental vulnerability of people to brick kiln hazards".
15. M. M. R. Bhuiyan, "Assessment of environmental laws in Bangladesh: a GIS based case study on brickfields of Savar," BRAC University, 2013.
16. M. R. Ullah, "Economic Impacts of Globalization on Urban Environment at Dhaka city in Bangladesh," *Journal of Economics and Sustainable Development*, vol. 5, no. 25, pp. 15–29, 2014.
17. L. Rushton, "Occupational causes of chronic obstructive pulmonary disease," *Reviews on environmental health*, vol. 22, no. 3, pp. 195–212, 2007.
18. S. M. H. Ullah, M. Hasan, S. I. Ahmad, and T. Ahmed, "Performance of industrial sludge-amended bricks manufactured in conventional kilns," *J Mater Cycles Waste Manag*, vol. 22, no. 6, pp. 1932–1942, Nov. 2020, doi: 10.1007/s10163-020-01080-9.
19. S. K. Guttikunda, B. A. Begum, and Z. Wadud, "Particulate pollution from brick kiln clusters in the Greater Dhaka region, Bangladesh," *Air Qual Atmos Health*, vol. 6, no. 2, pp. 357–365, Jun. 2013, doi: 10.1007/s11869-012-0187-2.
20. A. Abbas *et al.*, "Assessment of long-term energy and environmental impacts of the cleaner technologies for brick production," *Energy Reports*, vol. 7, pp. 7157–7169, Nov. 2021, doi: 10.1016/j.egyr.2021.10.072.
21. M. K. Saha, S. Ahmed, A. Sheikh, and M. Mostafa, "Impacts of Brick Kilns on Environment around Kiln areas of Bangladesh," vol. 12, pp. 241–253, Nov. 2021.
22. H. R. Ahmad, Z. U. R. Farooqi, M. Sabir, and M. F. Sardar, "Brick Kilns: Types, Emissions, Environmental Impacts, and their Remedial Measures," in *Biodiversity, Conservation and Sustainability in Asia: Volume 2: Prospects and Challenges in South and Middle Asia*, M. Öztürk, S. M. Khan, V. Altay, R. Efe, D. Egamberdieva, and F. O. Khassanov, Eds., Cham: Springer International Publishing, 2022, pp. 945–958. doi: 10.1007/978-3-030-73943-0_52.
23. B. Skinder, A. Sheikh, A. Pandit, and B. Ganai, "Brick kiln emissions and its environmental impact: A Review," *Journal of Ecology and the Natural Environment*, vol. 6, pp. 1–11, Dec. 2013, doi: 10.5897/JENE2013.0423.
24. M. S. S. Chowdhury, M. Haque, and M. S. Engr. MD. ANISUR RAHMAN ~ TiTU, "GREEN ECO-BRICK, BRICK KILNS EMISSION AND IT'S ENVIRONMENTAL IMPACT", Accessed: Nov. 02, 2023. [Online].

Available: https://www.academia.edu/84857795/GREEN_ECO_BRICK_BRICK_KILNS_EMISSION_AND_IT_S_ENVIRONMENTAL_IMPACT

25. S. K. Joshi and I. Dudani, "Environmental Health effects of Brick Kilns in Khatmandu Valley," *Kathmandu University medical journal (KUMJ)*, vol. 6, pp. 3–11, Jan. 2008.
26. M. F. Jerin, S. K. Mondol, B. C. Sarker, R. H. Rimi, and S. Aktar, "Impacts of Brick Fields on Environment and Social Economy at Bagatipara, Natore, Bangladesh," *Journal of Environmental Science and Natural Resources*, vol. 9, no. 2, p. 31, 2017, Accessed: Nov. 02, 2023. [Online]. Available: https://www.academia.edu/32483248/Impacts_of_Brick_Fields_on_Environment_and_Social_Economy_at_Bagatipara_Natore_Bangladesh
27. A. Abir, "Role of Laws to Control Brick Manufacturing and Kiln Establishment in Bangladesh: Scope of Alternative Bricks," *VNU Journal of Science: Earth and Environmental Sciences*, vol. 35, Mar. 2019, doi: 10.25073/2588-1094/vnuees.4371.
28. H. Valdes, J. Vilches, G. Felmer, M. Hurtado, and J. Figueroa, "Artisan Brick Kilns: State-of-the-Art and Future Trends," *Sustainability*, vol. 12, no. 18, Art. no. 18, Jan. 2020, doi: 10.3390/su12187724.
29. Md. S. Haque and S. Sharif, "The need for an effective environmental engineering education to meet the growing environmental pollution in Bangladesh," *Cleaner Engineering and Technology*, vol. 4, p. 100114, Oct. 2021, doi: 10.1016/j.clet.2021.100114.
30. Md. A. Ahmed and S. Chakrabarti, *Analysis on Solid Waste Management Practices and Development of Integrated Solid Waste Management Model for Developing Country With Special Reference to Jhenaidah Municipal Area, Bangladesh*. KUET, Khulna, Bangladesh: 4th International Conference on Civil Engineering for Sustainable Development (ICCESD 2018), KUET, Khulna, Bangladesh, 2018.
31. Md. A. Ahmed, M. Hossain, and M. Islam, *Prediction of Solid Waste Generation Rate and Determination of Future Waste Characteristics at South-western Region of Bangladesh Using Artificial Neural Network*. KUET, Khulna, Bangladesh: WasteSafe 2017, KUET, Khulna, Bangladesh, 2017.
32. A. A. Ananno, M. H. Masud, S. A. Chowdhury, P. Dabnichki, N. Ahmed, and A. Md. E. Arefin, "Sustainable food waste management model for Bangladesh," *Sustainable Production and Consumption*, vol. 27, pp. 35–51, Jul. 2021, doi: 10.1016/j.spc.2020.10.022.
33. Md. M. Rahman, D. B. P. Argha, and M. Haque, *PRESENT SCENARIO OF MUNICIPAL SOLID WASTE MANAGEMENT IN SATKHIRA MUNICIPALITY*. 2018.
34. T. Khan, D. B. P. Argha, and M. S. Anita, *An Analysis of Existing Medical Waste Management and Possible Health Hazards in Jhenaidah Municipality*. 2021.
35. Md. A. Ahmed and S. M. Moniruzzaman, *A Study on Plastic Waste Recycling Process in Khulna City*. KUET, Khulna, Bangladesh: 4th International Conference on Civil Engineering for Sustainable Development (ICCESD 2018), KUET, Khulna, Bangladesh, 2018.
36. K. Harshwardhan and K. Upadhyay, "Effective Utilization of Agricultural Waste: Review," *Journal of Fundamentals of Renewable Energy and Applications*, vol. 07, Jan. 2017, doi: 10.4172/2090-4541.1000237.
37. Md. A. Ahmed, P. Roy, A. Bari, and M. Azad, *Conversion of Cow Dung to Biogas as Renewable Energy Through Mesophilic Anaerobic Digestion by Using Silica Gel as Catalyst*, 5th ed. Chittagong: ICMERE 2019, Chittagong University of Engineering & Technology (CUET), 2019.
38. C.-M. Liu and S.-Y. Wu, "From biomass waste to biofuels and biomaterial building blocks," *Renewable Energy*, vol. 96, pp. 1056–1062, Oct. 2016, doi: 10.1016/j.renene.2015.12.059.
39. P. Roy, Md. A. Ahmed, and Md. H. Shah, "Biogas generation from kitchen and vegetable waste in replacement of traditional method and its future forecasting by using ARIMA model," *Waste Dispos. Sustain. Energy*, vol. 3, no. 2, pp. 165–175, Jun. 2021, doi: 10.1007/s42768-021-00070-3.
40. A. Hasib and D. B. P. Argha, *COVID-19: LACK OF CORONAVIRUS WASTES MANAGEMENT-AN UPCOMING THREAT FOR THE MEGACITY DHAKA*. 2021.
41. M. Prasad *et al.*, "Efficient Transformation of Agricultural Waste in India," in *Contaminants in Agriculture: Sources, Impacts and Management*, M. Naeem, A. A. Ansari, and S. S. Gill, Eds., Cham: Springer International Publishing, 2020, pp. 271–287. doi: 10.1007/978-3-030-41552-5_13.
42. P. Roy, Md. A. Ahmed, and Md. H. Shah, "Biogas generation from kitchen and vegetable waste in replacement of traditional method and its future forecasting by using ARIMA model," *Waste Dispos. Sustain. Energy*, vol. 3, no. 2, pp. 165–175, Jun. 2021, doi: 10.1007/s42768-021-00070-3.

43. A. M. Omer, "Demand for energy efficient, eco-friendly environment, applications and sustainable development," 2015, pp. 493–573.
44. M. A. Ahmed, P. Roy, M. H. Shah, D. P. Argha, D. Datta, and R. H. Rïyad, "Recycling of cotton dust for organic farming is a pivotal replacement of chemical fertilizers by composting and its quality analysis," *ERT*, vol. 4, no. 2, Art. no. 2, Jun. 2021, doi: 10.35208/ert.815322.
45. T. Kuthiala, K. Thakur, D. Sharma, G. Singh, M. Khatri, and S. K. Arya, "The eco-friendly approach of cocktail enzyme in agricultural waste treatment: A comprehensive review," *International Journal of Biological Macromolecules*, vol. 209, pp. 1956–1974, Jun. 2022, doi: 10.1016/j.ijbiomac.2022.04.173.
46. T. Dey, T. Bhattacharjee, P. Nag, Ritika, A. Ghati, and A. Kuila, "Valorization of agro-waste into value added products for sustainable development," *Bioresource Technology Reports*, vol. 16, p. 100834, Dec. 2021, doi: 10.1016/j.biteb.2021.100834.
47. L. L. D. R. Osorio, E. Flórez-López, and C. D. Grande-Tovar, "The Potential of Selected Agri-Food Loss and Waste to Contribute to a Circular Economy: Applications in the Food, Cosmetic and Pharmaceutical Industries," *Molecules*, vol. 26, no. 2, Art. no. 2, Jan. 2021, doi: 10.3390/molecules26020515.
48. D. B. P. Argha, A. Hasib, and M. Rahman, "A comparative study on the variation of air quality index of Dhaka city before and after the nationwide lockdown due to COVID-19," in *6th International Conference on Engineering Research, Innovation and Education (2021). Sylhet, Bangladesh*, 2021.
49. M. W. Khan, Y. Ali, F. De Felice, A. Salman, and A. Petrillo, "Impact of brick kilns industry on environment and human health in Pakistan," *Science of The Total Environment*, vol. 678, pp. 383–389, Aug. 2019, doi: 10.1016/j.scitotenv.2019.04.369.
50. M. Ilyas, W. Ahmad, H. Khan, S. Yousaf, M. Yasir, and A. Khan, "Environmental and health impacts of industrial wastewater effluents in Pakistan: a review," *Rev Environ Health*, vol. 34, no. 2, pp. 171–186, Jun. 2019, doi: 10.1515/reveh-2018-0078.
51. T. Rajaram and A. Das, "Water pollution by industrial effluents in India: Discharge scenarios and case for participatory ecosystem specific local regulation," *Futures*, vol. 40, no. 1, pp. 56–69, Feb. 2008, doi: 10.1016/j.futures.2007.06.002.
52. J. Odigie, "Harmful effects of wastewater disposal into water bodies: a case review of the Ikpoba river, Benin city, Nigeria," *Tropical Freshwater Biology*, vol. 23, p. 87, Aug. 2015, doi: 10.4314/tfb.v23i1.5.
53. M. A. Ahmed* and M. Redowan, "Fate and Transport of the Biologically Treated Landfill Leachate Induced Dissolved Organic Nitrogen (DON)," *AEESP Research and Education Conference, Northeastern University, June 20-23, 2023*, Jun. 2023, Accessed: Sep. 10, 2023. [Online]. Available: https://par.nsf.gov/biblio/10431230-fate-transport-biologically-treated-landfill-leachate-induced-dissolved-organic-nitrogen-don
54. M. M. Akhtar, T. Zhonghua, A. Dawood, and M. T. Sohail, "A Study to Investigate and Compare Groundwater Quality in Adjacent Areas of Landfill Sites in Lahore City," *Nature Environment and Pollution Technology*, vol. 13, pp. 1–10, Mar. 2014.
55. M. R. Rashid and M. Ashik, "Evaluation of Physicochemical Treatment Technologies for Landfill Leachate Induced Dissolved Organic Nitrogen (DON).," *AEESP Research and Education Conference, Northeastern University, June 20-23, 2023*, Jun. 2023, Accessed: Sep. 10, 2023. [Online]. Available: https://par.nsf.gov/biblio/10431232-evaluation-physicochemical-treatment-technologies-landfill-leachate-induced-dissolved-organic-nitrogen-don
56. J. Lee *et al.*, "Scalable deep learning to identify brick kilns and aid regulatory capacity," *Proceedings of the National Academy of Sciences*, vol. 118, no. 17, p. e2018863118, Apr. 2021, doi: 10.1073/pnas.2018863118.
57. D. B. P. Argha and Q. Bari, *EXTENT OF EFFLORESCENCE IN A BRICK MASONRY PARTITION WALL OF A GARAGE*. 2018.
58. K. Roy, Q. Bari, S. Mostakim, and D. B. P. Argha, *Water Supply History of Khulna City*. 2019.
59. A. Allen, J. Davila, and P. Hofmann, *Governance of Water and Sanitation Services for the Peri-urban Poor A Framework for Understanding and Action in Metropolitan Regions Governance of Water and Sanitation Services for the Peri-urban Poor*. 2006.
60. P. Roy, M. A. Ahmed, Md. S. Islam, Md. A. K. Azad, Md. S. Islam, and Md. R. Islam, "Water Supply, Sanitation System and Water-borne Diseases of Slum Dwellers of Bastuhara Colony, Khulna," presented at the 5 th International Conference on Civil Engineering for Sustainable Development (ICCESD 2020), Khulna, Bangladesh: Department of Civil Engg., KUET, Feb. 2020.
61. P. Roy, M. A. Ahmed, and A. Kumer, "AN OVERVIEW OF HYGIENE PRACTICES AND HEALTH RISKS RELATED TO STREET FOODS AND DRINKING WATER FROM ROADSIDE RESTAURANTS OF

KHULNA CITY OF BANGLADESH," *EJERE*, vol. 3, no. 2, Art. no. 2, Dec. 2019, Accessed: Aug. 08, 2023. [Online]. Available: https://dergipark.org.tr/en/pub/ejere/issue/49620/590483

62. C. L. Moe and R. D. Rheingans, "Global challenges in water, sanitation and health," *J Water Health*, vol. 4 Suppl 1, pp. 41–57, 2006.
63. M. Pal, Y. Ayele, A. Hadush, S. Panigrahi, and V. Jadhav, "Public Health Hazards Due to Unsafe Drinking Water," vol. 7, May 2018, doi: 10.4172/2167-7719.1000138.
64. N. J. Ashbolt, "Microbial Contamination of Drinking Water and Human Health from Community Water Systems," *Curr Envir Health Rpt*, vol. 2, no. 1, pp. 95–106, Mar. 2015, doi: 10.1007/s40572-014-0037-5.
65. N. J. Ashbolt, "Microbial contamination of drinking water and disease outcomes in developing regions," *Toxicology*, vol. 198, no. 1, pp. 229–238, May 2004, doi: 10.1016/j.tox.2004.01.030.
66. S. Das, R. Akhter, S. Huque, S. Khandaker, M. Shahriar, and Md. Z. H. Gorapi, "Socioeconomic conditions and health hazards of brick field workers: A case study of Mymensingh brick industrial area of Bangladesh," *Journal of Public Health and Epidemiology*, vol. 9, pp. 198–205, Jul. 2017, doi: 10.5897/JPHE2017.0927.
67. D. Biswas, E. S. Gurley, S. Rutherford, and S. P. Luby, "The Drivers and Impacts of Selling Soil for Brick Making in Bangladesh," *Environmental Management*, vol. 62, no. 4, pp. 792–802, Oct. 2018, doi: 10.1007/s00267-018-1072-z.
68. S. P. Luby, D. Biswas, E. S. Gurley, and I. Hossain, "Why highly polluting methods are used to manufacture bricks in Bangladesh," *Energy for Sustainable Development*, vol. 28, pp. 68–74, Oct. 2015, doi: 10.1016/j.esd.2015.07.003.
69. M. A. I. Juel, A. Mizan, and T. Ahmed, "Sustainable use of tannery sludge in brick manufacturing in Bangladesh," *Waste Management*, vol. 60, pp. 259–269, Feb. 2017, doi: 10.1016/j.wasman.2016.12.041.
70. B. A. Begum, P. K. Hopke, and A. Markwitz, "Air pollution by fine particulate matter in Bangladesh," *Atmospheric Pollution Research*, vol. 4, no. 1, pp. 75–86, Jan. 2013, doi: 10.5094/apr.2013.008.
71. M. Imran, M. Baten, B. Nahar, and N. Morshed, "Carbon dioxide emission from brickfields around Bangladesh," *International Journal of Agricultural Research, Innovation and Technology*, vol. 4, Mar. 2015, doi: 10.3329/ijarit.v4i2.22653.
72. I. Makrygiannis and A. Tsetsekou, "Efficient Recovery of Solid Waste Units as Substitutes for Raw Materials in Clay Bricks," *Recycling*, vol. 7, no. 5, Art. no. 5, Oct. 2022, doi: 10.3390/recycling7050075.
73. S. N. Monteiro and C. M. F. Vieira, "On the production of fired clay bricks from waste materials: A critical update," *Construction and Building Materials*, vol. 68, pp. 599–610, Oct. 2014, doi: 10.1016/j.conbuildmat.2014.07.006.
74. A. Uzzaman, "" Financial Feasibility of Environment Friendly Brick Manufacturing in the Context of Bangladesh "", Accessed: Nov. 02, 2023. [Online]. Available: https://www.academia.edu/35504114/_Financial_Feasibility_of_Environment_Friendly_Brick_Manufacturing_in_the_Context_of_Bangladesh_
75. S. Guttikunda, "Impact Analysis of Brick Kilns on the Air Quality in Dhaka, Bangladesh," 2009. Accessed: Nov. 02, 2023. [Online]. Available: https://www.semanticscholar.org/paper/Impact-Analysis-of-Brick-Kilns-on-the-Air-Quality-Guttikunda/87685662c718f9aa64b9833202e3f2004f5bfd28
76. B. A. Begum and P. K. Hopke, "Identification of Sources from Chemical Characterization of Fine Particulate Matter and Assessment of Ambient Air Quality in Dhaka, Bangladesh," *Aerosol Air Qual. Res.*, vol. 19, no. 1, pp. 118–128, 2019, doi: 10.4209/aaqr.2017.12.0604.
77. M. I. Haque, K. Nahar, M. H. Kabir, and A. Salam, "Particulate black carbon and gaseous emission from brick kilns in Greater Dhaka region, Bangladesh," *Air Qual Atmos Health*, vol. 11, no. 8, pp. 925–935, Oct. 2018, doi: 10.1007/s11869-018-0596-y.
78. M. Hasan, Md. A. Islam, M. Aziz Hasan, Md. J. Alam, and M. H. Peas, "Groundwater vulnerability assessment in Savar upazila of Dhaka district, Bangladesh — A GIS-based DRASTIC modeling," *Groundwater for Sustainable Development*, vol. 9, p. 100220, Oct. 2019, doi: 10.1016/j.gsd.2019.100220.
79. M. A. Islam, S. Murshed, and M. Hasan, "Selecting suitable landfill site with multi-criteria evaluation and GIS: a case of Savar upazila in Bangladesh," *Arab J Geosci*, vol. 13, no. 18, p. 952, Sep. 2020, doi: 10.1007/s12517-020-05925-3.
80. "Bangladesh - Population and Housing Census 2011." Accessed: Nov. 02, 2023. [Online]. Available: https://catalog.ihsn.org/index.php/catalog/4376

81. P. S. Bindraban, J. J. Stoorvogel, D. M. Jansen, J. Vlaming, and J. J. R. Groot, "Land quality indicators for sustainable land management: proposed method for yield gap and soil nutrient balance," *Agriculture, Ecosystems & Environment*, vol. 81, no. 2, pp. 103–112, Oct. 2000, doi: 10.1016/S0167-8809(00)00184-5.
82. R. Lal, "Restoring Soil Quality to Mitigate Soil Degradation," *Sustainability*, vol. 7, no. 5, Art. no. 5, May 2015, doi: 10.3390/su7055875.
83. S. Tahir and P. Marschner, "Clay Addition to Sandy Soil Reduces Nutrient Leaching—Effect of Clay Concentration and Ped Size," *Communications in Soil Science and Plant Analysis*, vol. 48, no. 15, pp. 1813–1821, Aug. 2017, doi: 10.1080/00103624.2017.1395454.
84. M. Hamza and W. Anderson, "Response of soil properties and grain yield to deep ripping and gypsum application in a compacted loamy sand soil contrasted with a sandy clay loam in Western Australia," *Crop and Pasture Science*, vol. 54, pp. 273–282, Apr. 2003, doi: 10.1071/AR02102.
85. D. Wu *et al.*, "Effect of biochar origin and soil pH on greenhouse gas emissions from sandy and clay soils," *Applied Soil Ecology*, vol. 129, pp. 121–127, Aug. 2018, doi: 10.1016/j.apsoil.2018.05.009.