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AN OVERVIEW OF HEALTH AND ENVIRONMENTAL THREATS FROM THE BRICK KILN INDUSTRY AROUND THE CAPITAL OF BANGLADESH

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ABSTRACT

Bangladesh is one of the top brick manufacturing countries in the globe. With rapid urbanization and industrialization, the brick manufacturing industry is elevating to its peak level day by day and contributing to the country's GDP significantly. This research aims to investigate the current environmental and health threat coming from brick kilns around the capital of Bangladesh. The selected areas are Savar, Tongi, Amin Bazar and Ashulia. The methodology followed in this study was field surveying in the selected areas and information acquisitions from the secondary data. Results from this study revealed that brick kilns are highly responsible for environmental pollution that subsequently deteriorates the air quality, causes land degradation, threatens biodiversity and poses a potential impact on human health. Results also revealed that there are mainly four types of brick kilns found in selected areas e.g. Chimney Kiln (CK), Zigzag kiln (ZK), Hoffman Kiln (HK) and Hybrid Hoffman Kiln (HHK). Of these, the Fixed Chimney Kiln is found to be very obsolete at present days and creates environmental pollution at different levels. Besides these, strict implementation of the Brick Manufacturing and Brick Kilns Establishment (Control) Act, 2013 in the studied locations is still far away. This paper urges the attention of the policymakers as well as the researchers to prioritize the solution to this promising but ever-increasing pollution-causing industry of Bangladesh in sustainable ways.

INTRODUCTION

Brick kilns are very promising sectors of Bangladesh. This sector supporting the ever growing urbanization and industries with production eligibility of 12 billion pieces of bricks/year. There are approximately 5000 brick kilns throughout the country and this figure will be increased is by 50% in the year of 2020 (UNDP, 2011a; World Bank, 2006; Darain et al., 2013; Gomes & Hossain, 2003). Brick kilning industry contributing to the country's % 1% of GDP with the employment of nearly 1 million people. Studies conducted by UNDP revealed that every year Bangladesh is producing 1200 crore pieces of bricks to cope with the rapid urbanization rate of about 7-8% (UNDP, 2011a). However, this big economic market also poses potential losses to the environment. For this reason, the objective of this study was set to evaluate the environmental and health threats coming from the brick kiln industries. Alternative brick kiln industries were also considered since they are emitting less pollutants. Possible recommendations were also included to overcome the problems. Thus this study could be used as base line study regarding brick kiln industry induced environment and health threat in perspective of Bangladesh.

LITERATUR REVIEW

The reasons of abundance manufacturing of brick are due to availability of alluvial soil and scarcity of stone materials. Conventional methods are followed to make bricks in Bangladesh and no precaution with environmental factors like fume toxicity and emitted particles are considered. The main fuel used in brick kiln is low grade coal and firewood. Besides these, tires and natural gas are also used (Ahmed & Hossain, 2008; DoE, 2017).

These fuel create toxic fumes and particulate matters of different types that deteriorate the environment with increasing heat effect in nearby city areas including Narayanganj, Savar, Tongi, Amin bazar, Ashulia, Keraniganz, Gazipur

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etc. The air quality and cropping yield in the vicinity of these areas are largely affected. The use of low grade fuel, error in chimney design, breaking the legal laws and establishing unplanned brick kiln adjacent to the crop land and residential area pose potential threat to both human and environment (Siddique et al., 2014). The conventional brick field in the vicinity of city area of Bangladesh manufacture more than 18 billion pieces of bricks that require 20 tons of fossil fuel that subsequently reduce the annual crop production and accelerates the greenhouse effects. Study found that manufacturing of 3.5 billion pieces of bricks require 0.85 million tons of coal annually causing about 2,200-4,000 early stage death with 0.2-0.05 million respiratory disease cases in and around capital Dhaka (Ahmed & Hossain, 2008).

Another study revealed that about 23 tons of coal or 3,500 ft^3 of trees are required to fire up 1,00,000 pieces of brick (Roy, 2012). This amount of wood constitutes 2.52 million hectares equivalent to 17.4% of forest area (BBS, 2011). World Bank reported that air quality of Dhaka has been deteriorating due to pollution from vehicles, metal smelters, road dust and brick kilns worsen the scenario (World Bank, 2006). In addition, brick kilns are the root causes of destroying crop land and its fertility (Khan et al., 2007). The infertile land cannot be used for cropping for several years (Khan et al. 2007).

MATERIALS AND METHODS

Field based survey was done to assess the current pollution scenario from the brick kiln industries in Bangladesh. The selected area was Savar, Tongi, Amin bazar and Ashulia. Alternative brick field was also visited. It was found that alternative brick kiln was less polluting site than other conventional brick fields. Secondary data from literature reviews also considered to evaluate the environmental pollution and health threats from the brick kilns. The overview of current brick manufacturing industry is given in Table 1 (Guttikunda & Khaliquzzaman, 2014; Ahmed & Hossain, 2008).

Table 1. Overview of Brick Manufacturing Scenario in Bangladesh

Serial	Parameter	Approximate Value
1.	Brick field	5,000
2.	Kilns within 50km of capital	1,000
3.	Natural gas based kiln	26
4.	Rate of Brick production in a year	17.2 billion
5.	Bricks market value	15 million BDT (1.3 billion USD)
6.	Gross domestic product value	1.0%
7.	Coal fired/year for brick kiln	3.50 million tons
8.	Cost of imported coal for brick kilns	22.6 billion BDT (322 million USD)
9.	Clay consumption/year	45 million tons
10.	Emission CO_2	9.8 million tons
11.	Total employment in brick industry	1 million people
12.	Brick Industry growth between 2000-2010	5.6%
13.	Expected growth between 2010-2020	2-4%

RESULTS AND DISCUSSION

Table 2 displays the characteristics of bricks in studied locations by field survey.

Table 2. Characteristics of Bricks found in Surveyed Brick Field

Product Type	Size (inch)	Application
Solid brick	9.5x4.5x2.75	Wall, partitions, dividers
Block	15.35x7.48x7.48	do
Block	15.35x5.11x7.48	do
Paver I Shaped	7.87x6.29x2.36	Pavement
Paver Square Shaped	9.84x9.84x2.36	Pavement
Paver Triangular Shaped	49.21x2.36	Pavement
Paver Ripple Shaped	8.25x 4.4X2.36	Pavement
Raw Materials	Ratio (%) by volume	Remarks
Cement	12.5%	Local
Local Sand (FM 1.2-1.)	40%	Local
Sylhet Sand (FM.)	27.5%	Locally sourced
Aggregate (Stone dust/gravel) dia<10mm	20%	Locally sourced
Water	10 ltr (approx.)	Pure Drinking Water
Chemical- pigment, additives	As required	

Existing Brick Making Technologies in Bangladesh

There are basically 4 categories of kiln technologies observed in the studied locations. The fixed chimney kiln (FCK) and bull's trench kiln (BTK), consist more than 90% of kilns in Bangladesh creating environmental pollution significantly. For this reason, BTK technology has already banned in Bangladesh. The two other technologies are natural gas fired Hoffmann kilns and coal fired zigzag kilns. These two technologies are relatively environmental friendly than FCK and BTK.

Fixed Chimney Kiln (FCK)

FCK is mostly used technology in the country. Though this technology requires low investment, it degrades the environment very badly. FCK is mostly seen in the north side of the capital remain operational for 6-7 months in a year. FCK is an upgraded version of BTK technology. The height of the chimney was 30 feet for BTK while it is now 120-130 feet for FCK.

This elevated height offers efficient passage of gases than BTK. FCK is basically found in large land especially on the surface level.

Zigzag Kiln

Zigzag technology used in the country is basically the replication of Indian brick manufacturing technology. It is mostly seen in the Comilla region. This kiln shows high energy efficiency with lower emission if properly constructed and operated. The reason of high energy efficiency is due to efficient burning of the bricks. Another positive side of this kiln is that it requires less fossil fuel and complex air flow outlet. The shape of the zigzag kiln is rectangular with 250 feet length and 80 feet wide. The height of the chimney is 55 feet. The kiln has 44-52 chambers. This makes better burning of the brick in zigzag pattern. All of these cause efficient fuel use, and better brick grade than FCK. However, zigzag kilns in Bangladesh is operating with lack of proper maintenance and design and do not reduce the pollutants at desired level.

Hoffman Kiln (HK)

This technology was widely used in Europe during the mid-19th century and developed by Germany later. During the year of 1980s, this technology was adopted in Bangladesh. The rectangular shaped Hoffman kiln is 400 feet long and 70 feet wide. The height of the chimney is 100 feet. An adjust fan is placed at the bottom of the chimney. This technology possesses very good insulation system. The possible usage of natural gas as fuel further reduce the emissions. However, HK requires special building expertise. One of the advantages of HK is that the brick production can remain operational all around the year. Another advantage is that HK has roof system and monsoon season does not hamper its production rate.

Hybrid Hoffman Kiln (HHK)

This method is developed by China and is the upgraded version of HK technology. The main difference between these two technologies is in fuel usage that is HHK run by coal instead of natural gas thus upgrade the brick quality and reduce the air pollution. This technology was first introduced in the country in 2006 by GEF supported project (UNDP, 2011). About ten HHKs are running in Bangladesh at present and many more in its way to build. The HHK constitutes efficient heat optimization technology named forced draft tunnel kiln (FDTK) to produce environmental friendly bricks. Another positive site of this technology is that this does not require tall chimney like the other kilns. However, there are challenges to adopt this technology. First, establishment of HKK needs large capital investment when compared to other brick kiln technologies. Second, HHK needs larger high land area that is hardly found and very costly especially near sub-urban areas of a major city. Following Table 3 displaying the different brick manufacturing technologies in brief

Table 3. Comparative Scenario of Different Brick Manufacturing Technology in Study Areas

Kiln type	FCK	Zigzag	HHK
Pollution level	High	Moderate	Low
Emission (mg/m^3/1000 brick)	>1,000	500-800	20-40
CO_2 emission (tons/million brick)	582	440	315
Coal consumption (tons/million brick)	240	180-220	120-130
Total market share	92.2%	3.1%	0.2%
Approximate investment (USD)	70,000	80,000	2 million
Operating & manufacturing cost (USD)	1,50,000	1,60,000	5,00,000
Labor required/day	150	150	80
Annual brick production	3 million	3 million	15 million
Brick quality (PSI)	<2,500	<2,500	4,500-6,000
Brick unit price (BDT)	5.5-6.0	5.5-6.0	7.0-7.5

Pollution Emitted From Brick Field and Their Consequences

The commonly used fuel for brick field in study areas are wood and fossil fuel. They emit the greenhouse gases (GHGs) e.g. carbon dioxide, methane etc. (Lee et al., 2013; Chuah et al., 2006; Zong et al., 2002; Co et al., 2009). Besides that, the combustion of clay and fuel during brick manufacturing produce PCBs, PBBs dioxins and volatile liquid as extra products. These byproducts reacted with chlorine and remain for several months to year together and can even fly country to country. Another negative side is that these volatile compounds have bio accumulative characteristics because of having strong affinity to fats that subsequently create toxicity in the ecosystem thus is hazardous to flora and fauna (Hilten et al., 2008; Yarin, 1993). Table 4 represents the GHGs and other hazardous gas emission from brick kilns in Bangladesh (Darain et al., 2013).

Table 4. Emissions from Brick Industry

Fossil Fuel Name	Consumption	Emission (tons)						
		Carbon dioxide	**Methane**	**Nitrous oxide**	**Nitrogen oxides**	**Carbon monoxide**	**Non-methane volatile organic compounds**	**Sulfur dioxide**
Coal	1,800 kilo tons	34,92,681	376.74	52.7436	19,854.2	2,976.24	753.48	1,71,000
Wood	1,260 kilo tons	40,06,246.86	567	75.6	1890	37800	945	541

Crude Oil	2.9 kilo tons	7,004	0.19	0.06	19.30	0.96	0.0006	183
Total		75,05,932	944	128.50	21,763.9	40,777.3	1,698.49	1,76,224

Studies found that this emission level deviated with the season. For example, pollutant concentration from the brick kiln is higher in the winter (Begum & Hopke, 2013). The reason behind this is the low precipitation and stagnant wind (Akpinar et al., 2006).

Another report of World Bank, 2014 published that about 9.8 million tons of GHGs are being emitted by brick kiln in Bangladesh every year while the total CO_2 emission in Bangladesh was noted to be 15.67 million tons in 2017 (Al Faruque, 2017). Using of low grade coal as fuel in the brick kilns further increase the CO_2 emission and can be recognized as one of the driver factors of climate change. The consequences of climate change rise the sea level and aerial heat, change the rainfall pattern and accelerates the frequency of natural disaster like cyclone, floods etc. significantly that create negative impacts in the country's economic growth (Hossain, 2004).

Impact on Land

Conventional brick kilns in study areas use clay as the main raw material of brick manufacturing. Alam, 2009 suggested that it takes 500000 to 1000000 cft top soil to produce 3-4 million pieces of brick. It is obvious that the loss of top soil is even bigger in the present year. This scenario also results the loss of farm lands and their fertility that directly hampering the national food reserve. In addition, areas near one or more brick kilns facing reduction in crop yield due to presence of air pollutants in the atmosphere. Nutrients present in the top soil are Ca, Mg, B, Mo, Fe, Mn, N, P, K, S, Zn etc. All of these nutrients are essential to grow crops. So the affected land remains fallow for several years that subsequently affect the country's net crop production (Roy & Roy, 2016).

Impacts on Biodiversity

Studies found that each brick kiln requires at least 80000 kg of wood to run the operation each year (Daily Star, 2011). This makes destruction of trees and shrinkage of the forest cover every year. Ash and other dust particles from brick kilns hinder photosynthesis process. The fruit bearing trees adjacent to the brick kiln lost their regular size and quality. (Hossain, 2015). Besides these, the heated smoke from chimney degrade fruit quality, flower and other vegetative body since it is responsible to exceed the optimum temperature of photosynthesis phenomena. Again this hot fume is also responsible for the slow death of nearby trees (Daily Star, 2018).

Impacts on Human Health

Many of the brick kilns in studied areas are mostly situated near the crowd areas. The inhabitants of these area are facing different chronic and acute disorders. This type of toxic gases is carcinogenic, reduce eye contact capacity and cause skin diseases. (Jerin et al., 2016).

The CO emitted from brick field reduce air O_2 concentration thus lead to breathing difficulties. Both the aged and children generation suffer most. The children are suffered from fever frequently while the elder often suffered from bronchitis and asthma (Shams et al., 2015).

Particulate matter pollution is also produced from brick kilns. WHO, 2018 reported that about 7 million people become death every year because of the presence of excessive particulate matter in the air as it enters into the lungs and cardiovascular system (Alam, 2019).

Laws Regarding Brick Kiln in Bangladesh

The Bangladesh government however, made the Brick Manufacturing and Brick Kilns Establishment (Control) Act, 2013 to protect the environment and biodiversity and to further the development of the country. This Act has 25 sections and has been come into force on 1st July 2014.

License for Establishing Brick Kiln and Brick Making

Establishing brick kiln and making any brick except block brick without license given from the District Commissioner of concerned area is illegal for anyone. On other hand, no brick can be framed in any place except in the brick kiln defined in this act.

Controlling and Reducing of Using Mud

Any kind of clay collected from arable land or hill or hillock can be used as raw materials for brick making. Getting pre-approval of the District Commissioner, anyone can collect clay from any other place though the source of the clay with affidavit shall be included in his license for brick making. In addition, hollow brick or block brick shall be made in the area determined by the government to reduce the exploitation of clay for brick making. Block brick making may be made mandatory by the government to reduce the excessive use of clay.

Provisions for fuel using

No one can use wood as fuel in making brick though he is allowed to use coal. Coal, however, exceeding the determined standard sulfur, ash, mercury, or any other element of the same kind can be used as fuel for burning brick.

Prohibited Place for Brick Kiln

Any residential, protected or commercial area, city corporation, municipal area, or center of Upazila (local administration),

any forest whether it may be owned by the government or any person, crop land, environmentally vulnerable area etc. shall be prohibited for establishing any brick kiln. And no authority of the Department of Environment or any other organization after the commencement of this act provide license or any kind of approval for establishing brick kiln in those places.

Provisions for Issuing License

To get a license for establishing a brick kiln, a person shall have to make an application in the prescribed manner in 'Form-A' of the Schedule of this act to the District Commissioner or any officer empowered by him of the district where the kiln locates. The application shall accompany by the prescribed fee and all documents concerned to the kiln. The application, however, is not allowed without an environment clearance certificate issued by the Department of Environment under the Environment Conservation Act, 1995. After application, District Commissioner shall be sent it to the investigation committee and order the committee to resent it with their recommendation. If the District Commissioner is pleased with the recommendation made by the Committee, issue a license for making brick in 'Form-B' of the Act.

Penalty for Offence

In this existing Act, the maximum imprisonment is 5 years while punishment can be given up to 20 lacs Taka. However, there is a provision to provide either punishment, imprisonment, or fine, together. Offenses under this act are non-cognizable and billable. Cases under this act maybe disposed of only by the Mobile Court established under the Mobile Court Act, 2009 or Environment Tribunal established under the Environment Court Act, 2010, or by a special magistrate. To complete all proceedings in disposing of the case under this act provisions of the Mobile Court Act, 2009, or the Environment Court Act, 2010, or the Code of Criminal Procedure, as the case may be, shall be applied.

Barriers/Challenges

The challenges in the brick kilns of Bangladesh are-

- The Brick Manufacturing and Brick Kilns Establishment (Control) Act 2013 has not defined responsible authorities that would enforce the law with specific procedure.
- Most of the brick field owners are politically influential persons and do not have any concern on regulatory matters and environmental consequences.
- Nor rules and regulation in using of alternative bricks.
- Lack of comprehensive programs to make the brick industry environmental friendly with profit.
- No activity to enhance energy efficient technology that ultimately reduce the production cost.

Potential Alternatives

The Housing and Building Research Institute (HBRI) of Bangladesh has done investigation to establish alternative bricks. Thermal block, compressed stabilized earth block (CSEB), sand-cement Hollow Block and Interlocking CSEB are some of research findings of clay brick alternatives. Their insulation capacity is high. The block size is about 16"×4.5"×8" with nearly 3 kg only. It's crushing strength is 5-6 MPa with water bearing capacity <10%. A comparative scenario between traditional clay made brick and alternative is displayed in Table 5 (based on Field Survey and Ahmed & Struges, 2014).

Table 5. Comparative Scenario between Clay Brick and Alternative Brick

Serial	Parameter	Clay Made Brick	Alternative Brick
1.	Size (inch)	9.5"×4.5"×2.75"	16"×4.5"×8" (this size can be customized)
2.	Area (inch^2)	9.5"×2.75" = 26	16"×8" = 128
3.	Making time	Slow	Fast
4.	Constituents	Sand, lime, clay, iron oxide, magnesia.	Cement, sand, crushed stone
5.	Raw material	Crop land, hill tracts.	Dredged sand, construction rubbish
6.	Unit weight	3-3.5 kg	Size dependent
7.	Dry density	1,800-2,000 kg/m^3	600-800 kg/m^3
8.	Compression	3 MPa	4 MPa
9.	Water absorption capacity	15-20%	>10%
10.	Efflorescence	Present	Absent
11.	Thermal conductivity	High	Low
12.	Fire resistance	Low	High
13.	Workability	Low	High
14.	Breaking tendency	High during transportation	Low during transportation
15.	Earthquake resistance	Moderate	Good
16.	Environmental Impact	Reduce the top soil of arable land and cause loss of fertility and emit pollutants	No loss of top soil or fertility; the pollutant emission level is very low
17.	Labor cost	Costly	Cheap
18.	Maintenance cost	Costly	Cheap
19.	Unit price	0.0011 USD/in^3	0.00071 USD/in^3
20.	Social impact	Unorganized sector Child labor Unsafe working place	Well organized sector No child labor Standard factory facility with automated process
21.	Starting principle	4000000 taka	3.2000000 taka
22.	Land required	10,200 m^2	205 m^2
23.	Working environment	Unhealthy	Healthy
24.	Fuel type	Coal	Electricity, oil

25.	Pollutant e.g. CO_2, PM, SO_2, NO_x, CO	High	Low
26.	Operation time	November-April	All the year round
27.	Manufacturing rate	2.5 billion brick/year	2.7 billion brick/year
28.	Wastage	5-8%	2-3%

CONCLUSIONS

Though the brick kiln industry in Bangladesh is a promising sector in terms of economical point of view, it also degrades the environmental quality in different ways. It is high time to think about it and put emphasize to manage this sector in a sustainable manner. The following recommendations could be some of the good options-

- Preparing short term policy for the existing brick kiln and long term policy for the future brick kiln to protect the environmental degradation.
- Motivating the brick kiln owners to switch into environmental friendly kilns or alternative kilns with financial support.
- Prepare effective training and awareness programs for both owners and consumers.
- Give importance to do more research to establish sustainable technology in perspective of country's economy.
- Increase strict monitoring and proper enforcement of the existing laws related to brick kilns.

Since Bangladesh is already ranked as mostly polluted countries in the world, there is no alternative to coming back from existing trends and moving forward to sustainable solution in brick kiln industry of Bangladesh.

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REFERENCES

Ahmed, S., & Hossain, I. (2008). Applicability of air pollution modelling in a cluster of brickfields in Bangladesh. *Chemical Engineering Research Bulletin, 12*, 28-34. https://doi.org/10.3329/cerb.v12i0.1495

Ahmed, A., & Sturges, J. (2014). *Materials Science in Construction: An Introduction* (1st ed.). Routledge. https://doi.org/10.4324/9780080958507

Alam, M. S., Han, B., Mizan, A. & John, P. (2020). Assessment of soil and groundwater contamination at a former Tannery district in Dhaka, Bangladesh. *Environmental Geochemistry and Health, 42*, 1905-1920. https://doi.org/10.1007/s10653-019-00457-6

Al Faruque, A. (2017). Environmental Law: Global and Bangladesh Context, Dhaka. New Warsi Book Corporation. *Australian Journal of Environmental Education, 35*(2), 153-155. https://doi.org/10.1017/aee.2019.6

BBS. (2011). Statistical Pocketbook of Bangladesh. *Bangladesh Bureau of Statistics, Planning Division, Ministry of Planning.* Retrieved from http://bbs.portal.gov.bd/sites/default/files/files/bbs.portal.gov.bd/page/d6556cd1_dc6f_41f5_a766_042b69cb1687/2021-06-30-09-25-67bbe4c5c15d7773d82c86adbd26bba9.pdf

Chuah, T., Wan Azlina, A., Robiah, Y. & Omar, R. (2006). Biomass as the renewable energy sources in Malaysia: An overview. *International Journal of Green Energy, 3*, 323–346. https://doi.org/10.1080/01971520600704779

Co, H.X., Dung, N.T., Le, H.A., An, D.D., Chinh, K.V. & Oanh, N.T.K. (2009). Integrated management strategies for brick kiln emission reduction in Vietnam: A case study. *International Journal of Environmental Studies, 66* (1), 113–124. https://doi.org/10.1080/00207230902760507

Daily Star. (2011). *Brick kilns burn firewood, destroying CHT forest, Khagrachhari*. Retrieved from https://www.thedailystar.net/news-detail-119443

Daily Star. (2018). *Crack down on kilns near farmlands and habitation, Faridpur.* Retrieved from https://www.thedailystar.net/editorial/news/crack-down-kilns-near-farmlands-and-habitation-1648717

Darain, K. M., Rahman, A. B. M. S., Ahsan, A., Islam, A. B. M. S. & Yusuf, B. (2013). Brick manufacturing practice in Bangladesh: a review of energy efficacy and air pollution scenarios. *Journal of Hydrology and Environment Research, 1*(1), 60–69. https://www.researchgate.net/publication/265419175_Brick_Manufacturing_Practice_in_Bangladesh_A_Review_of_Energy_Efficacy_and_Air_Pollution_Scenarios

DoE. (2017). National strategy for sustainable brick production in Bangladesh. *Department of Environment, Ministry of Environment and Forests, Government of the people's republic of Bangladesh.* Retrieved from https://www.ccacoalition.org/en/resources/national-strategy-sustainable-brick-production-bangladesh

Gomes, E. & Hossain, I. (2003). Transition from traditional brick manufacturing to more sustainable practices. *Energy for*

Sustainable Development, *7*(2), 66–76. https://doi.org/10.1016/S0973-0826(08)60356-7

Guttikunda, S. K., & Khaliquzzaman, M. (2014). Health benefits of adapting cleaner brick manufacturing technologies in Dhaka, Bangladesh. Air Quality, *Atmosphere & Health*, *7*(1), 103–112. https://doi.org/10.1007/s11869-013-0213-z

Hilten, R.N., Lawrence, T.M. & Tollner, E.W. (2008). Modeling storm water runoff from green roofs with HYDRUS- 1D. *Journal of Hydrology*, *358*(3–4), 288–293. https://doi.org/10.1016/j.jhydrol.2008.06.010

Hossain, S. (2015). Firewood-based brick kilns pose threat to environment, Patuakhali. *The Daily Star*. Retrieved from https://www.thedailystar.net/country/firewood-based-brick-kilns-pose-threat-environment-192430

Hossain, I. (2004). *International Environmental Law Bangladesh Perspective* (1st ed.), Dhaka International University, Aligarh Library, Dhaka.

Jerin, M. F., Mondol, S. K., Sarker B. C., Rimi, R. H. & Aktar, S. (2016). Impacts of Brick Fields on Environment and Social Economy at Bagatipara, Natore, Bangladesh. *Bangladesh Journal of Environmental Science and Natural Resources*, *9*(2), 31-34. https://doi.org/10.3329/jesnr.v9i2.32148

Khan, H. R., Rahman, K. A., Rouf, A. J. M., Sattar, G. S. & Oki, Y. T. A. (2007). Assessment of degradation of agricultural soils arising from brick burning in selected soil profiles. *International Journal of Environmental Science and Technology*, *4*(4), 471–480. https://doi.org/10.1007/BF03325983

Lee, Z. H., Sethupathi, S., Lee, K. T., Bhatia, S. & Mohamed, A.R. (2013). An overview on global warming in Southeast Asia: CO_2 emission status, efforts done, and barriers. *Renewable and Sustainable Energy Reviews*, *28*(8), 71–81. https://doi.org/10.1016/j.rser.2013.07.055

Roy, P. (2012). Forests for bricks: brick kilns puff away 240 lakh (24 million) trees a year. *The Daily Star*. Retrieved from https://www.thedailystar.net/news-detail-237058

Roy, S. D. & Roy, P. (2016). PRECIOUS TOPSOIL burnt for bricks, *The Daily Star*. Retrieved from https://www.thedailystar.net/frontpage/brick-kilns-breed-woes-farmers-207520

Shams, S., Rahman, M. H., & Sahu, J. N. (2015). CFD Analysis of Brick Kiln Flue Gases and Its Health Impact: A Case Study of Northern Part of Bangladesh. *IUT Journal of Engineering and Technology*, *12*(1), 33-40. Retrieved from https://old.jet.iutoic-dhaka.edu/assets/publishedPaper/12_1_4.pdf

Siddique, M. N. A., Islam, M. M., Sultana, J., Kamaruzzaman, M., & Halim, M. A. (2014). Potential of soil sensor EM38 measurements for soil fertility mapping in the Terrace soil of Bangladesh. *Journal of Science, Technology and Environment Informatics 1*(1), 1–15. Retrieved from https://www.journalbinet.com/0101v114.html

UNDP (2011). Improving Kiln Efficiency in the Brick Making Industry, *Dhaka: GEF-United Nation Development Program, UNDP*. Retrieved from https://info.undp.org/docs/pdc/Documents/BGD/20161028%20IKEBMI%20TE%20Final%20Report.pdf

World Bank (2006). *Country environmental assessment*. Washington, DC: The World Bank. Retrieved from https://openknowledge.worldbank.org/handle/10986/2163

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