CARBON DIOXIDE EMISSION FROM BRICKFIELDS AROUND BANGLADESH

M.A. Imran1,*, M.A. Baten2, B.S. Nahar3 and N. Morshed4

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Abstract

The study was undertaken at six divisions of Bangladesh to investigate the CO2 emission from brickfields, to explore the rate of carbon emission over the last 10 years, based on existing technology for brick production. The finding reveals that there were more than 45,000 Brick kilns in Bangladesh which together account for about 95% of operating kilns including Bull's Trench Kiln, Fixed Chimney Kiln, Zigzag Kiln and Hoffman Kiln. These kilns were the most carbon emitting source but it varies on fuel type, kiln type and also for location. It has been found that, maximum carbon emission area was Chittagong, which was 93.150 with percentage of last 10 years and 9.310 per cent per year. Whereas Sylhet was lower carbon emission area indicating percentage 17.172 of last 10 years and 4.218 percent per year. It has been found that total annual amount of CO2 emission for 4 types brick kilns from Dhaka, Chittagong, Rajshahi, Khulna, Sylhet and Barisal were 8.862 Mt yr⁻¹, 10.048 Mt yr⁻¹, 12.783 Mt yr⁻¹, 15.250 Mt yr⁻¹, in the year of 2002, 2005, 2007 and 2010 respectively. In Mymensingh district, the maximum CO2 emission and coal consumption was obtained in Chamak brick field, which was 1882 tons and 950 tons, respectively and minimum was obtained in Zhalak brick field, which was 1039.5 tons and 525.0 tons, respectively during the year of 2010. The percentage in last 10 years of CO2 emission was 72.784 and per cent per year 7.970, which is very alarming for us. The estimates obtained from surveys and on-site investigations indicate that these kilns consume an average of 240 tons of coal to produce 1 million bricks. This type of coal has a measured calorific value of 6,400 KJ, heating value of 4.880 (Butler et al., 2004) brickfields are highly polluting Fixed Chimney Kilns (FCK) because of a combination of low capital cost requirement and high investment return. However, these kinds of kiln use more coal/wooded fuel, which

Keywords: CO2 Emission, Carbon, Brick Kiln, Consumption

1,2,4Department of Environmental Science, Bangladesh Agricultural University, Mymensingh, Bangladesh
3Principal Scientific Officer, Bangladesh Agricultural University, Mymensingh, Bangladesh

*Corresponding author’s email: imran.pstu@gmail.com (M.A. Imran)

Introduction

Brick making is a significant sector in Bangladesh, contributing about one percent to the country’s gross domestic product (GDP) (BUET, 2007) and generating employment for about one million people. Due to the unavailability of stone aggregate, brick is the main building material for the country's construction industry, which grew an average of about 5.6 per cent per year (Arifur, 2006).

Despite the importance of brick making, the vast majority of kilns use outdated, energy-intensive technologies that are highly polluting the environment. In the North Dhaka cluster, brick kilns are the city's main source of fine particulate pollution, accounting for nearly 40 per cent of total emissions (Biswas et al., 2009) during the 5-month operating period. It leads to harmful impacts on health, agricultural yields and global warming. The New technologies, such as the Vertical Shaft Brick Kiln (VSBK) and the Hybrid Hoffmann Kiln (HHK), are substantially cleaner than the Fixed Chimney Kiln (FCK) currently used. These improved technologies consume less energy and emit lower levels of pollutants and greenhouse gases (GHGs) (BUET, 2007; Heirli and Maithel, 2008). The existing brick kilns are the number one cause for fine particulate pollution in Bangladesh and its total greenhouse gas (GHG) emission is estimated to be 15.67 million tons of carbon dioxide (CO2) equivalent (tCO2e) per annum.

Global warming is an issue that calls for a global response. The rapid change in climate will be too great to allow many eco-systems to suitably adapt, since the change has direct impact on biodiversity, agriculture, forestry, dry land, water resources and human health. In addition, Bangladesh is one of the most climate change vulnerable countries. In Bangladesh, 92% of the 4,880 (Butler et al., 2004) brickfields are highly polluting Fixed Chimney Kilns (FCKs) because of a combination of low capital cost requirement and high investment return. However, these kinds of kiln use more coal/wooded fuel, which
emits more carbon. Brick making significantly contributes to local air pollution including emission of various harmful gases such as Sulphur Oxides (SO₂), Nitrogen Oxides (NOₓ), Carbon dioxide (CO₂) and Suspended Particulate Matter (SPM) and PM10 (Iqbal, 2007). About half of Bangladesh’s bricks are baked with the use of coal, which is now considered the source of some 20 per cent of global greenhouse-gas emissions (Enters, 2000).

Realizing the importance of estimating the level of greenhouse gas emission to combat against climate change and related ill consequences the present research was taken to fulfill the following objectives:

- To estimate the amount of greenhouse gas mainly CO₂ emission from brick kilns in Bangladesh;
- To compare CO₂ emission among four types of brick kilns running in Bangladesh;
- To evaluate the future prediction of environmental condition and/or problems associated with the present level of GHG emission to help the policy makers to take necessary steps in time.

Equation (1) direct \( CO₂ = R \times CEF \times f_0 \times \frac{44}{12} \)
Equation (2) direct \( e_i = FC \times CEF \)

Where,

\( FC = \) Total annual natural gas and/or coal consumption in energy conservation unit of brick kiln during a year (TJ)
\( CEF = \) Carbon emission factor of natural gas and coal (tC/TJ)
\( f_0 = \) Carbon fraction of natural gas and coal that has been oxidized during combustion process
\( \frac{44}{12} = \) Mass conversion factor of mass carbon to mass CO₂ generated during combustion processes
\( e_i = \) Emissions level of non-CO₂ GHGs and other gas pollutant component (metric tons)

Firstly, the quantities of natural gas and coal consumption are converted into energy units as tera joules, (TJ) using appropriate conversion factors, and then transformed into carbon emissions based on carbon emission factor (CEF). Though the IPCC has established CEF values, which can be used for general cases, data regarding fuel combustion in particular countries has not been determined. As an approximation, IPCC provides CEF value of natural gas, diesel, and coal that are 15.3 tC/TJ, 20.2 tC/TJ, and 26.4 tC/TJ (the average value of CEF for anthracite, coking coal, other bituminous coal, sub-bituminous coal and lignite). The fraction-oxidized value is used to account the carbon compound of natural gas and other fossil fuel that are not oxidized during combustion process. As an approximation, fraction-oxidized value of natural gas, diesel, and coal that are 0.995, 0.99, and 0.98, respectively (IPCC, 2000).

Materials and Methods

To determine the Carbon emission from brick kiln, six divisions has been selected all over Bangladesh (24° 00’ N and 90° 00’ E) on the basis of BTK, FCK, Zigzag, Hoffman technology for brick production from January 2013 to June, 2013. Currently, there is no recommended estimation method to estimate CO₂, non-CO₂ GHGs and other gas pollutant emission from brick kilns. In this research study, CO₂, non-CO₂ GHGs and other gas pollutant emissions have been estimated based on natural gas and coal consumptions. CO₂, non-CO₂ GHGs and other gas pollutant emissions of brick kilns are divided into two categories, namely direct and indirect emissions. In this research study, direct gas emissions have been estimated independently. Direct an emission, which is due to natural gas and coal combustion from energy conservation units, were calculate based on Intergovernmental Panel on Climate Change (IPCC) guideline by using natural gas and other fossil fuel consumption. The CO₂, non-CO₂ GHGs and other gas pollutant emissions from brick kiln was calculated by the following equations: 44/12
Table 1. A comparative study of the four kilns being used in Bangladesh

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Bull's Trench Kiln</th>
<th>Fixed Chimney Kiln</th>
<th>Zigzag Kiln</th>
<th>Hoffman Kiln</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Initial Investment</td>
<td>Taka (Tk.)</td>
<td>2,500,000</td>
<td>4,000,000</td>
<td>4,000,000</td>
<td>32,000,000</td>
</tr>
<tr>
<td></td>
<td>US$ = Tk. 77</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Working Capital</td>
<td>Tk.</td>
<td>1,000,000</td>
<td>900,000</td>
<td>900,000</td>
<td>7,500,000</td>
</tr>
<tr>
<td></td>
<td>acres</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>Min 10 year round</td>
</tr>
<tr>
<td>3. Land</td>
<td>Clay ft³</td>
<td>100,000</td>
<td>95,000</td>
<td>95,000</td>
<td>425,000</td>
</tr>
<tr>
<td></td>
<td>Labor</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>(5% skilled, 10% semiskilled, rest unskilled)</td>
<td>(15% skilled, 15% semi-skilled, rest unskilled)</td>
<td>(15% skilled, 15% semi-skilled, rest unskilled)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electricity</td>
<td>Not essential</td>
<td>Not essential</td>
<td>Necessary in small scale</td>
<td>Necessary</td>
</tr>
<tr>
<td>4. Raw Material</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Fuel Consumption</td>
<td>Tons Per 100,000 Bricks</td>
<td>22-26</td>
<td>20-24</td>
<td>20-24</td>
<td>15,000-17,000 m³</td>
</tr>
<tr>
<td>6. Pollution</td>
<td></td>
<td>Severe pollution</td>
<td>Pollution</td>
<td>Pollution</td>
<td>Very little pollution Round the year</td>
</tr>
<tr>
<td>7. Production Period</td>
<td></td>
<td>Nov to mid-Apr</td>
<td>Nov to mid-Apr</td>
<td>Nov to mid-Apr</td>
<td>7.5 to 9.0</td>
</tr>
<tr>
<td>8. Estimated Annual</td>
<td>Million bricks</td>
<td>2.0 to 2.5</td>
<td>2.0 to 2.5</td>
<td>2.0 to 2.5</td>
<td>15 - 18</td>
</tr>
<tr>
<td>Production</td>
<td>%</td>
<td>10 - 12</td>
<td>4 - 8</td>
<td>4 - 8</td>
<td>Very good</td>
</tr>
<tr>
<td>9. Wastage</td>
<td>Medium</td>
<td>3000-3500</td>
<td>3000-3500</td>
<td>3200-3800</td>
<td>3500-4000</td>
</tr>
<tr>
<td>10. Quality of Bricks</td>
<td></td>
<td>Medium</td>
<td>Good</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>11. Bricks Sale Price</td>
<td>Tt./1000 Bricks</td>
<td>3000-3500</td>
<td>3000-3500</td>
<td>3200-3800</td>
<td>3500-4000</td>
</tr>
</tbody>
</table>

Source: (DOE, 2010)

From the table 1 it is showed that, Initial Investment is varies on the basis of land type, location, kiln type, production period, etc. Eleven parameter has been identified on the table to understand the Study of the four kilns being used in Bangladesh.

Table 2. Amount of CO₂ emission from four types of brick kilns

<table>
<thead>
<tr>
<th>Parameter</th>
<th>BTK</th>
<th>FCK</th>
<th>Zigzag</th>
<th>Hoffman</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td>coal</td>
<td>coal</td>
<td>coal</td>
<td>natural gas</td>
</tr>
<tr>
<td>Total fuel (tons)</td>
<td>28 t</td>
<td>20 t</td>
<td>18 t</td>
<td>16320 m³</td>
</tr>
<tr>
<td>Total energy consumption</td>
<td>586 GJ</td>
<td>4180 GJ</td>
<td>376 GJ</td>
<td>571 GJ</td>
</tr>
<tr>
<td>CO₂ emission (tons)</td>
<td>55.58 t</td>
<td>39.8 t</td>
<td>35.7 t</td>
<td>31.86 t</td>
</tr>
</tbody>
</table>

Basis: 100,000 bricks produced

Conversion factors: Heating value of coal = 20.93 GJ/t (Giga Joules/tons)
Calorific value of coal = 6,400 KJ
Heat value of natural gas = 35 MJ/m³ (Mega Joules/m³)
CO₂ emission of coal = 94.61 CO₂/TJ (Tera Joules/tons)
CO₂ emission of natural gas = 56.11 CO₂/TJ (Tera Joules/tons)

(Source: BCAS, 2005)

Fuel consumption and carbon emission rate of different types of kilns

Coal was used in the BTK, FCK and zigzag kilns. Natural gas was used only in Hoffman kilns. The most coal demanding kiln is BTK (Bull trench kiln) which consumes 28 tons coal per 100,000 bricks production where as FCK and Zigzag kilns consume 20 tones and 18 tons respectively for same number of brick production (BCAS, 2011). The production period for BTK, FCK and Zigzag was November to mid-April. But Hoffman kiln can run all over the year. It concludes that to reduce CO₂ emission, at first Hoffman kiln should be chosen for brick manufacturing then gradually Zigzag kiln, FCK and then after BTK. (BCAS, 2005).
Coal consumption and CO₂ emission for individual brick kiln

**CO₂ emission from different brick field of Mymensingh district**

The statistical data of CO₂ emission from different brick field of Mymensingh and its surroundings are presented in Fig. 2. In those brick field they normally used different types of kilns such as Zigzag, Hoffman brick kiln etc. It has been found that highest amount of CO₂ is being emitted from Chamak brick field was 1882 t during the year of 2013 and the lowest amount of CO₂ is being emitted from Zhalak brick field was 1039.5 t during the year of 2013.

**Fig. 2. CO₂ emission from different brick field of Mymensingh**

Coal consumption from different brick field of Mymensingh district

The statistical data of coal consumption from different brick field of Mymensingh and its surroundings are presented in Fig. 3. The data shows that the maximum coal was consumed in Chamak brick field, which was 950 t and the minimum was in Zhalak brick field, which was 525 t during the year of 2013.

**Fig. 3. Coal consumption from different brick field of Mymensingh**
**Total CO₂ emission from brick kilns**

Total annual amount of CO₂ emission for six divisions are presented in Table 12. It has been found that total annual amount of CO₂ emission for 4 types brick kilns from Dhaka, Chittagong, Rajshahi, Khulna, Sylhet and Barisal are 8.862 Mt yr⁻¹, 10.048 Mt yr⁻¹, 12.783 Mt yr⁻¹, 15.250 Mt yr⁻¹, in the year of 2002, 2005, 2007 and 2010, respectively. The percentage in last 10 years of CO₂ emission geographically increasing which is very alarming for us.

![Graph showing CO₂ emission from brick kilns](image)

*Fig. 4. Total CO₂ emission from brick kiln for six divisions for different years*

All of the statistical graphs of total CO₂ emission in 2002, 2005, 2007 and 2010 of six divisions are presented in Fig. 4 shows the increasing rate of CO₂ emission in all of those years simultaneously around Bangladesh. The above result concludes that CO₂ emission rate are increasing day by day.

**Conclusion**

In the country such as Bangladesh with high level of poverty, malnutrition, and low human development index, it is unlikely that climate change will be a central focus for policies and measures. However, there are many interesting; conventional as well as innovative options, polices and measures those can benefit GHG (Green House Gas) reduction, better adaptation and increase sustainable livelihood potential. In spite of the issue of climate change, environment and resource management becomes important for sustainable development, which practically required integrated approach for accomplishment. Almost all the coal being used is imported from the Indian State of Meghalaya. This is because the brick industry has been growing at about 5.28% over the last decade with this trend leveling after 2014.

This baseline analysis indicates that GHG emissions from the brick industry are already at a high level and are expected to increase by at least 5.28% every year for the foreseeable future. This means that direct carbon emissions from kilns alone will rise to 8.7 million tons annually by 2014 or earlier depending on the growth rate of the industry. In addition, the brick industry is contributing in various ways to growing carbon emissions from other sources. Most notable, is the impact of brick making on land degradation and deforestation. In a country where the pressure of population growth on a relatively small land mass is significant, farmland depletion can have alarming prospects for food security. Total farmland in Bangladesh is about 14 million hectares and this is depleting by about 80,000 hectares every year, a 0.05% depletion rate. Moreover, wood fuel is used as a secondary fuel for brick making accelerating the depletion of scarce carbon sinks in Bangladesh.

The results consist of different types of information regarding number of brick kiln, annual amount of fuel consumption (natural gas and coal) and CO₂ emission from brick kilns around Bangladesh and presented in the following sections. According to Kyoto protocol, being a developing country it is not obligatory for Bangladesh to reduce green house gas emission but clean development mechanism (CDM) should be promoted here. Finally, Government needs to push people by creating awareness against traditional kilns and make the technology simply available to the brick manufacturers. Electronic and print media should come forward to encourage people for using such kinds of bricks. More marketing is required to familiarize people with green bricks and to reduce carbon emission for better future and sustainable development.

**References**


