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Air Pollutants Emission from Coal Fired Kiln and Its Variation for Use of Different Fuel Types

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ABSTRACT
Air pollution due to brick kiln has been an increasing environmental concern in Bangladesh. This study investigates the emission from Coal fired brick kiln in Rupdia, Jessore. The emission of air pollutants such as PM_{10} SO_2, CO, NO_x, and VOC_s are calculated using the Emission Factor Method. Brick kiln emission was found for PM_{10} (9.45 ton/yr), SO_2 (8.1 ton/yr), CO (5.4 ton/yr) and NO_x (3.037 ton/yr). Total amount of VOC_s emission is calculated as 9.91 kg/yr. There are also some metal emissions from the brick kiln which emitted in the form of particulate matter. It is observed that emission of PM_{10}, SO_2, and $NO_x$is higher in coal fired kiln whereas CO and VOC_s are dominant in Natural gas fired kiln. This emission assessment of brick kiln is significant for emission reporting, and emission database for the brick kiln in Bangladesh.

Keywords: Air pollutants, Emission estimation, Particulate matter, Volatile organic content.

1. Introduction

Brick as popular construction material has been using sinceancient times. Like other developing countriesBangladesh has its major priority is on infrastructure development which poses increasing demand of bricks. Brick manufacturing industry is a significant industrial sector in Bangladesh which contributes about one per cent to the country's gross domestic product (GDP). [1] About one million people in this country are working in brick manufacturing industry. As there are some paucity of stone aggregate in this country, brick has become the main building material for the country's construction industry. It's grew an average of about 5.6 per cent per year [2]. The current population of the country is assessed at around 160.8 million [3]. A large portion of this huge population is migrating to the urban areas for better living condition. This trend eventually directed the brick sector to increase annually at a projected 2-3 per cent over the next decade for housing construction and commercial sector development [4].For long time the brick kilns and technology which are used in this country remained unchanged and still consumes energy inefficiently. Most of the kilns are using Biomass, mainly firewood and rice husk as their major energy sources [5]. Manufacture of brick is traditionally a cottage industry which produces bricks only for local consumption in this country. But its technological development is inadequate.Though brick making is a significant industry in this country, most of the kilns use outdated, energy intensive technologies. They are greatly harmful for the environment. Brick kilns are the main sources of fine particulate pollution. It leads to harmful impacts on human health, animals, agricultural yields and global warming. Fixed chimney kiln (FCK) are currently used all over the country. But there are some new technologies such as Vertical Shaft Brick Kiln (VSBK) and the Hybrid Hoffmann Kiln (HHL), which are substantially cleaner than the previous one. These improved technologies consume less energy and emit lower levels of pollutants and greenhouse gases (GHGs) [1, 6]. In Bangladesh, existing brick kilns are mainly responsible for fine particulate pollution. The total greenhouse gas (GHG) emission in this country is estimated to be 15.67 million tons of carbon dioxide (CO_2) equivalents (tCO_2e) per annum.In Bangladesh, 92% of the 4880 [7] 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 manufacturing causes the emission of various harmful gases such as Sulphur oxides (SO_x), Nitrogen Oxides (NO_x), Carbn dioxide (CO_2) and Suspended Particulate Matter (SPM) and PM_{10} [8]. These gases have major contribution to the local air pollution. In Bangladesh, about 50 per cent of the brick kiln use coal to bake brick. Now a day's coal is considered the source of some 20 per cent of global greenhouse gas emissions [9]. The poor quality of coal and uses of biomass cause poor emission from brick kilns. The main pollutants which emitted from the brickfields are particulate matter (PM), some hazardous gas like CO_2, CO, NO_x, NO and SO_2. Though the PM concentration appears to be low but it is expected to have long term massive impact on global environments as well as on human health. The particulate matter consists of dust, smoke, fumes and fly ash[10].It was found that particulate matter was a major pollutant in the cluster region of brick kilns in Bangladesh when studied the pollutant load within that region.The objectives of this study is to estimate the emission of air pollutants from brick kiln and compare the emission of air pollutants due to different fuel types (coal, natural gas, sawdust) used in brick kiln.

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2. Research Method

This study is to be based mostly on information that has been collected from field survey and hand calculation.

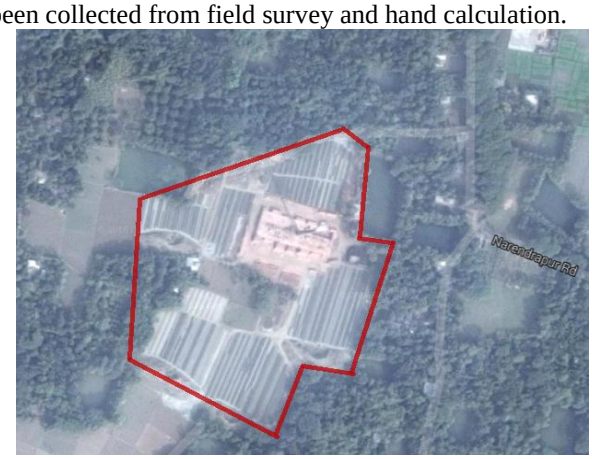


Fig. 1: The selected brick field for the study

2.1Emission Estimation

An emission factor is a tool that is used to estimate emissions to the environment. In this Manual, it relates the quantity of substances emitted from a source to some common activity associated with those emissions. Emission factors are obtained from US, European, and Australian sources and are usually expressed as the weight of a substance emitted multiplied by the unit weight, volume, distance, or duration of the activity emitting the substance.This emission factors are developed from measurements for a specific brick kiln. But they may sometimes be used to estimate emissions at other sites also. A company needs not to operate several units of similar size and configuration. When emissions were measured from one brick kiln or kiln process, an emission factor could be developed and applied to similar kilns and processes. As previously mentioned, it is advisable to have the emission factor reviewed and approved by your local environmental authority prior to its use for NPI estimations.There are various methods for estimating brick kiln emission. Here we will follow emission factor and fuel analysis data method from Emission Estimation Technique Manual for Brick, Ceramics & Clay Product Manufacturing which is under National Pollutant inventory (NPI) of Australia 1998. [11]

Air pollutants like PM_{10}, CO, SO_2, NO_x and VOC_s from brick kiln can be estimated directly by using emission factors with the following equation (i)

$$E = A * T * EF * [1 - (ER/100)] \quad \text{..... (i)}$$

Where:

E = emissions;
A = activity rate (usually production rate);
T = time (or another variable);
EF = uncontrolled emission factor; and
ER = overall emission reduction efficiency, %.

From the above equation we have calculated the amount of air pollutants emission from the brick kiln. In this equation there are four variables. Among the four variables activity rate or production rate and annual operating time of the brick kiln have to be collected from field visit. And if the brick field use any emission reduction techniques then the overall percent emission reduction efficiency should also have to be collected from the field visit. All the uncontrolled emission factor are collected from Emission Estimation Technique Manual for Brick, Ceramics & Clay Product Manufacturing which is under National Pollutant inventory (NPI) of Australia 1998. [11] Emission factor for various air pollutants are given below on the Table-1.

Table 1: Emission Factor for Brick Manufacturing

Process	PM_{10}	SO_2	CO	NO_x
Natural gas fired kiln	0.435	0.39	0.6	0.175
Uncontrolled coal fired kiln	0.7	0.6	0.4	0.255
Sawdust fired kiln	0.425	0.435	0.8	0.185

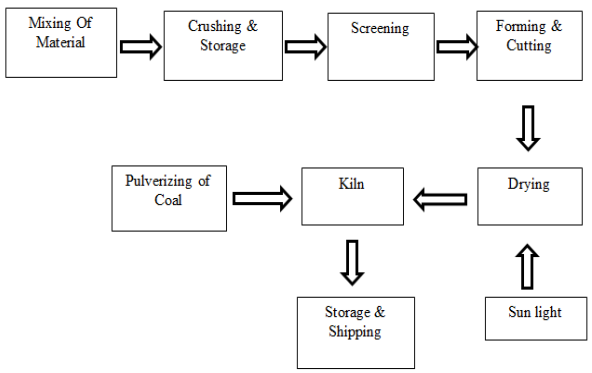


Fig. 2: Process Flow Diagram of a Brick Manufacturing

3. Results and Discussion

The brick kiln is a moderate size kiln. It is 200 ft in length and about 70 ft in width. It has 46 burning chamber in which the brick are burnt. The smoke which emits from the burning of coal was collected by a pump and released by the chimney. The chimney is about 120 ft in height. Its radius is 16 ft in bottom and 3 ft in the top. The mold of soil and water is mixed first then it is formed in the shape of desired size and dried in the sun light. After drying the brick is brought to the kiln and burnt there. Meanwhile the coal is pulverized and used in the kiln as fuel. After burning the brick are unloaded.

3.1 Emission from Brick Kiln

Table 2: Emission from Brick Kiln at Rupdia, Jessore

Process	PM_{10} (ton/yr)	SO_2 (ton/yr)	CO (ton/yr)	NO_x (ton/yr)	VOC_s (ton/yr)
Uncontrolled coal fired kiln	9.45	8.1	5.4	3.037	9.9×10^{-3}

The following figures (fig 3 to 7) show various types of emission and their specification due to use of different fuel types. Such as coal fired kiln, natural gas fired and sawdust fired. Such fuels have their own criteria for emission of different element. The main elements that emits from a brick kiln are PM_{10}, SO_2, CO, NO_x and VOC_s.

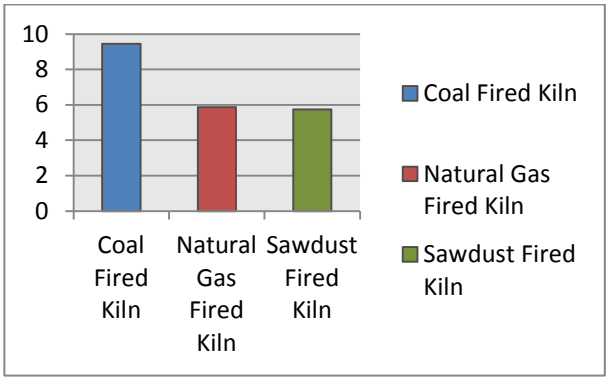


Fig 3: PM_{10}Emission(Ton/yr)

From this figure (fig 3) it is visible that emission of PM_{10} in coal fired kiln is very high than other kiln. In case of Natural Gas and Sawdust fired kiln its emission is quite same. As because coal emits lots of Black Carbon and other micro particle as the kiln use very fine coal. Chance of emission of fine particle is very much less in Natural gas and Sawdust fired kiln.

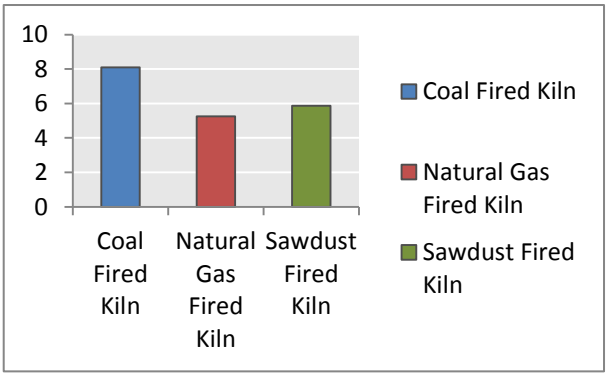


Fig 4: SO_2Emission (Ton/yr)

This figure (fig 4) shows that in Natural gas and Sawdust fired kiln there is a little difference in SO_2 emission but in case of Coal fired kiln the deviation is very high and it emits a large amount of SO_2 than the other as the coal have a greater proportion of Sulphur than any other gas or dust particle.

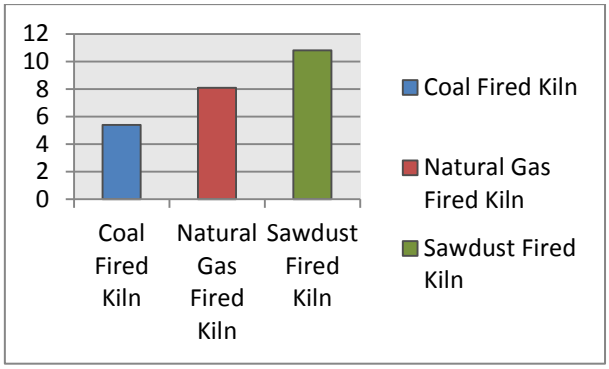


Fig 5: COEmission (Ton/yr)

Natural gas and Sawdust possess larger amount of organic content. Combustion of this organic content produces a huge amount of carbon monoxide. Coal has other inorganic content also so a coal fired kiln emits less amount of CO than other. Meanwhile Sawdust and Natural gas fired kiln emits huge amount of CO.

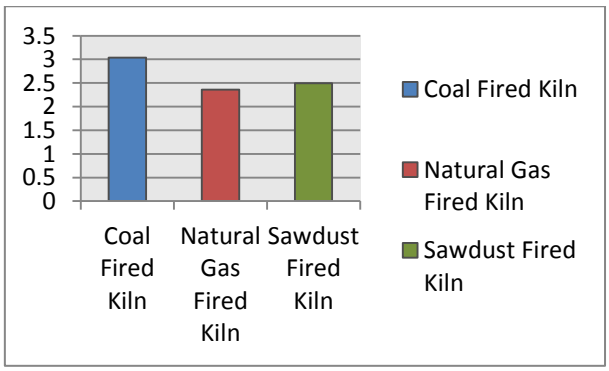
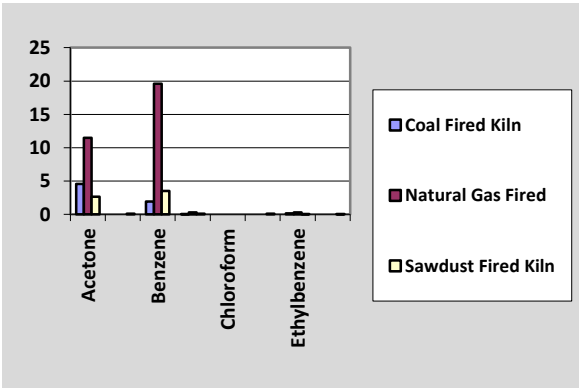


Fig 6: NO_x Emission (Ton/yr)

Emission of NO_xfluctuates very less for different fuel. It is clearly visible in the above figure. All types of fuel generate about same amount of NO_x.



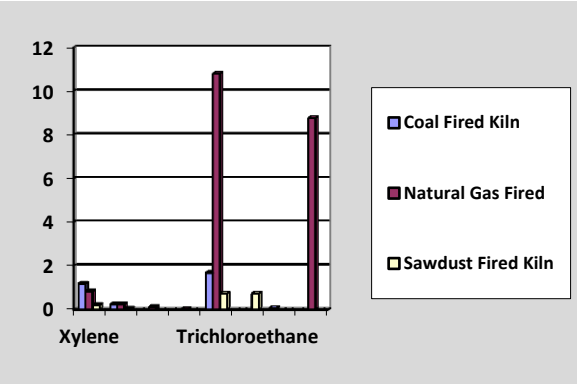


Fig 7: Typical VOC_sEmission(kg/yr)

Emission of VOC_s is almost same for all type of fuel excluding some particle such as Acetone, Benzene, toluene and Chlorine. In every case it has been shown that Natural gas fired kiln emits the maximum amount of VOC_s. from the following figure it can be seen that emission of Acetone, Benzene, toluene and Chlorine are larger and maximum emission occurred in case of Natural gas fired kiln. In Natural gas there are a lot of organic content which decomposed and produce different hydrocarbon.

The following figure (fig 8) shows the other types of emission like Arsenic, Beryllium, Manganese and Mercury. Arsenic is emitted much by Coal fired kiln but the maximum amount of manganese is emitted by Natural gas fired kiln.

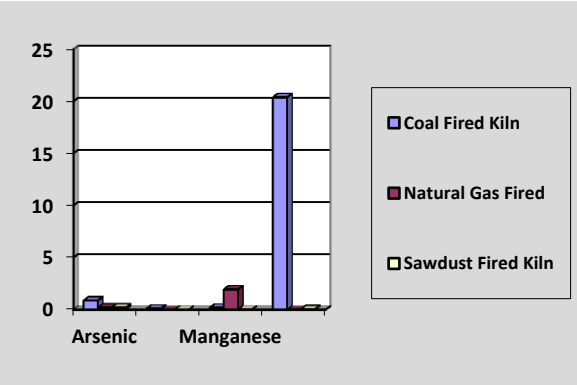


Fig 8: Metal Emissions (kg/yr)

4. Conclusion

Air pollution due to brick kiln emission is an increasing environmental concern in Bangladesh. This study was visualized the current state of air pollution from brick kiln , major sources of air pollutant, and suggests future strategies to reduce the air pollution in Jessore city and throughout the country.The emission from brick kiln were found for PM_{10} (9.45 tone/yr), SO_2 (8.1 tone/yr), CO (5.4 tone/yr), NO_x (3.037 tone/yr) and various type of VOC_s as respectively.comparison between emission due to use of different fuel types was shown where it is visible that Coal fired kiln emits more amount of PM_{10}, SO_2 and NO_x but less amount of CO than Natural gas and Sawdust fired kiln. Maximum amount of CO emission occurred at sawdust fire kiln. Whereas VOC_s is dominant in natural gas fired kiln.

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