Chemical Characterization of Coal And Pollutants Management From Different Bricks Fields In Uttar Pradesh

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Abstract

Air pollution is a serious public health problem in all over the world. Coal burning in the brick kilns is contributing significantly to the worst air quality in Uttar Pradesh. Five coal samples were collected from five different brick fields in Uttar Pradesh (Kursi Road - Lucknow, Sitapur Road - Lucknow, Diamond - Barabanki, Awadh – Barabanki and Suraj - Barabanki). Elemental composition (C, N, H and S) with CHN analyzer and trace metals (Na, K, Ca, Fe, Cr, Cd, Cu, Pb, and Ni) with atomic absorption spectrophotometer (AAS) were determined in the coal samples. Coal samples were grinded and extracted with distilled de-ionized water with temperature control water bath and sonicator. The average concentration of nitrogen, carbon, hydrogen and sulfur were 13.4 (wt%), 34.2 (wt%), 5.89 (wt%) and 4.59 (wt%), respectively. Carbon and sulfur are very important for the atmospheric pollution as they may undergo many primary and secondary chemical reactions. The average concentrations of the determined trace metals were 14.2±7.5 ppm for Sodium, 0.8±0.6 ppm for Potassium, 11.4±11.7 ppm for Calcium and 11.0 ± 12.7 ppm for Iron. Chromium, Cadmium, Cupper, Lead and Nickel concentrations were found below detection limit. The results showed that pollutants containing coals are the potential threat for human health especially for the worker those who are working in the brick industries. The management of pollutants emitted from brick kilns has to be high combustion efficiency coal particles during process of devolatisation, use of coal with particle size smaller than 3/4 inch and keep sufficiently long firing zone (coal feeding zone of at least 3-4 lines) so that the volatiles get sufficient space (high temperature zone) to mix and burn.

1. INTRODUCTION

Air pollution plays an important role on human health, climate and ecosystem. Air pollution is a serious issue in many developing countries like India. Many sources are contributing and also responsible for the poor air quality near Lucknow-Uttar Pradesh (e.g., traffic emissions, biomass burning, industries, brick kilns, rice mills, construction activities, etc.). Brick manufacturing industry is the most important and fastest growing sector in Bangladesh especially in winter season [1]. The energy used in the brick industry is mainly from coal along with biomass, natural gas and electricity. In fact, biomass burning in the brick kilns has banned in India sine long. Particulate matters, black carbon, carbon monoxide and sulfur dioxide are the main pollutants from brick industries [2].

Pollution may be reduced slightly by improving the kilns design and also the quality of fuel. Many varieties of coal are using in the brick kilns. Some of them have very high sulfur and mercury content. Sulfur ultimately converted to SO_4^{2-} through oxidation processes and contributed to the acid rain formation and brick industries also have significant contribution to the ground level ozone formation. Only brick industries produced about sixty percent of atmospheric sulfur dioxide and particulate matters in the Kathmandu valley, Nepal [3]. Typical uncontrolled coal plants emit approximately 170 pounds of mercury each year. Due to the blooming of brick kilns in the Kashmir valley the concentration of sulfur oxide and nitrogen oxide and particulate around brick kilns areas were above the permissible levels during the operational phase of the brick kilns. Their annual emission estimated that about eight tons of PM and seven toms of nitrogen oxide and five tons of sulfur oxide were from brick industries. Other harmful pollutants emitted annually from a typical, uncontrolled coal plant include approximately, 114 pounds of lead, 4 pounds of cadmium, other toxic heavy metals, and trace amounts of uranium.

Rivera et al. [4] reported that ash samples were mainly composed of Si (20-27% w/w), Al (10-14% w/w), Fe (4-6% w/w), and Ca (4-6% w/w). Skinder et al. [5] reported that the total emissions in brick manufacturing industries in the Uttar Pradesh is 3.9 billion bricks per year and has been estimated about 24300 tons of particulate matter having aerodynamic diameter < 2.5 µm ($PM_{2.5}$), 15800 tons of sulfur dioxide (SO_2), 303000 tons of carbon monoxide (CO), 6300 tons of black carbon (BC) and 1.9 million tons of carbon dioxide (CO_2). Average emission factors per 1000 brick were 6.34 to 12.4 kg of CO, 0.53 to 5.9 kg of SO_2 and 0.65 to 1.4 kg of PM. Guttikunda et al. [6] studied that a total of 1000 kilns producing 3.5 billion bricks and consuming 0.85 million tons of coal per year resulted in an estimated 2200 to 4000 premature deaths and 0.2 to 0.5 million asthma attacks per year. Skinder et al. [5] also presented that the total emissions are estimated at 23300 tons of $PM_{2.5}$, 15500 tons of sulfur dioxide (SO_2), 302,000 tons of carbon monoxide (CO), 6,000 tons of black carbon, and 1.8 million tons of CO_2 emissions to produce 3.5 billion bricks per year, using energy inefficient fixed chimney bull trench kiln technology and predominantly using coal and agricultural waste as fuel. Therefore, brick making industries can be considered as one of the important sources of greenhouse gases. Also raw coal contain quite high amount of water soluble ions including sulfate, nitrate and other ions. These possess very high health risks for the workers due to their long term exposure. These may also be washed out to the nearer water reservoirs and reduce the pH of the water body. The brick kilns emit toxic fumes containing carbon monoxides and oxides of sulfur (SOx) are harmful to eye, lungs and throat. These air pollutants inhibit the mental and physical growth of children and affect crops and plants in the areas nearby to brick fields [7].

To assess the emission of the coal burning and human health impact, it is very urgent to know the chemical constituents in the coal as a first step. Therefore we have collected coal samples from different brick fields in near Lucknow, Uttar Pradesh for the trace metals concentrations (sodium, potassium, calcium and iron, etc.) and elemental composition. These results will give better scientific understanding for the emissions of coal burning, and data will be useful for the emission inventory study.

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2. SAMPLING PROCEDURE

From each of the five brick fields about 1.0 kg of coal samples were collected in air tight bags. These were stored in the laboratory for analyze. 5.0 g of coal samples were taken and grinded them for the extraction of chemical analysis.

2.1. Extraction of Procedure

The finely ground coal samples were weighed in an analytical balance to about 1.0 g and in a well stopper bottle and 50.0 mL de-ionized water was added. The mixture was then shaken in a shaking machine at 25°C for 60 minutes and then sonicated in an ultrasonic sonicator for 35 minutes. The mixture was then allowed to settle overnight and then filtered using filter paper. The filtrate was then used for the analysis of trace metals.

2.2. Chemical Analysis

Elemental composition was determined using CHNS analyser (Model vario Micro V1.3.1, Germany). The water soluble ions were analyzed using Ion Chromatogram (Model 881 compact IC-Pro 1, Metrohm Ltd., Switzerland), Trace metals by Atomic Absorption spectrophotometer (Make: GBC Avanta-Sigma, Australia). Working standard solution of metals was prepared by CRM multi element standard solution IV.

3. RESULT AND DISCUSSION

The concentrations of the determined components were relatively below detection limit in coal samples. The concentrations also varied among the brick fields. The detail of the results has given as follows.

3.1. Elemental Composition

Coal is a complex heterogeneous mixture of

3.1.1 Sulfur (S)

The amount of sulfur that are obtained from the analysis of coal samples in Kursi Road is 6.2 (wt%), in Sitapur Road is 3.6 (wt%), in Diamond is 5.57 (wt%), in Awadh is 3.07 (wt%) and in Suraj is 4.33 (wt%). The highest organic matter and inorganic matter containing various solid and fluid intimately associated phases of autochthonous origin. The inorganic matter includes: (1) dominantly crystalline constituents (2) to a lesser extent semi-crystalline components for instance, poorly crystallized mineraloids of some silicates, phosphates and hydroxides and (3) occasionally amorphous compounds. The elemental composition of coal sample collected from different brick kilns and its analyzed results has given in Table 1.

Table-1 : Elemental composition of coal sample (wt%)

Brick Fields	N	C	H	S
Kursi Road	13.4	33.2	4.34	6.20
Sitapur Road	14.7	45.9	4.54	3.60
Diamond	13.7	41.7	4.59	5.57
Awadh	14.0	-	11.6	3.07
Suraj	15.3	55.6	4.89	4.33
Average value	13.4	34.2	5.89	4.75

amount of Sulfur is 6.2 (wt %) in Kursi Road and lowest is 3.07 (wt %) in Awadh. The elemental sulfur content is not very high.

3.1.2 Carbon (C)

The amount of nitrogen that are obtained from the analysis of coal samples in Kursi Road is 13.41 (wt%), Sitapur Road is I4.71(wt%), in Diamond is 13.69 (wt%), Awadh is 14.08 (wt%) and Suraj is 15.27 (wt%). The highest amount of Nitrogen is 15.27 (wt %) in Suraj and lowest is 13.69 (wt %) in Diamond. The amount of carbon that are obtained from the analysis of coal samples in Kursi Road is 33.25 (wt%), Sitapur Road is 45.91(wt%), Diamond is 41.68(wt%), Awadh is 1.211 (wt%) and in Suraj is 55.65(wt%). The highest amount of carbon is 55.65 (wt %) in Suraj and lowest is 1.211 (wt %) in Awadh. The amount of hydrogen that are obtained from the analysis of coal samples in Kursi Road is 4.34 (wt%), Sitapur Road is 4.545 (wt%), in Diamond is 4.587 (wt%), in Awadh is 11.56 (wt%) and in Suraj is 4.9848 (wt%). The highest amount of Hydrogen is 11.56 (wt %) in Awadh and the lowest is 4.34 (wt %) in Kursi Road.

3.1.3. Measures to reduce air pollution from brick kilns

The measures to control air pollution can be classified into two categories as (a) Measures to reduce generation of pollutants at source or energy efficiency measures and (b) Measures to control or reduce the impacts of the emissions. To use an “add on” device to remove pollutants from the stack gases e.g. gravity settling chamber.

4. RATIO ANALYSIS

The carbon to nitrogen (C/N) and sulfur to carbon (S/C) ratios were determined. The C/N ratio varies from 0.08 (Awadh) to 3.64 (Suraj) with an average of 2.44 (Figure 1). The average ratio of sulfur to carbon was 0.60 ranging from 0.077 (Suraj) to 2.54 (Awadh). It is interesting if the C/N ratio is higher at a location then S/C ratio will be lower at that particular location.

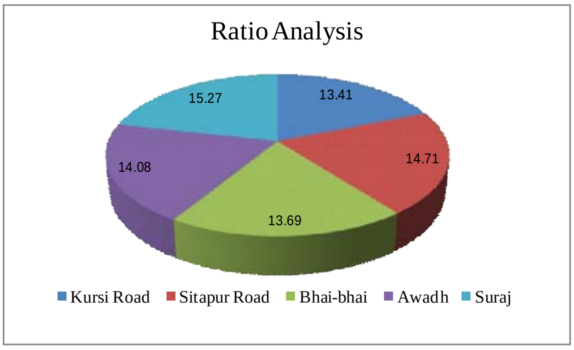

Fig.1: Ratio of carbon to nitrogen (C/N) and sulfur to carbon (S/C)

5. MEASURES TO REDUCE GENERATION OF POLLUTANTS BY IMPROVING COMBUSTION

One of the important sources of air pollution is incomplete combustion of fuel. Roughly about 10% of the fuel supplied to a brick kiln remains unburnt or partly burnt. Considerable scope exists for improving combustion in brick kiln and other traditional kilns. The main causes of incomplete combustion in a brick kiln are insufficient air supply and improper feeding of coal. By improving the kiln operation, particularly by increasing the draught, improving air control and improving fuel feeding practices, the unburnts can be reduced to a large extent.

6. ENERGY EFFICIENCY MEASURES

Anything that saves fuel conjointly helps in emission reduction because the total quantity of fuel burned is reduced. Except for the advance in combustion method, it’s doable to cut back energy consumption by 10-15% in a brick kiln by creating tiny enhancements in oven style, construction and operation. Higher chimney insulation and increase in fireplace travel rate is that the key to energy conservation in fastened chimney brick kilns. Major cause of SPM generation is that the high ash content in coal. The major portion of ash is carried by flue gases. It’s attainable to combine a neighborhood of the fuel within the pulverized type with the clay throughout clay preparation. This fuel is referred as internal fuel because it is gift within the brick because the brick is heated within the kiln, combustion of internal fuel takes place. However, during this case because the fuel particles area unit entrapped within the brick, the ash related to them remains within the brick and doesn’t pop out. This helps in reducing the pollution.

7. MEASURES TO CONTROL/REDUCE IMPACT OF POLLUTANTS

Reduction in pollution generation at supply by higher utilization of fuel is that the best ways to management pollution. However, it is not perpetually doable to cut back the emissions to tier below the suitable limit simply by improvement in combustion and energy conservation measures. In these circumstances techniques to arrest pollutants before discharged within the atmosphere are used. These techniques involve use of filters, scrubbers, gravity subsidence chambers etc. just in case of mounted chimney kilns gravity-settling chamber, the foremost basic technique for sensational SPM is used. It ought to be unbroken in mind that everyone the techniques for sensational pollutants end in pressure loss and therefore need extra energy. Low flue gas velocities and draught in mounted chimney kilns create it just about not possible to use the other add-on device on the other hand gravity subsidence chamber.

The harmful result of pollutants domestically is reduced by reduction in concentration of pollutants through dispersion of pollutants in an exceedingly giant space. That's why recommendations for taller chimneys square measure given. Tall chimneys guarantee unharness of pollutants at a better height, which supplies longer to pollutants to disperse within the atmosphere before reaching the bottom.

7.1 Achieve High Combustion Efficiency

When coal is heated to a temperature of 350°C, volatiles (gases corresponding to gas, hydrogen, carbon monoxide gas etc.) are square free from the coal. The method of devolatisation extends until a temperature of regarding 600°C. The volatiles combine with hot air, and once this mixture has earned the ignition temperature, your time is needed (ignition delay) before the mixture will ignite. The combustion reactions square measure quicker at higher temperatures i.e. ignition delay is lower at higher temperatures. The burning volatiles square measure ascertained as flames within the oven. The char (solid part) that continues to be once the discharge of volatiles will burn solely at temperatures in far more than 600°C. Smaller coal particles burn quicker compared to greater coal particles.

Therefore, the situation for achieving high combustion efficiency in the kiln is:

a) Feed coal only when the temperature in the firing zone is above 600°C.

b) Keep sufficiently long firing zone (coal feeding zone of at least 3-4 lines) so that the volatiles get sufficient space (high temperature zone) to mix and burn.

c) Use coal with particle size smaller than 3/4 inch. The combustion efficiency can be judged by observing the color of the smoke during the coal-feeding period (dark black smoke signifying poor combustion efficiency) as well as by the amount of char accumulated at the bottom of the kiln setting.

d) Optimum utilization of the kiln production capacity.

In general during a brick oven, increasing the outturn (daily production) helps in lowering the particular fuel consumption and therefore the fuel value per brick. For a given oven, the surface and structure heat loss per day nearly|is nearly|is sort of constant and it's almost freelance of the hearth travel rate or production rate of the oven. It implies that by increasing the hearth travel rate the particular energy consumption of the oven will be diminished.

7.2 Reducing the wastage of good quality agriculture soil in brick making

Use of good quality agriculture soil in large quantities for brick making is also a grave area of concern. In geographical regions having thin topsoil, this result in reduction in the productivity of land and in extreme cases the land does not remain fit for agriculture use. To reduce this wastage following steps can be taken:

a) Promoting deep mining of clay for brick making instead of surface mining.

At present only top surface is utilized for brick making, resulting in large surface area being affected due to excavation of soil for brick making. Deep mining of clay can reduce the area affected due to excavation of soil for brick making.

b) Promoting use of waste materials like fly ash in brick making.

Use of waste materials such as fly ash, boiler ash, stone dust etc. can reduce to use of good quality agriculture soil in brick making.

c) Promoting use of perforated and hollow bricks.

A reduction of up to four-hundredth within the material use is feasible by going for perforated/ hollow bricks rather than solid bricks. Perforated/ hollow merchandise need less energy for firing and turn out less pollution per unit. Perforated and hollow bricks even have higher insulating properties leading to reduction in air-con and heating masses within buildings made up of perforated and hollow bricks. All the higher than mentioned measures would need mechanization of a number of the processes in brick creating. Development of applicable low value machinery {for creating|for creating} perforated/hollow merchandise likewise as support for popularising these merchandise on massive scale square measure essential for reducing wastage of agriculture soil in brick making.

8. CONCLUSION

The pollution state of affairs is obtaining worse day by day in Uttar Pradesh. Coal is one in every of the vital supply for the worsen air quality in Uttar Pradesh. particularly winter time all the brick kilns and rice mills ar in operation and emit pollution. during this study 5 coal samples are collected from completely different Brick fields of close to Lucknow town, Uttar Pradesh for determination of parts and trace metals. the fundamental analysis shows highest concentration for Carbon and moderate concentrations of elemental Sulfur, particle analysis shows highest concentrations of salt ions. Chromium, Cadmium, Cupper, Lead and Nickel concentrations were found below detection limit. the common concentrations of the determined trace metals were followed the sequence atomic number 11 >Calcium>Iron>Potassium. The results of this study associate degreeticipated} to be terribly helpful for getting ready an emission inventory of the coal emissions from brick and alternative industries as there's no such emission inventory in Uttar Pradesh nevertheless. The management of pollutants emitted from brick kilns has got to be high combustion potency coal particles throughout method of devolatisation, use of coal with particle size smaller than 3/4 in. and keep sufficient ly long firing zone (coal feeding zone of a minimum of 3-4 lines) in order that the volatiles get sufficient house (high temperature zone) to combine and burn.

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