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COMPARISON OF EMISSION FACTORS FROM BIOMASS BURNING FACILITIES

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Abstract

Among different types of environmental imbalances, air pollution has been a global environmental and health issue with serious implications to both the surrounding and public health. One of the significant sources of atmospheric particles and gaseous pollutants is biomass burning. Even though biomass is the main source for alternative energy, this activity releases a large amount of air pollutants, which can cause serious effects on the ambient air quality, public health and climate. Emission of pollutants from biomass burning process and operation can be represented by emission factor. The interest of this paper is to compare the existing emission factors established for different type of biomasses. From the comparison, cereal waste gives the highest emission factor of PM (75±21g/kg), whereas the emission factor of element carbon emission rates being relatively higher from rice straw (57.7±27.9g/kg) and lower from wheat straw (0.42±0.23 g/kg). The emission factor of organic carbon is also considerably higher from rice straw burning (335.4±88.0 g/kg) and very much lower from Florida sugarcane burning (0.16±0.09 g/kg) wheareas corn stover had the highest emission factors of NO, NO_x and CO_2. Besides comparison of the established emission factors, the associated factors affecting the EFs establishment were also studied. Among the various factors with significant influence on the resulted emission factors are type of biomass, source of emission, condition of combustion (operating temperature and pressure), capacity of feedstock and Air Pollution Control (APC) system.

Keywords: Emission factors; air pollution; biomass; health and environment; combustion parameters.

Abstrak

Antara jenis ketidakseimbangan alam sekitar, pencemaran udara telah menjadi isu kesihatan dan alam sekitar global dengan implikasi serius kepada kedua-duanya dan kesihatan awam sekitarnya. Salah satu sumber penting zarah atmosfera dan bahan cemar gas adalah pembakaran. Walaupun biojisim adalah sumber utama tenaga alternatif , aktiviti ini membebaskan sejumlah besar bahan pencemar udara, yang boleh menyebabkan kesan serius kepada kualiti udara persekitaran, kesihatan awam dan iklim. Pelepasan bahan pencemar daripada proses pembakaran dan operasi boleh diwakili oleh faktor pelepasan. Kepentingan kajian ini adalah untuk membandingkan faktor pelepasan sedia ada yang dibangunkan bagi berlainan jenis biomas. Dari perbandingan, sisa bijirin memberikan faktor tertinggi pelepasan PM (75 ± 21g/kg), manakala faktor pelepasan unsur kadar pelepasan karbon yang lebih tinggi daripada jerami padi (57.7 ± 27.9g/kg) dan lebih rendah daripada jerami gandum (0.42 ± 0.23 g / kg). Faktor pelepasan karbon organik juga lebih tinggi daripada jerami padi terbakar (335.4 ± 88.0 g/kg) dan jauh lebih rendah dari Florida tebu membakar (0.16±0.09 g/kg) dimana jagung stover mempunyai faktor pelepasan tertinggi NO, NOx dan CO_2. Selain perbandingan faktor pelepasan dibangunkan, faktor-faktor yang berkaitan yang melibatkan penubuhan EFs juga telah dikaji. Antara pelbagai faktor dengan pengaruh besar ke atas faktor-faktor yang menyebabkan pelepasan adalah jenis biomass, punca pelepasan , keadaan pembakaran (suhu operasi dan tekanan), keupayaan bahan sua dan kawalan pencemaran udara.

Kata kunci: Faktor pelepasan; pencemaran udara; biomas; kesihatan dan alam sekitar; parameter pembakaran.

1.0 INTRODUCTION

Biomass burning can be broadly defined as the burning of living and dead vegetation, which include forests, grasslands and crops through natural or anthropogenic fires.[1] Example of typical types of burning such as savanna fires, domestic and industrial biofuel use, tropical forest fires, extratropical (mostly boreal) forest fires, and crop residue (burning wheat straw, corn straw, rice straw, etc.) are thought to account for the most global biomass consumption.[2] Biomass burning can be categorized as one of the methods of waste disposal. Besides waste disposal, biomass burning is also viable approach to generate electric power from utilization of agricultural residue which has gaining growing interests in many countries. Several feasibility studies have been conducted and numerous systems have been developed for energy recovery from various biomass sources.[3] In Turkey, agricultural residues represent an important source of biomass while in Finland and Denmark, straw and wood chips are the main source of biomass utilized in electric power generation plants.[4] Even though biomass is the main source for alternative energy, the burning of biomass however generates pollutants which biomass burning is the largest source of primary fine carbonaceous particles and the second largest source of trace gases in the global atmosphere.[5-8] The burning of biomass generates pollutants which may pose detrimental impacts on surrounding area and human health due to both acute and chronic exposures. Particles emitted and formed in biomass burning plumes have major direct and indirect effects on climate [9-10] and also contribute to dense continental-scale haze layers that occupy much of the tropical boundary layer during the dry season.[11-14] Meanwhile, the trace gases emitted by biomass burning have a significant influence on the atmosphere, which includes a major contribution to the formation of global tropospheric ozone (O3), an important greenhouse gas.[15] The impact from the emission of biomass burning process and operation can be indicated by emission factor (EFs). EFs data allows for early prediction of pollutants emission, which subsequently will assist in determining the degree of control and the air pollution control system needed, besides evaluating the effectiveness of the existing pollution control strategies. Based on the literature review conducted, no previous studies have been done in comparing the existing data of emission factor between difference biomasses. There is earlier study which compared the data of emission factor for different biomass (i.e. rice straw, wheat straw, corn stover, and cotton stalk) using experimental works,[16] however the data for palm oil was not included. This is the gap to be filled in this paper, which is to compare the emission factors data of particulate matter and gases from boiler in palm oil mill with the other types of biomasses. It is acknowledged that the comparison has flaws in a way that the basis for comparison is not the same. However to get such data is a challenge especially for palm oil which has almost non existing data of the emission factors. Therefore the objective of this study is to compare the existing emission factors established for different type of biomasses including the palm oil besides studying the associated factors affecting the establishment of the EFs data.

2.0 EMISSION FACTOR

Biomass burning emits many product of incomplete combustion such as particulate matters, anion, cation and gaseous pollutant that are exposed in many ways. The most intensive exposure way is cooking with unvented stoves, which is still common in developing countries.[17] Besides that, fire of vegetation lit on purpose in agriculture and forestry, or natural or accidental fires due to excessive dryness of the soil and vegetation, lead to exposures to pollution in large populations in both developed and developing countries.[17] Unfortunately, human exposure to smoke originating from these fires and the associated health effects have been generally overlooked. Eventually the human health impact of biomass burning can be estimated with the aid of emission factors (EFs). Emission factors can be defined as emissions that are emitted by a particular source type based on specific of pollutants, process, age, size, control technology and other pertinent factors affecting the emissions.[18] The emission factor is useful information from which the amount of particulate emission can be estimated based on certain characteristics of the industry or process.[19] Emission factors are usually expressed as the weight of pollutant emitted divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., pounds of particulate matter emitted per ton of coal burned).[20]

From the emission factors value, the data also can be subsequently used to determine the degree of air pollution control system needed by a process. Dhammapala *et al.* (2006) stated that the knowledge on emission factors (EF), which is defined as the mass of pollutants emitted per unit mass of dry stubble burned, is needed as an input to dispersion models that serve as management tools and are also needed in emission inventories to evaluate the effectiveness of pollution control strategies.[21] In addition, emission factors are a key input to emission inventories.[21] Emission inventories, in turn, are widely used for regulatory and air quality management purpose. Emission factors can also be defined as tool that is used to estimate air pollutant emissions to the atmosphere. It relates the quantity of pollutants released from a source to some activity associated with those emissions.

Emission factors are used to estimate emissions from a source using the following general equation:[18]

$$EF_{FFB} = \frac{Particulate\ mass\ flow\ rate\ \frac{g}{h}}{FFB\ processed\ \frac{kg}{h}} \quad \text{Eq.(1)}$$

Subsequently, the existing emission factors established from different type of biomass were compared in depth in the next subtopic as guidelines for estimating particulate pollution from a source has been carried out in many countries.

3.0 COMPARISON OF EMISSION FACRTOR FROM DIFFERENT TYPE OF BIOMASS

As aforementioned, the aim of this study is to compare the emission factor of aerosols and gases from different types of biomass which include wheat straw, corn straw, corn stover, rice straw, cotton stalk, Kentucky bluegrass, Florida sugarcane and cereal waste. Basically the emission factors of different biomass are compared on several aspects; source of emission (open burning or combustion experiment), types of biomass, specific burning condition, etc. The detailed values of the emission factors for the different considered biomasses are summarized in Table 1.

Varying emission of particulate matter (PM) from different studies was compared in this paper for different types of biomass. As shown in Table 1, cereal waste gives the highest emission factor of PM (75±21g/kg) compared to the others biomasses.[22] The emission factor of particulate matter for cereal waste is high because it contains several types of biomasses which are wheat, barley, oat and rye which may also give very high moisture contain.

The emission rates of element carbon (EC) are relatively higher for rice straw (57.7±27.9g/kg) and lower for wheat straw (0.42±0.23 g/kg) compared to the other biomasses type. Meanwhile organic carbon (OC) emission rate is also higher from rice straw (335.4±88.0 g/kg) and lower from Florida sugarcane (0.16±0.09 g/kg) compared to other biomass. For cation species such as Na^+, K^+, NH_4^+, Mg^{2+}, and Ca^{2+}, the emission factors of K^+ (50.0±34.0 g/kg) from rice straw burning was the highest compared to others biomass.[23] For anion species, such as, NO_2^-, NO_3^-, SO_4^{2-},F^-, Cl^-, the emission factor of Cl− (69.3±31.6g/kg) from rice straw burning was also the highest compared to others. Rice straw has the highest emission factor of most of ions such as Na^+, K^+, NH_4^+, Mg^{2+}, Ca^{2+}, NO_3^-, SO_4^{2-}, F^-, and Cl^- whereas wheat straw has the highest emission factor of NO_2^-. Gaseous pollutant emissions of various types of biomass are also presented in Table 1. As shown in the table, corn stover has the highest emission factors of NO, NO_x and CO_2. Agricultural residue has the highest emission factors of NO_2 and CO whereas wheat straw has the highest emission factors of SO_2.

According to Table 1, result analyses showed that the difference in emission factors of aerosol and gases pollution for each studies of biomass burning. For example, there is significant difference between the EF values of organic carbon from wheat straw presented by two separate studies by Guoliang *et. al.*,(2008) (3.46±2.05 g/kg) and Li *et. al.*,(2007) (0.49±0.12g/kg).[16,24] The major differences between these two studies are found in the source of emission which are experimental chamber used and the burning condition. There are various possible factors which could have affected the emission factors such as type of biomass, capacity of feedstock, operating temperature, pressure and etc. Thus, the associated factors affecting the EFs will be discussed in detail in the next subtopic.

Table 1 Pollutant emission database from different biomasses

Type of Biomass	Source of emissions	Country	Aerosol					Cation					Anion					Gaseous						APC	References
			PM	PM 2.5	PM10	EC	OC	Na+	NH4+	K+	Mg2+	Ca2+	F-	Cl-	NO2-	NO3-	SO42-	SO2	NO	NO2	NOx	CO	CO2		
Wheat straw	Combustion tower	China	8.75±4.18	na	na	0.42±0.23	3.46±2.05	0.098±0.097	0.011±0.024	0.837±0.377	0.005±0.004	0.068±0.030	0.003±0.002	0.949±0.378	0.007±0.012	nd	0.180±0.058	0.04±0.04	1.93±0.90	0.35±0.11	2.28±1.00	57.78±24.75	1377.72±431.12	NO	Guoliang et al. (2008)
Wheat straw	combustion and aerosol chamber	China	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	0.79 ±0.13	0.32 ±0.06	1.12 ±0.19	141.2 ±14.8	1557.9 ±85.8	NO	Zhang et al. (2008)
Wheat straw	Agricultural farm	India	na	na	na	na	0.3 ±0.1	na	na	na	na	na	na	na	na	na	na	na	0.78 ± 0.71	0.56±0.47	1.70±1.68	28.1 ± 20.1	1787 ±36	NO	Sahai et al. (2007)
Wheat straw	Open burning	China	na	7.6 ± 4.1	na	2.7 ±1.0	0.49 ± 0.12	na	0.23± 0.15	0.58 ± 0.58	na	na	na	0.83 ± 0.69	na	0.01 ±0.01	0.09 ± 0.05	0.85 ± 0.57	na	na	3.3± 1.7	60 ± 23	1470 ± 46	NO	Li et al. (2007)
Wheat stubble	open burn test chamber	Eastern Washington & northern Idaho	na	3.0±0.6	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	52.9±8.0	na	NO	Dhammapala et al. (2006)
Wheat residue			na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	0.23–1.14	61.1–179	959–1320	NO	Zhang et al. [illegible]
Rice straw	Combustion tower	China	6.28±1.59	na	na	0.49±0.21	2.01±0.67	0.077±0.035	0.003±0.008	0.715±0.533	0.006±0.005	0.061±0.029	0.001±0.002	0.855±0.491	0.006±0.012	0.047±0.076	0.182±0.072	0.18±0.31	3.09±0.91	0.33±0.17	3.43±1.08	67.98±25.58	1674.12±452.26	NO	Guoliang et al. (2008)
Rice straw (PM 2.5)	in situ burning	Pathumthani of Thailand	na	8.3±2.7	na	57.7 ±27.9	335.4 ±88.0	2.56 ±2.77	23.8 ±11.7	50.0 ±34.0	0.11 ±0.22	0.15 ±0.41	2.45±3.28	69.3 ±31.6	na	2.93 ±3.72	9.82 ±7.21	na	na	na	na	na	na	NO	Oanh et al. (2011)
Rice straw (PM 10)	in situ burning	Pathumthani of Thailand		na	9.4± 3.5	56.9 ±25.3	328.6 ± 84.7	3.53 ± 3.48	22.8 ± 9.2	47.3 ± 33.6	0.18 ± 0.28	1.08 ± 1.06	2.48 ±3.17	68.6± 30.7	na	2.91 ±3.20	15.53 ± 13.06	na	na	na	na	na	na	NO	Oanh et al. (2011)
Rice straw	combustion and aerosol chamber	China	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	1.02±0.03	0.79 ±0.05	1.81±0.09	64.2±4.9	791.3 ±12.5	NO	Zhang et al. (2008)
Corn stover	Combustion tower	China	5.31±1.79	na	na	0.95±1.08	2.25±0.74	0.095±0.060	0.001±0.002	0.180±0.080	0.001±0.002	0.072±0.055	0.003±0.003	0.372±0.104	0.007±0.013	0.017±0.048	0.134±0.080	0.04±0.04	3.25±0.72	0.34±0.13	3.60±0.85	67.64±13.01	2327.14±709.57	NO	Guoliang et al. (2008)
Corn stover	Open burning	China	na	11.7 ± 1.0	na	3.9 ± 1.7	0.35 ± 0.10	na	1.2 ± 0.37	1.0 ± 0.65	na	na	na	2.7 ± 1.1	na	0.07 ± 0.03	0.22± 0.15	0.44 ± 0.20	na	na	4.3 ±1.8	53 ± 4.0	1350 ± 16	NO	Li et al. (2007)
Corn straw	combustion and aerosol chamber	China	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	0.85 ±0.06	0.43 ±0.03	1.28 ±0.04	114.7 ±12.4	1261.5 ±59.9	NO	Zhang et al. (2008)
Cotton stalk	Combustion tower	China	4.53±0.95	na	na	0.82±0.20	1.83±0.54	0.102±0.009	nd	0.735±0.058	nd	0.046±0.002	nd	0.726±0.054	nd	nd	0.216±0.020	nd	2.28±0.21	0.22±0.02	2.49±0.23	105.82±6.02	345.42±108.0	NO	Guoliang et al. (2008)
Kentucky bluegrass	open burn test chamber	Eastern Washington & northern Idaho	na	12.1±1.4	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	51.8±3.3	na	NO	Dhammapala et al. (2006)
Florida Sugarcane	Open burning combustion chamber	Brazil	na	2.49 ±0.66	na	0.71 ± 0.22	0.16 ± 0.09	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	NO	Hall et al. (2012)
Cereal waste (wheat, barley, oats and rye)	Combustion chamber	Spain	75±21	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	1.03±0.23	na	440±120	NO	Zarate et al. (2000)
Agricultural residue	Open burning	Germany	na	na	na	na	3.3	na	na	na	na	na	na	na	na	na	na	na	na	2.5± 7 1.0	na	927 ±84	1515± 7 177	NO	Andreae and Merlet (2001)

Legend:

PM	= Particulate Matter
$PM_{2.5}$	= Particulate Matter 2.5 micrometers or less in diameter
PM_{10}	= Particulate Matter 10 micrometers or less in diameter
EC	= Elemental carbon
OC	= Organic carbon
Na^+	= Sodium ion
K+	= Potassium ion
NH_4^+	= Ammonium ion
Mg^{2+}	= Magnesium ion
Ca^{2+}	= Calsium ion
F^-	= fluoride ion
Cl^-	= Chloride ion
NO_2^-	= Nitrite ion
NO_3^-	= Nitrate ion
SO_4^{2-}	= Sulfate ion
SO^2	= Sulphur dioxide
NO	= Nitrogen oxide
NO^2	= Nitrogen dioxide
NO_x	= Generic term for the mono-nitrogen oxides
CO	= Carbon monoxide
CO_2	= Carbon dioxide

4.0 FACTORS AFFECTING THE EFs ESTABLISHMENT

There are various factors that greatly influence the establishment of emission factor of aerosol and pollution gases emitted from the burning of different biomass types, such as biomass properties, type of combustion chamber condition used, specific burning condition, etc. As mentioned earlier, for fair comparison, the emission factors data of the different biomasses should be in the same basis; however such data is not available for wide range of biomass types. The details of each possible factor affecting the EFs value are discussed below.

4.1 Types Of Biomass

Emission factors presented in the table above do actually reflected the difference in the type of biomass burned for each type of burning (e.g. wheat straw vs. rice straw). As previously mentioned, the types of biomass covered in this study are wheat straw, corn straw, corn stover, rice straw, cotton stalk, Kentucky bluegrass, Florida sugarcane and cereal waste –which are identified from extensive literature review of this area of study. As shown in Table 1 the study reported by Guoliang *et. al.*, (2008), the emission factor of particulate matter for wheat straw (8.75±4.18g/kg), rice straw (6.28±1.59g/kg), corn stover (5.31±1.79g/kg) and cotton stalk (4.53±0.95g/kg) are very different from each other.[16] The different between these type of biomass because each biomass types has different moisture content. The moisture content of biomass has an influence on the combustion efficiency and the temperature of the combustion which will tend to the high formation of tars and gases pollution.[25] The moisture content varies with geographical location, season, and weather where the biomass was obtained. In principle, any water content in solid fuel must be driven off before the combustion process can take place so the combustion efficiency may influence and also potentially reducing combustion temperature below the optimum. Reduction in combustion temperature below the optimum may result in incomplete combustion of the fuel which consequently gives rise to the emission of tars and creosote.

As a solution to this problem, the form of solid biomass should be taken into account in biomass burning to reduce pollution emission. Biomass briquettes including pellets, which are very small briquettes has been used as an alternative source of combustible biomass to convert loose biomass residues. The biomass pellets are now an accepted form of fuel rather than traditional form of residues straw because of the net calorific value is higher and moisture content is lower than the original form to improve combustion process. These are widely used and internationally traded.[26-27]

4.2 Source Of Emission

There are various methods of biomass combustion which has been reviewed in this paper. Several of the past studies used the experimental design (controlled combustion) technique through proper experimentally designed setup such as combustion tower and combustion chamber,[16,21,22,28] meanwhile some studies adopted open burning and in-situ burning method.[6,23,29,30] According to Table 1, there are have significant different of SO_2 emission factors from wheat straw combustion using different method which, combustion tower is 0.04±0.04g/kg[16] and open burning is 0.85±0.57g/kg[24]. The different in these two studies are found in the method of combustion used which greatly affects the amount of emissions produced. The phases of a combustion process include preheating, flaming and smoldering. Emissions do occur in all phases; however individual pollutants are emitted in different proportions during different phases.[31]

4.3 Conditions Of Combustion

Under ideal conditions, complete combustion of carbon would result in generation of carbon dioxide (CO_2) only.[32] Any products other than CO_2 are often called products of incomplete combustion, which include particulate matter and gases.[33] Incomplete combustion occurs when there exists condition which allow for gas-phase condensation reaction of the fuel and its decomposition products to incomplete with decomposition and oxidation which resulted the emission of gaseous hydrocarbon compounds, soot, condensable organic particle and char particle.[34] For example the emission factors of CO produced from rice straw combustion have significant different which are 67.98±25.58 g/kg by Guoliang et al., (2008) and 64.2±4.9 g/kg by Zhang et al., (2008) even using the similar method which experimental work (combustion tower).[16,28] The difference in the emission factor values was due to the different conditions for the combustion process, such as the temperature of combustion. Basically, emission of organic particles is strongly influenced by the combustion conditions. On the other hand, the emission of inorganic particles is only slightly influenced by the combustion conditions, because it also depends on other formation mechanisms than organic particles (Thomas et al., 2008). High temperature enhances the conversion of ash constituents to gas phase and consequently resulted in the emission of inorganic particles. For open burning, the emissions are also affected by combustion efficiency that is the proportion of the waste which is actually burned out of the total amount of waste that is subjected to burning. There are three Ts for good combustion process i.e. temperature, turbulence and time. Although with adequate temperature and turbulence for proper mixing, combustion process cannot be completed if there is not enough time for the combustion reaction to take place.

4.4 Capacity Of Feedstock

Emission factor establishment also does influenced by the capacity of feedstocks. Guoliang et al.[16] found that the emission factor of SO_2 emission from wheat straw burning (0.04±0.04 g/kg) was much lower than that reported by Li et al.[24] (0.85 ± 0.57 g/kg). The difference between these two studies are found in capacity of feedstock which Guoliang et al.[16] used 0.5-1.9 kg feedstock, meanwhile Li et al.[24] used 40-60 kg feedstock. The resulting emissions of biomass burning are directly proportional to the feedstock inlet or feeding rate. The more biomass feedstock are used, the higher air pollution emissions are produced. Optimum fuel feeding rate to boiler capacity (F/B) should be determined for each boiler and maintained during operation. Higher F/B ratio results in higher black smoke and particulate emission.

4.5 Air Pollution Controller (APC) System

The emission from biomass burning can be reduced or prevented through air pollution control (APC) system. For example, palm oil mill boiler in Malaysia is installed with cyclone dust collector as air pollution system to remove large particles and dark smoke from flue gas. Cyclone is usually used for removing particle 10μm in size and larger. For the air pollution control (APC) to work more effectively, a collector system such as fabric filter system or electrostatic precipitator system (ESP) needs to be installed after the mechanical cyclone. However based on the literature review conducted, to date there is no work which applies such efficient air pollution controller (APC) system in the country. This is one of the causes of high widespread release of particulate matters to the environment.

Besides, high particulate emissions from multicyclone system may occur in the event of failure of the system. Therefore, measures shall be undertaken to ensure the multicyclone system is working properly, which include:

- Frequent monitoring of the pressure drop of the multicyclone system.
- Conducting performance monitoring on the multicyclone system as recommended by DOE in the "*Technical Guidance on Performance Monitoring of Air Pollution Control Systems*" (Technical Guidance Document Series Number: DOE-APCS-5, First Edition: December 2006). These include daily, weekly, monthly, quarterly and annual monitoring procedures for the multicyclone system.

5.0 CONCLUSION

The existing emission factors from different types of biomass burning have been compared from different method of combustion that have been done by several studies. As a conclusion, cereal waste gives the highest emission factor of PM (75±21g/kg), while element carbon (EC) emission rates being relatively higher from rice straw (57.7±27.9g/kg) and lower from wheat straw (0.42±0.23 g/kg). Organic carbon (OC) emission a rate is also higher from rice straw (335.4±88.0 g/kg) and lower from Florida sugarcane (0.16±0.09 g/kg) wheareas corn stover had the highest emission factors of NO, NO_x and CO_2. This study also discussed the associated factors affecting the EFs establishment e.g. type of biomass, source of emission, and condition of combustion that prevent to lead the higher production of harmful emissions certainly threatening to health, i.e. damaging the respiratory system of human and animals as well as to the environment i.e. plants and buildings deterioration**.**

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