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An Overview on Biomass Burning Emissions and Its Impact on Environment

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Abstract- Biomass burning is a tool to used for number of land use and related changes. Biomass burning is a significant global source of gaseous and particulate matter emissions to the troposphere. Sources of biomass burning including aerosols, CO2, NOx, CO, CH4, N2O, CH3Br, NH3, NMHCs, organic trace gases, green house gases such as CO2, CH4, and N2O, halogenated compounds such as methyl bromide and methyl chloride, VOCs and other species.
An emission from biomass burning creates several impacts on environment, like impact on global atmospheric chemistry and biogeocycles, impact on formation of ozone, impact on depletion of ozone layer, impact on green house effect, impact on global warming, impact on climate, impact on indian monsoon, impact on radiative properties, impact on level of biodiversity, impact on health etc.
This paper focuses on the overview of biomass burning emissions and their impact on the environment.
Keywords – Biomass burning, Pollutant, Global warming, Health, Environment

Contents

I. INTRODUCTION

Biomass burning is a tool to used for number of land use and related changes, including the clearing of forests and savannas for agricultural and grazing use, shifting agricultural practices, the control of grass, weeds, litter- and sometimes pests on agricultural and grazing lands, the elimination of stubble and waste on agricultural lands after the harvest and domestic use.

Biomass burning is a significant global source of gaseous and particulate matter emissions to the troposphere, which play a pivotal role in tropospheric chemistry [1]. Sources of biomass burning including aerosols, carbon dioxide (CO2), nitrogen oxides (NOx), carbon monoxide (CO), methane(CH4), nitrous oxide(N2O), methyl bromide(CH3Br), ammonia(NH3), non-methane hydrocarbons (NMHCs) and other species. These emissions and their subsequent products act as pollutants and create green house effect and global warming of the atmosphere[2].

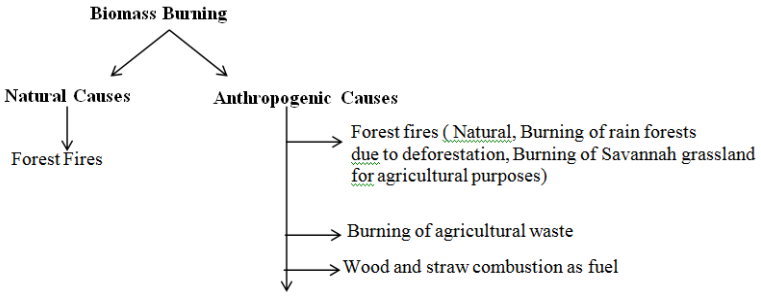
Biomass burning emissions impact on the photochemical ozone formation and influence the budget of tropospheric ozone. Ozone is formed when CO, CH4, and NMHCs react in the presence of NOx and sunlight[3]. In tropical regions where the bulk of biomass burning occurs ozone concentrations may increase due to biomass burning [4]. Biomass burning emissions are also a source of number of halogenated compounds such as methyl bromide and methyl chloride which destroy ozone in the stratosphere[5].

In addition to their impact on global atmospheric chemistry and biogeochemical cycles, the formation of ozone and other photooxidants due to the turnover of VOCs from biomass burning may have a significant impact on the regional environment and on the health of the population living in the vicinity of biomass burning [6].

Aerosol particles emitted from biomass burning are a major source of cloud condensation nuclei, which effect the microphysics of boundary layer clouds and then radiation budget of the earth[7]. Atmospheric aerosols and trace gases emitted from biomass burning impact on climate and human health.
Biomass burning can increase the concentration of nitric acid (HNO3), a key component of acid rain [8]. In addition to these impacts biomass burning emission creates several other impacts on environment, like impact on indian monsoon, on radiative properties, on level of biodiversity etc [9].
In this paper we review the literature regarding biomass burning emissions and to give an overview of the present state of knowledge regarding its impact on totality of the environment.The rest of the paper is organized as above given in contents.

II. TYPES OF BIOMASS BURNING

Biomass burning refers to the burning of vegetation either by natural causes as well as anthropogenic causes.



2.1 Forest fires

Forests are the main part of the terrain ecosystem and play an important role in maintaining the balance of terrain ecosystem [10]. Natural fires are grassland and forest fires mainly induced by lightning. In many parts of the world, forest fires are part of a natural cycle[11]. Savannas, for example, are maintained by fire. And in regions like the Amazon, where the annual fire season increased by 19 percent between 1979 and 2013, fire is deliberately used to clear forest to make way for agriculture. In 2016, forest fires have been noted in numerous places across the Indian state of Uttarakhand. These fires set mainly in pine forests in the slopes of the sub-Himalayan region, produced clouds of smoke, more fires mean more carbon released into the atmosphere, which in turn drives climate change[11,15]. Forest fires can be characterized in terms of the cause of ignition, their physical properties, the combustible material present, and the effect of weather on the fire. Forest fires are one of the major causes of global warming as well as global warming is a cause for forest fire[12]. Scientific evidence that climate change has been increasing the length of the fire season, the size of the area burned each year and the number of wildfires. Greenhouse gas emissions, via the greenhouse effect, are causing the global temperature to increase and the climate to change. This enhances the likelihood of forest fires. Because warmer temperatures increase evaporation, which means the atmosphere draws more moisture from soils, making the land drier. A warmer climate also leads to earlier snowmelt, which causes soils to be drier for longer and dry soils become more susceptible to fire. Drier conditions and higher temperatures increase the duration and the severity of the forest fire[13].
Forest fire represents one of the important sources of greenhouse gas (GHG) emissions due to biomass burning processes. During the process of biomass burning many gases are emitted into the atmosphere with direct (CO_2, CH_4, N_2O) or indirect (CO, NOx) effects on radiation balance within the atmosphere[12-14].
Savanna fires also have an important influence on greenhouse gas dynamics. They make a significant contribution to the nation's accountable (non-CO_2) emissions through the release of methane and nitrous oxide [15].

2.2 Burning of agricultural waste

Agricultural residues burning in field is a common practice in many parts of the world, mainly developing countries, to eliminate waste after harvesting. Agricultural crop production generates tremendous amounts of agricultural crop residues such as rice, wheat, and corn straws etc. Agricultural residues are the biomass left in the field after harvesting of the economic components i.e., grain. Large quantities of crop residues are generated every year, in the form of cereal straws, rice husk, woody stalks, and sugarcane leaves/tops during harvest periods. These residues are used as animal feed, thatching for rural homes, residential cooking fuel and industrial fuel. Out of these a large portion of the crop residues is not utilized and left in the fields. Disposal of these large amounts of crop residues is a major task. Farmers opt burning method as quick and easy way to dispose the large quantities of

agricultural residues and prepare the field for next crop in short time. For this during the summer/autumn harvest season, a large amount of agricultural straws are removed by burning in a short period in order to prepare the next crop planting. Open burning is the most convenient and less expensive way to eliminate agricultural straw.
Agricultural residues burning may emit significant quantity of air pollutants like CO2, N2O, CH4, emission of air pollutants such as CO, NH3, NOx, SO2, NMHC, volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) and particulate matter[15].
In 2017 Delhi smog severity is often aggravated by stubble burning in neighbouring agricultural areas. Much of the pollution came from farms in nearby states of Punjab, Haryana, and Western Uttar Pradesh. With the rice harvest over, farmers burned crop stubble, specifically the remnants of the rice crop to prepare the fields to plant wheat and return nutrients to the soil. Smoke from the outer area mixed with inside pollution of the city that emit from construction, vehicles, and fires from cooking. Mixing of rural and urban pollution intensifies in the cooler winter months and dirty air was lingered due to slow movement of air in Delhi.

2.3 Wood and straw combustion as fuel
Biomass fuel is a common practice for the population lives in rural areas as the domestic fuel for cooking/ heating. Biomass fuels burnt in low-efficient stoves produce substantial air pollutants and increase fine particulate matter (PM2.5) exposure in the indoor environment [16,17], which is associated with adverse health impacts such as pneumonia, tuberculosis and chronic obstructive pulmonary disease [17, 18].
Moreover, high concentrations of PM2.5 in the indoor environment have been regarded as a cardiovascular risk factor that is associated with heart attacks, stroke, heart rhythm disturbances, and sudden death. Inhalation of fine particles elicits pro inflammatory effects, cytokine production, and enhancement of allergic responses in the upper and lower airways [19,20].

III. POLLUTANTS FROM BIOMASS BURNING

Biomass burning is a source of greenhouse gases, carbon dioxide, methane and nitrous oxide. In addition, biomass burning is a source of chemically active gases, including carbon monoxide, nonmethane hydrocarbons, and nitric oxide. Pollutants of biomass burning including aerosols, carbon dioxide (CO2), nitrogen oxides (NOx), carbon monoxide (CO), methane(CH4), nitrous oxide(N2O), methyl bromide(CH3Br), ammonia(NH3), mon-methane hydrocarbons (NMHCs) and other species. These emissions and their subsequent products act as pollutants and create green house effect and global warming of the atmosphere[4,10].
The percentage production of CO2, CO, CH4, NHMCs, and carbon ash during the flaming and smouldering phases of burning based on laboratory studies is summarized in Table 1[10]

Table 1. Gas Production during Flamming and Smoldering Phases of Burning Based on Laboratory Experiments

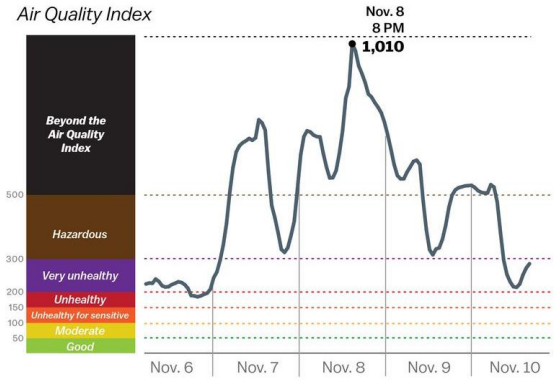
Gas	Percentage in Burning Stage (%)	
	Flaming	Smoldering
CO2	63	37
CO	16	84
CH4	27	73
NMHCs	33	67
NOx	66	34
NH3	15	85
HCN	33	67
CH3Cl	28	72

IV. IMPACT OF BIOMASS BURNING

Biomass burning apparently alters the composition of the lower atmosphere and ultimately makes the environment jeopardised. Although biomass is burned to clear woodland for agriculture, controlling weeds and agriculture wastes but it carried out several impurities in the form of pollutant (including carbon dioxide, nitrogen oxide, aerosols, carbon monoxide, methane nitrous oxide, ammonia, methyl bromide, non-methane hydrocarbons etc.). Thus biomass burning would have a severe impact on the environment.
Forest fires have had impact on biosphere-atmosphere interface, atmospheric chemistry, composition of ecosystem system and its distribution, environmental degradation and air quality monitoring[3], [7], [1], [11],[13], [14]. They emit large amounts of trace gases (both chemically active and greenhouse gases), non-methane hydrocarbons, and aerosols [3]. These aerosols and pollutants are cloud properties, Earth radiation budget and climate change, global

carbon cycle, ecosystem and biodiversity, vegetation, rainfall, air quality and atmospheric circulation[3], [6], [35]. A recent study by Johnston et al. (2015) [41] shows that forest fire/BB was responsible for about 339,000 premature deaths per year. The increasing intensity and spread of forest fires in Asian countries, and their impact on ecosystems and climate change suggest that the real-time monitoring of forest fire activities is essential.

Delhi has earned the unenviable distinction of becoming the most polluted city on Earth last year in November 2016, as air quality has reached epically bad proportions. On November 8, pollution surged so high that some monitoring stations reported an Air Quality Index of 999, way above the upper limit of the worst category, Hazardous. (An extra-sensitive air quality instrument at the US embassy got a reading of 1,010, as we can see in the chart below.)



According to the US Embassy's measurements, air in New Delhi reached PM2.5 concentrations of more than 1,200 micrograms per cubic meter, 48 times the guideline value established by the World Health Organization. This is still short of the record set in Shenyang, China, where concentrations topped 1,400 micrograms per cubic meter. These particles can come from different sources — diesel exhaust, natural dust, wildfires — and can lead to heart attacks, strokes, breathing difficulties, and cancer as they penetrate deep into lungs.

Thus biomass burning would have a severe impact on the environment. These impacts can be experienced in the following arena.

4.1. Atmospheric effect

4.1.1 Impact on atmospheric aerosols and their properties

Biomass burning is one of the largest sources of aerosol and size differs from 10-3 to 102μm[42]. It is mainly black carbon (soot particles) that governs the atmospheric circulation and variation in the context of weather and climate. Beside this aerosols perform a major function in global warming as it has the ability to absorb the radiation which enhances the global warming. Aerosols are sub-micro nanoparticles, poised of oxidised organic materials, are efficient to scatter and absorb the radiation. Primarily there are 2 main effects of aerosol: a direct radiative force that scatters and absorb the radiation smoke aerosol; while indirect radiative force denotes interaction of smoke aerosol with clouds[28].

4.1.2 Impacts on increase in greenhouse gas emission

Biomass burning is an eminent source of gaseous and particulate matters in the troposphere. During burning an immense amount of greenhouse gases, volatile organic compounds and chemically active gases (nitric oxide, non methane hydrocarbons and carbon monoxide)are evicted into the atmosphere. The common greenhouse gases include methane, nitrous oxide, carbon dioxide, CFC and water vapour. During transportation emissions have substantial impact on trace gases mainly in tropical marine atmosphere [34], [35] as well as in remote troposphere [36],[37]. Greenhouse gases have usually long persistence and these gases directly promote the global warming since they have the capability to absorb the radiation. When the concentration of greenhouse gases augmented in the atmosphere then it is referred as enhanced greenhouse.

4.2 Climatic effect

4.2.1 Impact on climate, cloud absorption

The climate of the 21st century has been altering drastically owing to great variation. The burning of biomass introduces different gaseous products and particles (aerosols). These emissions have resulted from discarded material and waste as well as organic materials[21], [22], [23], [24]. The ejection of gases like CO2, CO, CH4, hydrocarbons and oxide of nitrogen promote the warming effect. These gases are the chief spring of global warming

which eventually leads to climate change. Aerosol plays a key factor and regulates the radiation budget as well. Beside this, it also affects the cloud absorption properties. Black carbon is a prevalent source of biomass burning and also named as absorbing aerosols (AAs) that have the ability to capture the incoming solar radiation and bother the temperature of the atmosphere, and influence cloud cover. The effects relyon several factors, like the elevation of the absorbing aerosol relative to the cloud and the cloud nature. BC adds to the number of cloud condensation nuclei and hence affects cloud cover. BC may also act as ice nuclei and hence change ice or mixed-phase clouds. Atmospheric aerosols that are suspended near clouds have been believed to contribute cloud evaporation and referred as a semi-direct effect [25], [26]. The loss of cloud cover aggravates the warming effect of BC. Like the black carbon, clouds have also the dual nature. i.e cooling and warming effect[27],[28].

4.2.2 Impact on Indian monsoon

Modelling study has revealed that black carbon can influence and regulate the monsoon of Asia[29], [30]. This black carbon makes a huge part and referred as the atmospheric brown cloud (ABC) over Asia. When atmospheric brown cloud combine with dust over Tibetan plateau emphasise to high heat source during pre-monsoon period, and thus enhancing the meridional temperature gradient and finally leads to increased rainfall over India during summer monsoon as well as pre-monsoon season [31],[32] ocean coupling and sea surface temperature have massive effectiveness leads to increase in pre-monsoon rainfall and declines in summer monsoon.

4.3 Effect on Environment

4.3.1 Impact on haze pollution

Biomass burning is a global problem of air pollution and it has an adverse effect on the regional and global level. The open biomass burning has a severe influence on visibility, human health and climate [33], [34],[35]. In order to identify the impact, a huge proportion of crop residues were burned (in eastern china) during May-June and October-November [36].The open burning leads to haze and air pollution in the vicinity. Haze pollution is directly associated with visibility and climate; visibility reduces exponentially with a hike in haze concentration. China always faces such problem at greater extent (e.g. haze episode occur in 2011) while India also experiences the same phenomenon in 2016. The key reason for this episode was heavy biomass burning as well as cracking near the NCR region.

4.3.2 Impact on ocean water pollution

The augmentation of nutrients in aquatic systems can lead to detrimental effects like the introduction of algal blooms and depletion of oxygen. In ocean water, nutrients are deposited from the atmosphere which quickens the eutrophication and other environmental concern [37]. It has been reported that in last 50 years pH of ocean water increases by .3. While other parameters like turbidity and DO also experience a great variation due to such ocean water contamination. The common sources of ocean pollution are oil seepage, agricultural runoff, and combustion of fossil fuels. It has been stated that 20-40% of nitrogen inputs into a coastal region having an atmospheric origin [38], the atmospheric deposition consist a large volume (40-50%) in the open sea [29]. It has been also reported that atmospheric nitrogen fixation will face an upsurge of 60% by 2020 [39]. In 1970 tropical vegetation biomass burning was a primary global source of gases such as CO2, NOX, NH3, CO and aerosol which adversely the regional and global climate, hydrological cycle, and atmospheric cycle.

4.4 Impacts on health

Basically, there are 3 ways of exposure to pollutants. i.e inhalation, ingestion and dermal. Burning activity produces smokes which contain a variety of pollutants. The output of burning (smoke) can harmfully effect on human health. Table 2 shows different most notable cardiopulmonary problems resulting from biomass smoke. The lower concentration of smoke may not affect the health of the individual, however, can be a nuisance [39]. Inhalation is the most frequent path through which humans absorb constituents of biomass smoke. Dermal absorption might happen through an individual surface cell. When free radicals absorbed on skin cell may lead to Emphysema (It is a long-term, progressive disease of the lungs that causes shortness of breath due to over-inflation of alveoli), Acute Respiratory Distress Syndrome and lung cancer [40]. Another way of introduction to the pollutants is gastrointestinal absorption. It can occur through the ingestion of products like plants that have absorbed pollutants through the soil or ash, wildlife and freshwater species can also be affected if they inhale or absorb pollutants through contaminated water. Other health effect may occur like Asphyxia (due to CO), airway irritation, pulmonary inflammation and oxidative stress, lowered pulmonary function. Table 3 depicts different diseases from different pollutants.

Table 2. The most notable cardiopulmonary problems resulting from biomass smoke

- Decline in lung functioning
- Decline in breathing rate
- Breathing discomfort
- Emphysema Asthma Allergies
- Bronchitis
- Angina Myocardial infarction
- Heart attack
- Pneumonia

Table 3. Diseases from different pollutants

Pollutant	Disease
CO2	Heart disease, Asthma, COPD, Cancer, Sleep apnoea, Liver cirrhosis
CO	Headache, dizziness, vomiting, and nausea, Shortness of breath, Confusion, Blurred vision, Loss of consciousness
PM	Mortality, Cardiovascular disease, risk of bladder cancer, lung cancer, risk for stroke, Parkinson's disease, and neurodevelopmental disorders, increased respiratory symptoms, coughing or difficulty breathing
NO2	Mortality, risk for childhood asthma, risk of lung cancer, asthma, chronic obstructive pulmonary disease
SO2	Mortality, arterial hypertension, atherosclerosis, pulmonary arterial hypertension

4.5 Ecological effect

The ecological effects of biomass burning have been well documented, especially in western United States[26], [27], [38] identified five ecosystems, totalling >160 Mha, that are undergoing a change in species composition, species diversity, and/or relative abundance due to altered fire regimes. In general, continued burning over a number of years results in a long-term reduction in levels of biodiversity.

V. CONCLUSION

Biomass burning is a significant global source of gaseous and particulate matter emissions to the troposphere.

Biomass burning refers to the burning of vegetation either by natural causes(Forest fires) as well as anthropogenic causes(Burning of rainforests, Savannah, Burning of agricultural wastes).

Sources of biomass burning including aerosols, CO2, NOx, CO, CH4, N2O, CH3Br, NH3, NMHCs and other species.

Biomass burning may significantly change the atmospheric environment and chemical climatology of our atmosphere.

Biomass burning results in Global warming, Acid rain, loss of biodiversity, creates different health problems and other environmental problems.

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