

Efforts for reducing greenhouse gases emissions from burning of biomass

[Environment](#), [Nature](#)



Efforts For Reducing Greenhouse Gases Emissions From Burning Of Biomass

Abstract—The build-up so called greenhouse gases in the atmosphere -CO₂ in particular along with other active trace gases such as CH₄, NO₂, O₃ and CFCs allows the sun's radiations to pass through them and strike the earth surface having an adverse impact on the global climate as the glass roof of greenhouse gases is permeable to radiations from the sun. Biomass used as fuel for cooking purpose in rural areas on burning emits large amount of pollutants, just like burning other solid fuels such as coal, burning organic material emits particulate matter NO_x, CO, SO₂, lead, mercury, and other hazardous air pollutants. This review paper serves to provide an overview on contributions of biomass towards increase in level of greenhouse gases and how to mitigate intensity of gases emitted from biomass burning. Studies show that emissions from household stoves, especially those using solid fuels such as biomass, can contribute significantly towards greenhouse gases. A database is also presented for emission factor of direct and indirect GHGs and other airborne pollutants. It has been found that biomass fuel type, increasing overall stove efficiency tends to increase emissions of products of incomplete combustion. Biomass is typically burned with substantial production of nonCO₂ GHGs with greater radioactive forcing, indicating biomass fuels to have potential to produce net global warming commitment even when grown renewably. Research shows substituting biofuels for gasoline will reduce GHGs because biofuels sequester carbon through the growth of the feedstock. But there analysis have failed to count the C emissions that occur as farmers worldwide respond to higher prices and

convert forest and grasslands to new cropland to replace the grain diverted to biofuels.

Keywords—Greenhouse Gases, Global Warming, Hazardous air pollutants, Carbon sequester.

INTRODUCTION

In today's age of industrialization and urbanization the expansion of human economic and industrial activity has reached a level of intensity that ultimately threatens the stability of the global atmosphere-biosphere system. Thus, one of the consequences is a significant warming of the earth's climate. The proximate cause is a buildup of the concentrations of several active trace gases in the atmosphere. These so-called Radioactively Important Gases (RIGs) are carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄), tropospheric ozone (O₃), and chlorofluorocarbons (CFCs). Chlorofluorocarbons (CFCs) are purely anthropogenic, having been invented in the early 1930s. They are used commercially as refrigerants, solvents, and foaming agents. These greenhouse gases or RIGs are transparent to incoming short-wave (visible) radiation but they strongly absorb and reradiate long-wave thermal radiation. The ultimate result is to change the radioactive balance of the earth in such a way that more energy is trapped.

[1] Composition Percentage CO₂ 25% N₂O 96% CH₄ 8% O₃ 0-25% Table 1:

Contributions of various greenhouse gases in atmosphere It has been analyzed that the amounts of biomass which is exposed to burning and the fate of this material represent major areas of uncertainty in our understanding of atmospheric chemistry, including the historical and likely

future changes in gas concentrations affecting global warming.[2] Also, the fact reveals that wood is the fuel that heats you twice — when we cut it and once again when we burn it. Similarly, fossil fuels, however, biofuels also have the ability to heat you a third time as a result of enhanced greenhouse warming effects due to the gases released by combustion. It has generally been assumed that this ability is only realized when the biomass being burned is harvested on a non-sustainable basis. It is argued that with sustainable harvesting, an equivalent amount of carbon is recaptured by the re-growing biomass as is released by combustion. Thus, the net increase in greenhouse gas is negligible. Even when this is true with regard to the number of carbon atoms, it may not be with regard to their greenhouse equivalence. In particular, photosynthesis captures only carbon dioxide (CO₂) from the atmosphere, but actual biomass combustion emits other carbon containing materials with atmospheric warming impacts.

These products of incomplete combustion (PICs) are also of concern Review On Efforts For Reducing Greenhouse Gases Emissions From Burning Of Biomass because of their effects on human health. Analysis in village homes throughout the world have shown that health-impairing concentrations of PICs are often encountered where people use wood or other biomass for cooking or heating in poorly ventilated conditions [3]. Burning of biomass is a source for emitting, carbon dioxide, methane, and nitrous oxide. In addition, it also leads to some chemically active gases, including carbon monoxide, non-methane hydrocarbons, and nitric oxide. These gases, along with methane, lead to the chemical production of tropospheric ozone

(another greenhouse gas) as well as control the concentration of the hydroxyl radical, which regulates the lifetime of almost every atmospheric gas. Following biomass burning, biogenic emissions of nitrous oxide, nitric oxide, and methane are significantly enhanced. It is hypothesized that enhanced post burn biogenic emissions of these gases are related to fire induced changes in soil chemistry and or microbial ecology [4].

COMPOSITION OF BIOMASS

When comes to composition of biomass process of photosynthesis leads to production of structural and non-structural carbohydrates comprising the plant tissues. The main constituent of biomass includes cellulose, hemicelluloses, lignin, lipids, proteins, simple sugars, starches, water, hydrocarbons, ash, and other compounds. The net concentrations of each class of compound varies depending on species, type of plant tissue, stage of growth, and growing conditions. Cellulose is a linear polysaccharide of beta-D glucopyranose units linked with (1-4) glycosidic bonds. Hemicelluloses, polysaccharides of variable composition including both five and six C monosaccharide units. The lignin is an irregular polymer of phenyl propane units [8-12]. Plants producing large amounts of free sugars, such as sugar cane and sweet sorghum, are attractive as feed stocks for fermentation, as are starch crops such as maize (corn) and other grains. Although lignin is not yet generally considered fermentable, and thermochemical means are usually proposed for their conversion. Typically, 60-80% of the feedstock mass is ultimately fermentable. Combustion can be applied either to the direct conversion of the whole biomass, or to portions remaining following

some sort of biochemical separation such as fermentation. Combustion, unlike the biochemical and some other thermochemical conversion strategies, is essentially non-selective in its use of the biomass, and intends to reduce the whole fuel to simple products. This is not to suggest that the complex structure of biomass does not have significant influences on its combustion behavior.

Biomass is highly oxygenated with respect to conventional fossil fuels including HC liquids and coals due to carbohydrate structure. About 30 to 40 wt.% of the dry matter in biomass is O₂. The principal constituent of biomass is carbon, making up from 30 to 60 wt. % of dry matter depending on ash content. Of the organic component, hydrogen is the third major constituent, comprising typically 5 to 6% dry matter. Nitrogen, sulfur, and chlorine can also be found in quantity, usually less than 1% dry matter but occasionally well above this. The latter are important in the formation of pollutant Emissions and sulfur and chlorine in certain ash reactions leading to fouling and slagging. Nitrogen is a macronutrient for plants, and critical to their growth. Certain inorganic elements can be found in high concentration as well. In annual growth tissues, concentrations of the macronutrient potassium frequently exceed 1% dry matter. In hi some of the gramineae grasses and straws, silica is the third largest component in rice straw, silica is 10-15% of dry matter).[5]

HISTORICAL CHANGES IN BIOMASS BURNING

Studies shows that emissions resulting from burning of biomass has shown a great increment in recent decades, due increase in human activities to utilize

the biomass for various purposes particularly for cooking which ultimately led to deforestation in tropics. Research show that the gaseous and particulate emissions due to deforestation has increased by a factor of 3-6 over the years. Also, burning of grasslands, savannas, and agricultural lands has increased over many years because rarely burned ecosystems, such as forests, have been converted to frequently burned ecosystems, such as grasslands, savannas, and agricultural lands. Historical data, reveal that the burning of biomass burning has ultimately resulted into a net global increase in the level of greenhouse gases over the years. Burning of biomass is usually human initiated and as the level of greenhouse gases emitted from burning increase day by day the temperature of atmosphere also goes up ultimately it have adverse impact on humans. Various policies were also led to put a control for mitigation of biomass burning.[4]

GASEOUS EMISSIONS DUE TO BIOMASS BURNING

Biomass burning consists of combustion of living and dead material in forests, savannas, and agricultural wastes, and the burning of fuel wood. During complete combustion, the burning of biomass material produces carbon dioxide (CO₂) and water vapor (H₂O), according to the reaction, $\text{CH}_2\text{O} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$ Where C, H, O represents the average composition of biomass material. Practically the combustion of biomass burning is never completely achieved under any conditions, due to this other carbon species, including carbon monoxide (CO), methane (CH₄), non-methane hydrocarbons (NMHCs), and particulate carbon, result through the incomplete combustion of biomass material. In addition, N₂ and S species are

produced from the combustion of N₂ and S in the biomass material. While CO₂ is the overwhelming carbon species produced by biomass burning, its emissions into the atmosphere resulting from the burning of savannas and agricultural wastes are largely balanced by its reincorporation back into biomass via photosynthetic activity within weeks to

Proceedings of the NEWAGE – 2018 National Conference on Energy, Water and Chemical Technologies for Green Environment, 2nd October, 2018 years after burning. However, CO₂ emissions resulting from the burning of forests converted to non-forested areas and other carbon combustion products from all biomass sources including CH₄, CO, NMHCs, and particulate carbon, are largely “ net” fluxes into the atmosphere Since these products are not reincorporated into the biosphere. Gases present in biomass Percentage in burning stage (%)

	Smoldering	Flaming
CO ₂	63	37
CO	16	84
CH ₄	27	73
NMHCs	33	67
NO _x	66	34
NH ₃	15	85
HCN	33	67
CH ₃ CL	28	72

Table2: Gas production during flaming and smoldering phase of burning based on laboratory experiments. Biomass material contains about 40% carbon by weight, with the remainder hydrogen (6. 7%) and oxygen (53. 3%). Nitrogen accounts for 0. 3-3. 8%, and sulfur for 0. 1-0. 9%) depending on the nature of the biomass material. The nature and amount of the combustion products depend on the characteristics of both the fire and the biomass material burned. Hot, dry, fires with a good supply of oxygen produce mostly carbon dioxide with little CO, CH₄ and NMHCs. The flaming phase of the fire approximates complete combustion, while the smoldering phase approximates incomplete combustion, resulting in greater production of CO, CH₄, and NMHCs. The percentage production of CO₂, CO, CH₄, NMHCs, and carbon ash during the flaming and smoldering phases of

burning based on laboratory studies is shown in above Table Typically for forest fires, the flaming phase lasts on the order of an hour or less, while the smoldering phase may last up to a day or more, depending on the type of fuel, the fuel moisture content, wind velocity, topography, and other param. [4]

EMISSION RATIOS

The total mass of the carbon species ($\text{CO}_2 + \text{CO} + \text{CH}_4 + \text{NMHCs} +$ particulate carbon) $M(\text{C})$ is related to the mass of the burned biomass (M) by $M(\text{C}) = f(x) M$, where $f(x)$ mass fraction of carbon in the biomass material (40% by weight). To quantify the production of gases other than CO_2 , we must determine the emission ratio (ER) for each species. The emission ratio for each species is defined as $\text{ER} = \frac{X}{\text{CO}_2}$ where X is the concentration of the species X produced by biomass burning, $X = X^* - X$, where X^* is the measured concentration of X in the biomass burn smoke plume, X is the background (out-of-plume) atmospheric concentration of the species, and CO , is the concentration of CO , produced by biomass burning, $\text{CO} = \text{CO}^* - \text{CO}$, where CO^* is the measured concentration in the biomass burn plume and CO_2 is the background (out of plume) atmospheric concentration of CO_2 . In general, all species emission factors are normalized with respect to CO_2 since the concentrations of CO_2 produced by biomass burning may be directly related to the amount of biomass material burned by simple stoichiometric considerations. [4]

METHODS TO REDUCE GREEN HOUSE GASES

Carbon Dioxide Removal(CDR)- It is the technology that removes carbon dioxide from the atmosphere.

Carbon Sequestration – The process which involves capture of atmospheric carbon in the form of carbon dioxide or other forms of carbon and its long-time storage to lower global warming and to reduce greenhouse gases is known as Carbon Sequestration. It is a good way to reduce atmospheric accumulation of greenhouse gases which are released due to burning of fossil fuels. [7] Carbon sequestration is the long-time storage of carbon in plants, soils, geological formations and ocean. It can occur naturally such as combustion or decomposition of plants and animals or due to anthropogenic activities like biomass burning or burning of fossil fuels which have Energy Biomass composes about 14% of all direct human energy use. It is about 33% of energy use in developing countries. It is about 75% of energy use in rural areas of developing countries. It is the most important fuel for the majority of humanity. Health Cause of up to 50% of total human exposure to RSP Affects second-largest occupational group (cooks), after farm workers Known risk factor for most important killer of developing-country children (pneumonia) Global warming Human biofuel consumption: 20–40% of all biomass combustion 1–5% of all CH₄ emissions 6–14% of all CO emissions 8–24% of all TNMOC emissions 1–3% of all human-generated global warming Review On Efforts For Reducing Greenhouse Gases Emissions From Burning Of Biomass released carbon from its original storage as coal, petroleum, wood, natural gas in the form of carbon dioxide. In CSS process carbon

dioxide is first separated from other gases, then it is compressed and transported to a faraway location for storage purpose. Carbon dioxide can be stored in geological formations such as sedimentary rocks, depleted oil and gas reservoirs or deep oceans.

BECCS (Bio-energy with carbon capture and storage) – It is a technology which helps in reducing greenhouse gases. This technology produces negative carbon dioxide emissions by combining energy from biomass with geologic carbon capture. Carbon dioxide which is captured from biomass sources removes carbon dioxide effectively from the atmosphere. [9]

Bio-Char- It is solid rich in carbon and can endure soil for many years.

Biochar is made from biomass via pyrolysis. It is the direct thermal decomposition of biomass in the absence of oxygen i. e. it does not undergo combustion and produces a mixture of solids, liquids and gas. Pyrolysis occurs more quickly at higher temperatures. Biomass burning and natural decomposition of biomass (agricultural waste) can add large amounts of carbon dioxide to the atmosphere. Bio char is the best way to store carbon in the ground and thus reducing the growth of greenhouse gases. It also helps to improve fertility of soil. It also helps to reduce methane and nitrogen. Smoldering agricultural waste and covering the burning biomass with soil in pits or trenches can help to reduce gas emissions i. e. if biomass is pyrolyzed to bio-char and put back into soil before it is completely burned can help to reduce carbon emissions. Thus, more carbon dioxide is removed from the atmosphere than released. [11][12]

Carbon Capture and Storage (CCS) – It is a technology that helps in trapping 90% of carbon dioxide emissions. The process involves collecting, transporting and burying CO₂ so that it won't escape into the atmosphere.

There are three main techniques:

Post Combustion – In this process the gases released are scrubbed using chemicals. The scrubbing is done by passing the gases released through ammonia which is then blasted clean with steam, and then carbon dioxide is released for storage purpose.

Pre-Combustion- It takes place before the fuel is combusted. In this process coal is first converted into clean burning gas and CO₂ is stripped out which is released by the process. The aim is to remove carbon from coal before it is burned.

Oxyfuel- It burns the coal in an atmosphere where concentration of oxygen is more thus resulting in almost pure carbon dioxide emissions. [9]

Storage-After the carbon dioxide is trapped, it is liquefied, and transported and buried. Storing carbon dioxide under the Earth's surface is called geo-sequestration. A carbon sink is a natural or artificial reservoir that helps in storing carbon containing compounds for an indefinite period. Natural carbon sinks are as follows: 1. Trees 2. Absorption of carbon dioxide by oceans 3. Photosynthesis by terrestrial plants. [10]

MEASUREMENT DESCRIPTION

Instrument Identifier Measurement Techniques Measurement Descriptions

Detection Qualifications GC-MS Gas chromatography (Quadrupole) mass spectrometry Discrete sampling via cryogenic pre-concentration, chromatographic separation, detection and identification via electron impact (EI) mass spectrum Melting point greater than $-185\text{ }^{\circ}\text{C}$; boiling point less than $220\text{ }^{\circ}\text{C}$; sufficiently non-polar (e. g. no acids); fragment ion (m/z): 29 to 150. PTR-MS Proton transfer reaction-(Quadrupole) mass spectrometry Real-time sampling via proton transfer reactions with H_3O^+ , quantification via protonated molecule $[\text{M}+\text{H}]^+$ Proton affinity greater than water; protonated molecular mass (m/z): 20 to 240. PIT-MS Proton transfer reaction (Ion Trap) mass spectrometry Real-time sampling via proton transfer reactions with H_3O^+ , quantification via protonated molecule $[\text{M}+\text{H}]^+$ Proton affinity greater than water; protonated molecular mass (m/z): 20 to 240. NI-PT-CIMS Negative ion proton transfer reaction (Quadrupole) mass spectrometry Real-time sampling via proton transfer reactions with $\text{CH}_3\text{C}(\text{O})\text{O}^-$, quantification via protonated molecule $[\text{M}+\text{H}]^-$ Gas-phase acidity greater than that of acetic acid; deprotonated molecular mass (m/z): 10 to 225. Proceedings of the NEWAGE – 2018 National Conference on Energy, Water and Chemical Technologies for Green Environment, 2nd October, 2018 OP-FTIR Open path-Fourier transform infrared spectroscopy Real-time spectral scanning via open path white cell (58m pathlength), offline identification via compound specific infrared absorption features. Strong absorption features between 600 to 3400cm^{-1} that are unique and free of interferences from other strong ir-absorbers (e. g. H_2O).

REFERENCES:

1. Robert U. Ayres and Jorg Walter, RR-91-12 July 1991, “ The Greenhouse Effects _Damages, Costs, and Abatement “, Laxinburg, Austria.
2. Philip. M. Fearnside, 2000, “ Global Warming And Tropical Land-Use Change: Greenhouse Gas Emissions From Biomass Burning, Decomposition And Soil In Land Conversion, Shifting Cultivation And Secondary Vegetation “, CP -478, 69011- 970 Manaus, Brazil.
3. Kirk R. Smith, November 1994, “ Health, Energy And Greenhouse Gas Impacts Of Biomass Combustion In Household Stoves “, USA.
4. Joel S. Levine, 1994, “ Biomass Burning And The Production Of Greenhouse Gas Virginia.
5. B. M. Jenkins, L. L. Baxter, T. R. Miles Jr., T. R. Miles, 1998, “ Composition Properties Of Biomass “, USA.
6. J. B. Gilman, B. M. Lerner, W. C. Kuster, P. D. Goldan, C. Warneke, P. R. Veres, J. M. Roberts, J. A. de Gouw, I. R. Burking And R. J. Yokelson, 2015,” Biomass Burning Emissions And Potential Air Quality Impact Of Volatile Organic Compounds And Other Trace Gases From Fuels Common In The US “.
7. Chris Woodford September 4, 2008
8. Carbon Sequestration in Forests and Soils Annual Review of Resource Economics.
9. ‘ Global Technology Roadmap for CCS in Industry Biomass based industrial CO2 sources : biofuels production facility begins
10. Balal Yousaf, Guijian Liu, Ruwei Wang, Qumber Abbas, Muhammad Imtiaz, Ruijia Liu: Investigating the bio-char effects on C-

mineralization and sequestration of carbon in soil compared with conventional amendments using stable isotope approach. GCB

Bioenergy 2016; doi10. 1111/gcbb. 12401

11. Lean, Geoffery (7december2008).
12. Lehmann, J.; Gaunt, John; Rondon, Macro; et al.(2006).” Bio-char Sequestration in Terrestrial Ecosystems-A Review”.