# Air pollutant emissions from crop residue biomass burning in Indo-gangetic plains of India.

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**Abstract:** In situ burning of crop residue biomass, a convenient and inexpensive way to prepare for the next crop planting, induces severe emission of air pollutants at global level. Among all the biomass burning types, agricultural residue burning in the field is estimated to contribute more than 10% of the total mass burned globally and its relative contribution is even larger in Asia (34 %), and especially in India (16%). The Indo-gangetic plains of northern states of India viz. Haryana, Punjab, Rajasthan and western Uttar Pradesh are known for its sprawling agricultural fields, but equally famous for burning of paddy and wheat stubbles by farmers after the harvesting season. Burning of straw emits emission of trace gases like $CO_2$, $CH_4$, CO, $N_2O$, $NO_X$, $SO_2$ and large amount of particulates matters ($PM_{10}$ and $PM_{2.5}$) which cause adverse impacts on human health. $CO_2$ alone accounts for 91.6% of the total emissions. Out of the rest (8.43%) 66% was CO, 2.2% NO, 5% NMHC and 11% NMVOC. Burning of rice crop residue contributed the maximum (40%) to this emission followed by wheat (22%) and sugarcane (20%). The reactive compounds emitted and formed due to crop residue biomass burning drives ozone and organic aerosol formation, affecting both air quality and climate. An integrated crop residue management approach is need of the hour to combat this anthropogenic disaster. In situ soil incorporation, utilization in power plants, paper pulp industry, bio gas & bio-ethanol production and compost formation can be sustainable alternatives for crop residue burning. Cultivators must be provided awareness on this issue and sustainable approached are need of the hour to manage this menace.

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## 1. Introduction

On the global scale, biomass burning is the main source of primary organic carbon (OC) (Huang et al, 2015), black carbon (Cheng et al, 2016), and brown carbon (Laskin et al., 2015). It is also the second largest source of non-methane organic gases (NMOGs) in the atmosphere (Stockwell et al, 2014). In addition, atmospheric aging of biomass burning plumes produces substantial secondary pollutants. Open burning of agricultural residues, a convenient and inexpensive way to prepare for the next crop planting, could induce severe regional haze events (Tariq et al., 2016). Among all the biomass burning types, agricultural residue burning in the field is estimated to contribute 10% of the total mass burned globally (Andreae and Merlet, 2001), and its relative contribution is even larger in Asia (34 %), and especially in India (16%) (Jain et al, 2014).

Both agricultural residue burning and domestic coal combustion have been recognized as contributing substantially to the deteriorating regional air quality, especially in northern NCR region (Singh et al., 2016). According to the Indian Agricultural Research Institute, New Delhi, cereal crops generate a maximum residue of 352 Mt, of which rice and wheat contribute to 34% and 22% respectively. To clear the agricultural field swiftly and allow tillage practices to proceed unrestrained by residual crop material, the crop residues biomass is burned *in situ* (Jain et al, 2014). Crop biomass residues burning release significant magnitude of air pollutants like $CO_2$, $N_2O$, $CH_4$, emission of air pollutants such as CO, $NH_3$, NOx, $SO_2$, NMHC, volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) and particulate matter like elemental carbon at a rate much different from that observed in savanna or forest fire due to different chemical composition of the crop residues and burning conditions (Zhang et al, 2011), (Mittal et al, 2009).

In this region of Indo-gangetic plains of India, the air pollutants released from agricultural residue burning causes smog (Delhi – NCR Smog in 2016 & 2017) which have adverse impacts on human health. Irritation in eyes and congestion in the chest were the two major problems faced by the people. It also led to chronic obstructive pulmonary disease (COPD), pneumoconiosis, pulmonary tuberculosis, bronchitis, cataract, corneal opacity and blindness. The cases of road accidents also enhance during the period of stubble burning. It also causes haze, global warming and climate change (Singh et al 2016). It becomes need of the hour to adopt alternate sustainable utilization of crop residue biomass to combat the problem of air pollution.

**2. The generation of crop residue biomass and its burning:**

Crop residues are the biomass left in the agricultural plots after harvesting of the grain. Large quantities of crop residues are generated every year, in the form of cereal straws, woody stalks, and sugarcane leaves/tops during harvest periods. Total amount dry crop residue generated by nine major crops was 620.4 Mt (Table 1).

Table 1: The amount of crop residue biomass generated in India according to various authors.

| Sr. No | Study and year | Total quantity of crop residue produced in India |
|---|---|---|
| 1 | Garg (2008) | 133,138 Gg |
| 2 | Mandal et al. (2004) | 350 × 106 kg year−1 |
| 3 | Gupta et al. (2004) | 347 million tonnes (2000) |
| 4 | Agarwal et al. (2008) | 184,902 Gg |

As per Jain et al, 2014, cereal crops generate maximum biomass followed by the fibres and sugarcane in India. Rice crop alone contributed 53% and wheat ranked second with 33% of cereal crop residues (Figure1).

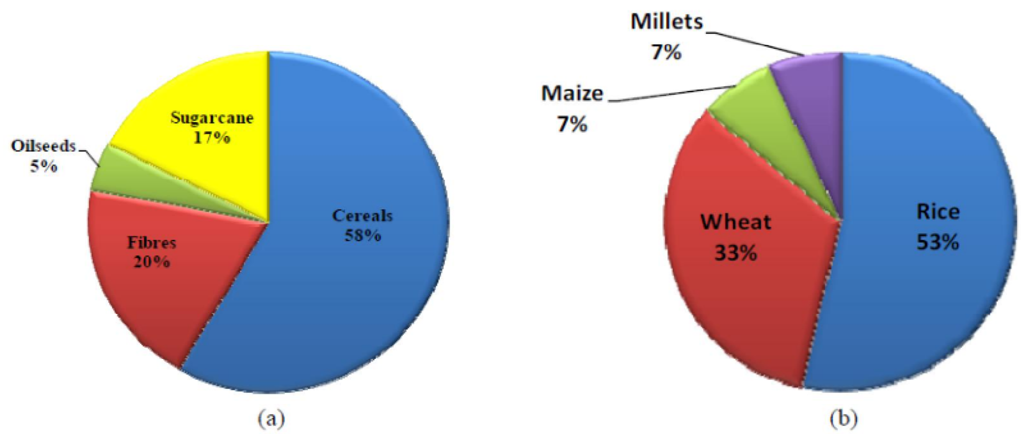


Figure 1. (a) Contribution of different crops categories in residue biomass generation. (b) Contribution of different cereal crops in residue biomass generation (Jain et al, 2014).

Figure.2: In situ stubble burning after harvesting of crop.

Figure 3: Farmer keeps on straw burning despite of ban by authorities.

It can be seen in figure 2 & 3, plumes of smoke are rising from the fields which by the end of October or sooner, becomes a thick blanket of smog in the air over northern states of India extending up to the national capital region (Sandhu 2016). It's the season for paddy crop residue burning, for preparing the blank plots to cultivate wheat.

**3. Effects of crop residue burning on air quality.**

According to a study conducted by Yevich and Logan, 2003, 91, 4.1, 0.6, 0.1 and 1.2 Tg/yr of $CO_2$, CO, $CH_4$, NOx and total particulate matter respectively were emitted due to burning of crop residues in India. Some scientist have estimated that burning of 63 Mt of crop residue emitted 4.86 Mt of $CO_2$ equivalents of GHGs 3.4 Mt of CO and 0.14 Mt of NOx (Sahai et al 2011). Gupta et al, 2004, concluded that one ton of straw on burning releases 3 kg of particulate matter, 60 kg of CO, 1,460 kg of $CO_2$, 199 kg of ash and 2 kg of $SO_2$. A study conducted by the National Remote Sensing Agency indicated that paddy burning in Punjab alone contributed 261 giga gm (1 gg=1,000 tonne) of carbon mono dioxide, 19.8 gg of nitrogen oxide, and other gases to the atmosphere. It is estimated that India annually emits 144719 Mg of total particulate matter ($PM_{2.5}$ & $PM_{10}$) from open field burning of paddy residue biomass.

Jain et al, 2014 estimated that, on farm burning of 98.4 Mt of crop residues led to the emission of 8.57 Mt of CO, 141.15Mt of $CO_2$, 0.037 Mt of SOx, 0.23 Mt of NOx, 0.12 Mt of $NH_3$ and 1.46 Mt NMVOC, 0.65 Mt of NMHC, 1.21 Mt of particulate matter. $CO_2$ alone accounts for 91.6% of the total emissions. Out of the rest (8.43%) 66% was CO, 2.2% NO, 5% NMHC and 11% NMVOC (Figure 4). Burning of rice crop residue contributed the maximum (40%) to this emission followed by wheat (22%) and sugarcane (20%).

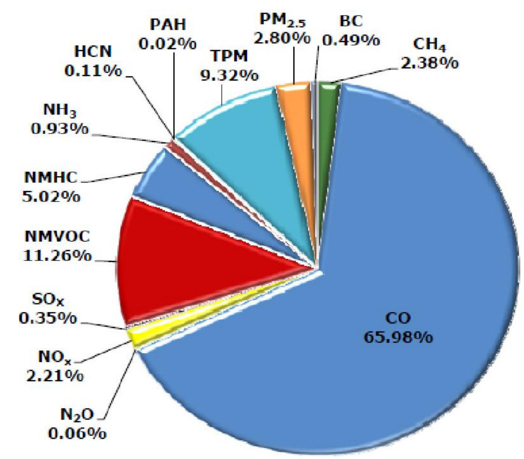


Figure 4: Emission of different pollutants and GHGs due to field burning of crop residues (Jain et al, 2014).

According to a study, open burning of crop stubble results in the emissions of harmful chemicals like polychlorinated dibenzo-p-dioxins, polycyclic aromatic hydrocarbons (PAH's) and polychlorinated dibenzofurans (PCDFs) referred to as dioxins. These air pollutants have toxicological properties and are potential carcinogens (Gadde et al 2009). Study conducted by V. Kumar et al, 2018 also suggests that the reactive compounds emitted and formed due to crop residue biomass burning drives ozone and organic aerosol formation, affecting both air quality and climate.

**4. Conclusion:**

The above discussed studies clearly establish that mass agricultural residue burning in the fields (in situ) is seriously damaging the environment. On farm burning of crop residue becomes a source of greenhouse gases ($CO_2$, CO, $CH_4$, $N_2O$, $SO_2$), aerosols, particulate matters, smoke, volatile organic compound and radioactive gases; thereby they exacerbate global and regional atmospheric chemistry. Furthermore, open burning of residue in the fields also leads to death of soil micro flora and fauna and may also damage nearby trees in addition to adjoining standing crops. The off-site impacts are health related due to general air quality degradation of the region resulting in aggravation of respiratory like cough, asthma, bronchitis, eye irritation, corneal opacity, pulmonary & cardiac problems and skin diseases. The black soot generated during burning also results in poor visibility which could lead to increased road side incidence of accidents.

Due to ever increasing problems associated with crop stubble burning in the north western states of India, several proposals for its proper management have been taken up in the past years. In situ soil incorporation, utilization in power plants, paper pulp industry, bio gas & bio-ethanol production and compost formation can be sustainable alternatives for crop residue burning.

Farming communities must be provided awareness and alternate opportunities by government authorities to manage crop residue biomass so that menace of open residue burning and associated air pollution problems can be combated.

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