

Greenhouse Gas Emission as a Result of Burning of Agricultural Residues in Karnataka

Omid Minooei^{1*} and S. Mokshapathy²

*Corresponding author email id: omid.minooee@gmail.com

Abstract — Burning of agricultural residues widely practiced in all over of India and bring Irrecoverable consequences such as Greenhouse gas emissions and health problems. So being aware of these consequences seems so necessary. Present study used the agro-residue biomass burning data during (2000-2004) in Karnataka. In addition, left dry matter, agro residue combustion and combustion efficiency percentages used to estimate CHG and atmospheric pollutant emission. Outcomes indicated as results of agro-residues burning, 6857.94 Gg of all kind of atmospheric pollutant would release to the atmosphere. Maximum emission by 4426.22 Gg and 64.5% share belonged to the rice residue burning. So controlling the agro-residues burning can be results to the decreasing the greenhouse gas emissions and other pollutant.

Keywords — Agro-Residue Combustion, Combustion Efficiency, Crop Harvest Management

I. INTRODUCTION

Burning fossil fuels results in the emission of carbon dioxide (CO₂), nitrous oxide (N₂O) and methane (CH₄) that act as barriers to thermal radiation and prevent it from leaving the Earth's atmosphere, the so called greenhouse effect (Aalde et al., 2006). As a consequence, the global mean temperature has increased during the past 100 years and raised concerns over global warming and uncertainty over future impacts on the climate (Pimentel et al., 1996).

All type use of energy would end to environmental issues, global security, source decline and economic growth issues as well. Emissions of sulphur and nitrogen oxides create acid pollution which may cause damage to buildings and plants, as well as acidification of soils, lakes, and rivers. Anthropogenic emissions of greenhouse gases enhance the natural greenhouse effect and may cause increased global mean sea level, changed vegetation zones, and retreated permafrost zones as the global mean temperature is raised. The strategic importance of oil in the world economy has been an important cause of political and military conflicts in the Middle East, where about two-thirds of the world's proven oil reserves are concentrated. These links have led to demands for major changes in the present energy systems (Barcena, 1992; Butlin, 1989).

As a general definition, open field burning is the burning of living and dead vegetation (Reid, Koppmann, Eck, & Eleuterio, 2005). Open field burning of crop residues is a human initiated activity to prepare the field for the next crop, remove residues, control weeds and release nutrients for the next crop cycle. The field burning of rice straw is commonly practiced in the region when there is a short duration to prepare the field for the next crop. Field burning is a process of uncontrolled

combustion during which carbon dioxide (CO₂), the principal product of the combustion, is emitted into the atmosphere along with carbon monoxide (CO), un-burnt carbon (as well as traces of methane i.e. CH₄), nitrogen oxides (NO_x) and comparatively less amount of sulphur dioxide (SO₂) (Gadde, Bonnet, Menke, & Garivait, 2009). In recent years, it has been observed that open burning of crop residues also contributes to emissions of harmful air pollutants, which can cause severe impacts on human health, including polycyclic aromatic hydrocarbons (PAHs) (Korenaga, Liu, & Huang, 2001), as well as polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs), referred to as dioxins (Gullett & Touati, 2003). These air pollutants have significant toxicological properties and are notably potential carcinogens. Air pollution not only affects human health and the environment, but also indirectly the economy of a country (Meesubkwang, 2007).

II. MATERIAL AND METHOD

In this study residues production data of some of the most important crops such as rice, sorghum, corn, sugarcane, cotton, all kinds of millets, peanut and wheat were extracted throughout the India biomass atlas. According to the IPCC instruction, air pollutant from agro-residues burning calculated (Aalde et al., 2006). So initially, Equation 1 was used to calculate the amount of burning agro-residues.

Equation 1:

$$FCRB = CRP * DMF * FB * CE$$

Where:

FCRB: fraction of crop residue burned in the field

CRP: crop residue production

DMF: dry matter fraction

FB: fraction burnt

CE: combustion efficiency

Fraction burnt in agricultural field in Karnataka for rice 0.5 is equivalent, sugarcane 0.25 and the other 0.1 equivalent considered. (Jain et al., 2014). agro-residue combustion efficiency of the rise (Turn et al., 1997; Aalde et al., 2006; Ni et al., 2015), Sorghum (De Zárate et al., 2000), maize (Turn et al., 1997; Ni et al., 2015), sugarcane (Aalde et al., 2006; Zhang et al., 2013), cotton and peanut (Aalde et al., 2006), millets (Braatz et al., 2013), and wheat (Turn et al., 1997; Ni et al., 2015) were derived from literature (Table 1).

After calculating the agro-residue burnt fraction in agricultural field, according to the equation 2, burnt crop residue emission was calculated.

Equation 2:

$$EBCR = FCRB * EF$$

Where:

EBCR: emission from burning crop residue

FCRB: fraction of crop residue burned in the field

EF: emission factor, all types of air pollutant

Emission factor depends upon the burning conditions like a using flammable materials and residues humidity, vary. (Reid et al., 2005; McMeeking et al., 2009; Chen et al., 2010). emission factor by examining the different research paper have been collected and brought in table 2. Products such as a rice, corn, sugarcane, cotton and wheat evaluated for their agro-residue burnt fraction in different sources .rice residues burnt fraction from (Jenkins et al., 1996; Turn et al., 1997; Gadde et al., 2009; Zhang et al., 2013; Ni et al., 2015)• corn from (Jenkins et al., 1996; Turn et al., 1997; Li et al., 2007; Cao et al., 2008; Ni et al., 2015)• sugarcane from (Zhang et al., 2013)•cotton from (Turn et al., 1997; Streets et al., 2003; Cao et al., 2008)and finally wheat from (Jenkins et al., 1996; Turn et al., 1997; De Zárate et al., 2000; Li et al., 2007; Cao et al., 2008; Ni et al., 2015) collected. Some pollutant like a BC, NMVOCs, NH₃, N₂O, CH₄ for corn, sugarcane, cotton, wheat and NH₃, NMVOCs and BC for rice, sorghum, peanut was not available in sources so emission factor for agricultural residues considered (default) according to the (Andreae and Merlet, 2001; Yamaji et al., 2010; Akagi et al., 2011; Yokelson et al., 2011; Kudo et al., 2014).in case of varied emission factor reported by different scientist, average emission factor used it.

III. RESULT AND DISCUSSION

Yearly biomass production of rice, sorghum, corn, sugarcane, cotton, millets, peanut and wheat brought up in Figure 1. Maximum biomass agro-residue production in one year respectively by 8677.3 kt/yr(30.3 %), 5871.4 kt/yr(20.5 %), 3894.1 kt/yr(13.6 %) and 3345 kt/yr(11.7 %) belonged to the rice, sorghum, cotton and corn. (Figure 1 & 2).Overall, atmospheric pollutant emission in result of burnt agro-residue biomass its equivalent to 6857.94 Gg. Rice has got the highest share with the 4426.22 Gg(64.5 %) and then sorghum corn, cotton, millet, sugarcane and peanut, residues respectively by 679.12 Gg, 387.99 Gg ,385.26 Gg, 331.96 Gg, 330.77 Gg and 286.06 Gg with share of 9.9, 5.7, 5.6, 4.8, 4.8, 4.2 percentage are in the next rank. (table 7, Figure 5). Since high percentage of CHG emitted it's because of rice residues burning, it seems to some kind of alternative plan such a burying in the ground and renewable energy production like a biogas ,apart from reducing the CHG emission, can have a so many side benefits.

IV. CONCLUSION

In this study depends on the Indian biomass atlas during 2000-04, agro-residue production and burnt agro-residue biomass for different crops such as a rice, sorghum, corn, sugarcane, cotton and wheat figured out. According to the different crops, agro-residue biomass production and burnt biomass are totally varied. So agro-residues biomass burnt

can be result of CHG emission, global warming and so many unwanted diseases. Therefore, estimating the air pollution emission and related downsides seems to be necessary. Agro-residue can be bury in the field or produce renewable energy. Accordingly warning the farmer about consequences of agro-residue burning and importance of burying the agro-residue in the ground due to the sustainable agriculture is crucial.

REFERENCES

- [1] Aalde, H., Gonzalez, P., Gytarsky, M., Krug, T., Kurz, W.A., Lasco, R.D., Martino, D.L., G., B., McConkey, Ogle, S., Paustian, K., Raison, J., Ravindranath, N.H., Schoene, D., Smith, P., Somogyi, Z., Amstel, A.v., Verchot, L., 2006. IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use, Chapter 2: Generic Methodologies Applicable to Multiple Land-Use Categories. 49.
- [2] Akagi, S., Yokelson, R.J., Wiedinmyer, C., Alvarado, M., Reid, J., Karl, T., Crouse, J., Wennberg, P., 2011. Emission factors for open and domestic biomass burning for use in atmospheric models. *Atmospheric Chemistry and Physics* 11, 4039-4072.
- [3] Andreae, M.O., Merlet, P., 2001. Emission of trace gases and aerosols from biomass burning. *Global biogeochemical cycles* 15, 955-966.
- [4] Braatz, B.V., Jallow, B.P., Molnár, S., Murdiyarslo, D., Perdomo, M., Fitzgerald, J.F., 2013. Greenhouse Gas Emission Inventories: Interim Results from the U.S. Country Studies Program. Springer Netherlands.
- [5] Butchaiah Gadde , Sebastien Bonnet , Christoph Menke , Savitri Garivait. Air pollutant emissions from rice straw open field burning in India, Thailand and the Philippines. *Environmental Pollution* 157 (2009) 1554–1558
- [6] Cao, G., Zhang, X., Gong, S., Zheng, F., 2008. Investigation on emission factors of particulate matter and gaseous pollutants from crop residue burning. *Journal of Environmental Sciences* 20, 50-55.
- [7] Chen, L.W.A., Verburg, P., Shackelford, A., Zhu, D., Susfalk, R., Chow, J.C., Watson, J.G., 2010. Moisture effects on carbon and nitrogen emission from burning of wildland biomass. *Atmos. Chem. Phys.* 10, 6617-6625.
- [8] De Zárate, I.O., Ezcurra, A., Lacaux, J., Van Dinh, P., 2000. Emission factor estimates of cereal waste burning in Spain. *Atmospheric Environment* 34, 3183-3193.
- [9] Gadde, B., Bonnet, S., Menke, C., Garivait, S., 2009. Air pollutant emissions from rice straw open field burning in India, Thailand and the Philippines. *Environmental Pollution* 157 1554-1558.
- [10] Gullett, B., Touati, A., 2003. PCDD/F emissions from burning wheat and rice field residue. *Atmospheric Environment* 37, 4893 4899
- [11] Jain, N., Bhatia, A., Pathak, H., 2014. Emission of air pollutants from crop residue burning in India. *Aerosol and Air Quality Research* 14, 422-430.
- [12] Jenkins, B., Turn, S., Williams, R., Goronea, M., Abd-el-Fattah, H., 1996. Atmospheric pollutant emission factors from open burning of agricultural and forest biomass by wind tunnel simulations. Volume 2. Results, cereal crop residues. Final report. California Univ., Davis, CA (United States).
- [13] Korenaga, T., Liu, X., Huang, Z., 2001. The influence of moisture content on polycyclic aromatic hydrocarbons emission during rice straw burning. *Chemosphere – Global Change Science* 3, 117–122
- [14] Kudo, S., Tanimoto, H., Inomata, S., Saito, S., Pan, X., Kanaya, Y., Taketani, F., Wang, Z., Chen, H., Dong, H., Zhang, M., Yamaji, K., 2014. Emissions of nonmethane volatile organic compounds from open crop residue burning in the Yangtze River Delta region, China. *Journal of Geophysical Research: Atmospheres* 119, 7684-7698.
- [15] Koopmans, A., Koppejan, J., 1997. Agricultural and forest residues – generation, utilization and availability. In: FAO (Ed.), *Regional Consultation on Modern Applications of Biomass Energy*. FAO, Kuala Lumpur, Malaysia.

- [16] Lin, L.-F., Lee, W.-J., Li, H.-W., Wang, M.-S., Chang-Chien, G.-P., 2007. Characterization and inventory of PCDD/F emissions from coal-fired power plants and other sources in Taiwan. *Chemosphere* 68, 1642-1649.
- [17] Li, X., Wang, S., Duan, L., Hao, J., Li, C., Chen, Y., Yang, L., 2007. Particulate and trace gas emissions from open burning of wheat straw and corn stover in China. *Environmental Science & Technology* 41, 6052-6058.
- [18] McMeeking, G.R., Kreidenweis, S.M., Baker, S., Carrico, C.M., Chow, J.C., Collett, J.L., Hao, W.M., Holden, A.S., Kirchstetter, T.W., Malm, W.C., 2009. Emissions of trace gases and aerosols during the open combustion of biomass in the laboratory. *Journal of Geophysical Research: Atmospheres* 114.
- [19] Meesubkwang, S., 2007. Chiang Mai's Polluted Air: Chiang Mai's Polluted Air Available from: <http://www.chiangmai-mail.com/212/news.shtml> (accessed in August 2007)
- [20] Ni, H., Han, Y., Cao, J., Chen, L.W.A., Tian, J., Wang, X., Chow, J.C., Watson, J.G., Wang, Q., Wang, P., Li, H., Huang, R.-J., 2015. Emission characteristics of carbonaceous particles and trace gases from open burning of crop residues in China. *Atmospheric Environment* 123, Part B, 399-406.
- [21] Reid, J.S., Koppmann, R., Eck, T.F., Eleuterio, D.P., 2005. A review of biomass burning emissions part II: intensive physical properties of biomass burning particles. *Atmos. Chem. Phys.* 5, 799-825.
- [22] Streets, D.G., Bond, T., Carmichael, G., Fernandes, S., Fu, Q., He, D., Klimont, Z., Nelson, S., Tsai, N., Wang, M.Q., 2003. An inventory of gaseous and primary aerosol emissions in Asia in the year 2000. *Journal of Geophysical Research: Atmospheres* 108.
- [23] Turn, S., Jenkins, B., Chow, J., Pritchett, L., Campbell, D., Cahill, T., Whalen, S., 1997. Elemental characterization of particulate matter emitted from biomass burning: Wind tunnel derived source profiles for herbaceous and wood fuels. *Journal of Geophysical Research: Atmospheres* 102, 3683-3699.
- [24] United Nations Conference on Environment and Development, Agenda 21, UNCED, P.O. Box 80, CH-1231 Conches, Switzerland (1992).
- [25] United Nations Commission on Environment and Development, *Our Common Future*, Oxford Univ. Press, Oxford (1989).
- [26] Yamaji, K., Li, J., Uno, I., Kanaya, Y., Irie, H., Takigawa, M., Komazaki, Y., Pochanart, P., Liu, Y., Tanimoto, H., 2010. Impact of open crop residual burning on air quality over Central Eastern China during the Mount Tai Experiment 2006 (MTX2006). *Atmospheric Chemistry and Physics* 10, 7353-7368.
- [27] Yokelson, R.J., Burling, I.R., Urbanski, S.P., Atlas, E.L., Adachi, K., Buseck, P.R., Wiedinmyer, C., Akagi, S.K., Toohey, D.W., Wold, C.E., 2011. Trace gas and particle emissions from open biomass burning in Mexico. *Atmos. Chem. Phys.* 11, 6787-6808.
- [28] Zhang, Y., Shao, M., Lin, Y., Luan, S., Mao, N., Chen, W., Wang, M., 2013. Emission inventory of carbonaceous pollutants from biomass burning in the Pearl River Delta Region, China. *Atmospheric Environment* 76, 189-199.

AUTHOR'S PROFILE



S. Mokshapathy
 Assistant Professor in MBA
 (Agri-Business Management),
 Institute of Development Studies,
 University of Mysore, Mysore
 Email: drsmokshapathy@yahoo.co.in



Omid Minooei
 Research Scholar, Agribusiness Management,
 Institute of Development Studies,
 University of Mysore, Mysore
 Email: omid.minooee@gmail.com

Table 1. Crop residue production and coefficients used for air pollutants emission from crop residue burning

Crop residue	Dry matter fraction	Fraction burnt	Combustion factor
Rice straw	0.86	0.5	0.89-0.93-0.8
Sorghum straw	0.88	0.1	0.8
Maize stalk	0.88	0.1	0.92-0.93
Sugarcane stalk	0.88	0.25	0.9
Cotton stalk	0.8	0.1	0.8
Millet straw	0.88	0.1	0.9
Groundnut stalk	0.8	0.1	0.8
Wheat straw	0.88	0.1	0.86-0.91

Table 2- Emission factors extracted from literature for air pollutants emitted of crop residue burning (g/kg dry fuel).

Air pollutants	Rice straw	Sorghum straw	Corn straw	Sugarcane residue	Cotton straw	Wheat straw	Other Crop residue
CO ₂	1280.0	1494.7	1342.0	1152.5	1430.0	1344.0	1494.7
CO	48.37	114.89	47.96	40.1	85.33	58.20	114.89
CH ₄	3.51	5.78	4.41	5.82	5.82	3.36	5.78
NM VOCs	6.05	12.56	10.40	9.42	9.42	7.48	12.56
N ₂ O	0.07	0.07	0.14	0.07	0.07	0.07	0.07
NH ₃	2.20	1.86	0.68	2.2	2.20	0.37	1.86
SO ₂	1.01	0.40	0.32	0.4	0.40	0.66	0.40
NO _x	3.47	3.64	2.53	5.3	2.50	2.81	3.64
PM _{2.5}	11.18	5.49	11.85	4.12	6.30	9.49	5.49
OC	1.95	2.80	3.38	1.25	3.01	3.74	2.80
BC	0.51	0.75	1.30	0.8	0.82	0.52	0.75

Table 3- Air pollutants Emissions from the field burning of crop residues (Gg) in the whole year

Pollutants	Rice straw	Sorghum straw	Maize stalk	Sugarcane stalk	Cotton stalk	Millet's straw	Groundnut stlk	Wheat straw	Total
CO ₂	4171.03	617.85	365.40	311.97	356.39	302.01	260.25	25.38	6413.50
CO	157.61	47.49	13.06	10.85	21.27	23.21	20.00	1.10	294.84
CH ₄	11.44	2.39	1.20	1.58	1.45	1.17	1.01	0.06	20.30
NM VOCs	19.71	5.19	2.83	2.55	2.35	2.54	2.19	0.14	37.53
N ₂ O	0.23	0.03	0.04	0.02	0.02	0.01	0.01	0.00	0.36
NH ₃	7.17	0.77	0.19	0.60	0.55	0.38	0.32	0.01	9.97
SO ₂	3.28	0.17	0.09	0.11	0.10	0.08	0.07	0.01	3.90
NO _x	11.29	1.50	0.69	1.43	0.62	0.73	0.63	0.05	16.97
PM _{2.5}	36.44	2.27	3.23	1.12	1.57	1.11	0.96	0.18	46.88
OC	6.35	1.16	0.92	0.34	0.75	0.57	0.49	0.07	10.65
BC	1.66	0.31	0.35	0.22	0.20	0.15	0.13	0.01	3.04
Total	4426.22	679.12	387.99	330.77	385.26	331.96	286.06	27.02	6857.94

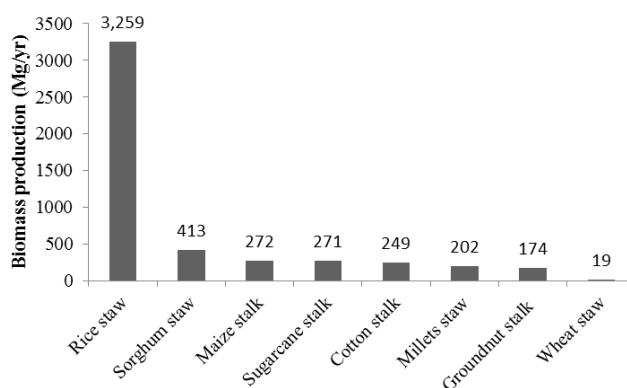


Fig. 1. Mass of burned crop residue (Mg/yr) in the Karnataka

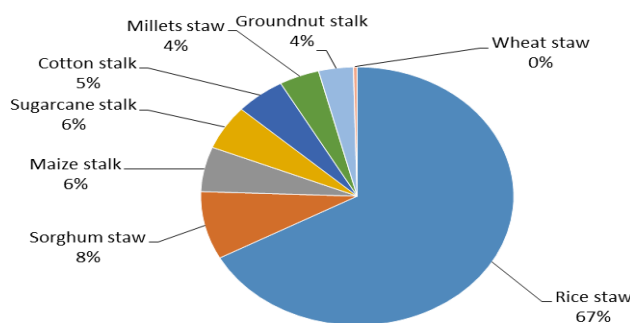


Fig. 2. The proportion of crop residue burned in the Karnataka

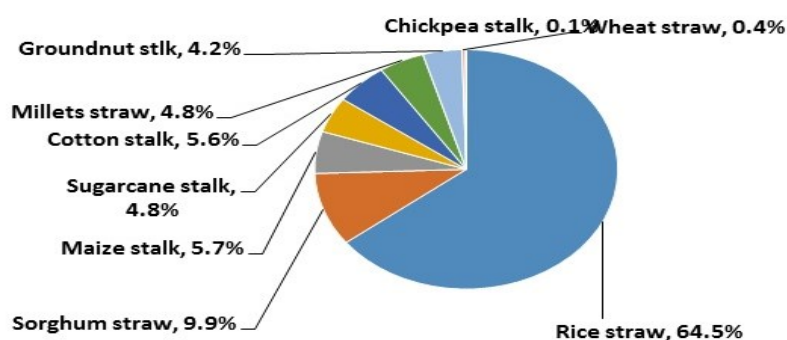


Fig. 3. Percent contribution of each crop residue in air pollutants emission in the Karnataka