Indian Journal of Air Pollution Control Vol. VIII No. I March 2008 pp 51-59

Air Pollution due to Burning of Agriculture Residue*

Sanjeev Agrawal, R.C. Trivedi, and B.Sengupta

Central Pollution Control Board, Parivesh Bhavan,
East Arjun Nagar, Delhi – 110032

Introduction

Nearly half of the World's Population and 75% of Indian Population depend on biomass for their energy needs for cooking. Main biomass types are trees, shrubs, crop residue, and dung. As per an estimate about 253 million tones per year of bio-fuels are used in the rural areas in the domestic sector, out of which 181 MT is estimated to be fuel wood, 40 MT crop residue (the fuel potential per year of crop residue is estimated to be 52 MT, out of which 40 MT per year of crop residue is used as fuel), and 32 MT dung cake. Forests contribute about 32% of fuel wood, and the rest comes from various other sources. Cooking consumes about 95% of total rural biomass energy. Besides the above, other major components of biomass burning are forest fires, burning of agricultural residue e.g. cereal straws, woody stalks, and sugarcane bagasse etc. in the fields, and burning of wood and dung cakes for heating.

Air Pollution due to Agricultural Burning

Data for Rice and wheat crop production and residue generation from the major Indian States has been collected for the year 1994, and the same is given in Table 1. It may be seen that U.P. produces the maximum followed by Punjab. Residue burning practice is followed in both of these States. Agricultural residue burning in the fields and used otherwise for rural domestic needs is responsible for a large number of toxic emissions, which are a health hazard.

The main pollutants contributed from biomass burning are aerosols (black carbon, organic carbon, organic matter, PM10 and PM2.5), and gases like carbon dioxide, carbon monoxide, sulphur dioxide, oxides of nitrogen, methane, non-methane volatile organic carbon and ammonia. Table 2 gives all-India emissions of some of the gaseous pollutants from rice and wheat residue open burning for the years 1994 and 2000. It may be seen that the emissions for the two years are almost the same. The quantities of the air pollutants generated globally and in India have also been estimated and are given in Tables 3 & 4. It may be seen from these Tables that the emissions from the burning of agricultural residues constitute a large part of the total emissions.

Health Effects

Airborne particulates and other gaseous emissions can lead to health risk. Particularly they can aggravate asthma and chronic bronchitis, decrease lung function, and can develop increase in respiratory symptoms like coughing and difficult or painful breathing, leading ultimately to premature death. Particulate matter can also develop visibility impairment in the eyes. Suspended fine particulate matter develops Haze in the atmosphere. This haze results in decreased visibility, decreased photosynthesis, and enhanced atmospheric deposition. All these adversely affect wild life and vegetation. Besides, particulates and acidic gases result in general aesthetic damage. Figures 1 & 2 show the health effects of particulate matter on tissues.

Management Practices to Control Air Pollution due to Agricultural Burning

Broadly speaking there are various remedial measures that can be adopted to control air pollution due to agricultural residue burning. These measures can be:

- Nationwide mass awareness programme to educate farmers about adverse impact of such activities and economic value of the agricultural residues;
- Commercial use of agriculture residues for recovering energy, material, and nutrients without adverse impact on environments;
- To use the agricultural residues for alternate options. These are Industrial use (in Paper industry, Pulp industry – rayon fibers etc., and Ethanol production), as a Bio-compost Manure, and as a Fodder;

Paper presented in the workshop on Agricultural Waste Burning held at PAU, Ludhiana on 29/07/2006

Table 1. Rice and wheat crop production and residue generation from major states in 1994 (Gg)

	Rice		Wheat		Total	
States - 1994	Production	Residue	Production	Residue	Production	Residue
UP	10326	13284	22126	33189	32452	46473
Punjab	7688	9890	13501	20251	21189	30141
MP	6308	8115	7151	10727	13459	18842
Bihar	6251	8041	4296	6443	10547	14484
Haryana	2185	2810	7285	10928	9470	13738
Maharashtra	2419	3112	1097	1646	3516	4758
Gujarat	916	1179	1704	2555	2620	3734
HP	110	141	553	829	663	970
All India	81435	88474	64285	96428	145720	184902

Table 2. Comparison of all-India emissions from rice and wheat residue open burning in 1994 and 2000 (Gg)

Year	CH_4	CO	N_2O	NO_x
1994	102	2138	2.2	78
2000	110	2305	2.3	84

Table 3

Burning's contribution to global emissions

Comparison of global emissions from biomass burning with emissions from all sources, including biomass burning *(2)*.

Species	Biomass burning (Tg element/year)	All sources (Tg element/year)	Biomass burning, %
Carbon dioxide (gross)	3500	8700	40
Carbon dioxide (net)	1800	7000	26
Carbon monoxide	350	1100	32
Methane	38	380	10
Nonmethane hydrocarbons*	24	100	24
Nitric oxide	8.5	40	21
Ammonia	5.3	44	12
Sulfur gases	2.8	150	2
Methyl chloride	0.51	2.3	22
Hydrogen	19	75	25
Tropospheric ozone	420	1100	38
Total particulate matter	104	1530	7
Particulate organic carbon	69	180	39
Elemental carbon (black soot)	19	<22	>86

*Excluding isoprene and terpenes.

3

Table 4

Estimated Quantity of Air Pollutants Generated in India, Venkataraman et. al. 2006

• **Aerosols**	
– Black carbon	• 86-372, Gg/yr
– Organic carbon	• 211-970, Gg/yr
– Organic matter	• 444-1639, Gg/yr
– PM2.5	• 572-2393, Gg/yr
• **Gases**	
– CO_2	
– CO	• 175-579, Tg/yr
– SO_2	• 10-74, Tg/yr
– NOx	• 46-172, Gg/yr
– Methane	• 289-1290, Gg/yr
– Non-methane volatile organic	• 313-1164, Gg/yr
carbon	• 1818-6767, Gg/yr
– NH_3	• 151-560, Gg/yr
– Total Biomass Burned	• 116-289, Tg/yr

7

Health Effects

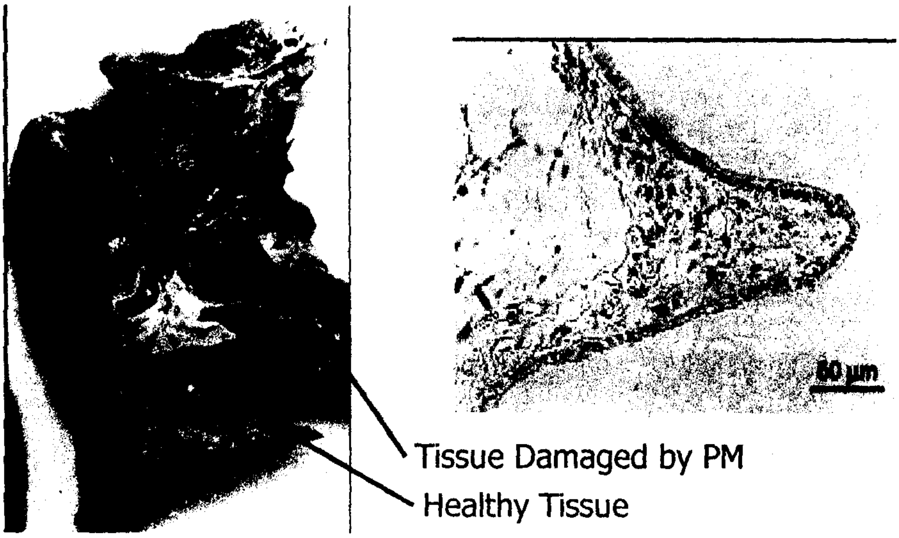

Figure 1

25

Health Impact of PM

Figure 2. Scanning electron micrograph of interstitial macrophages from case 1 loaded with an abundance of PM.

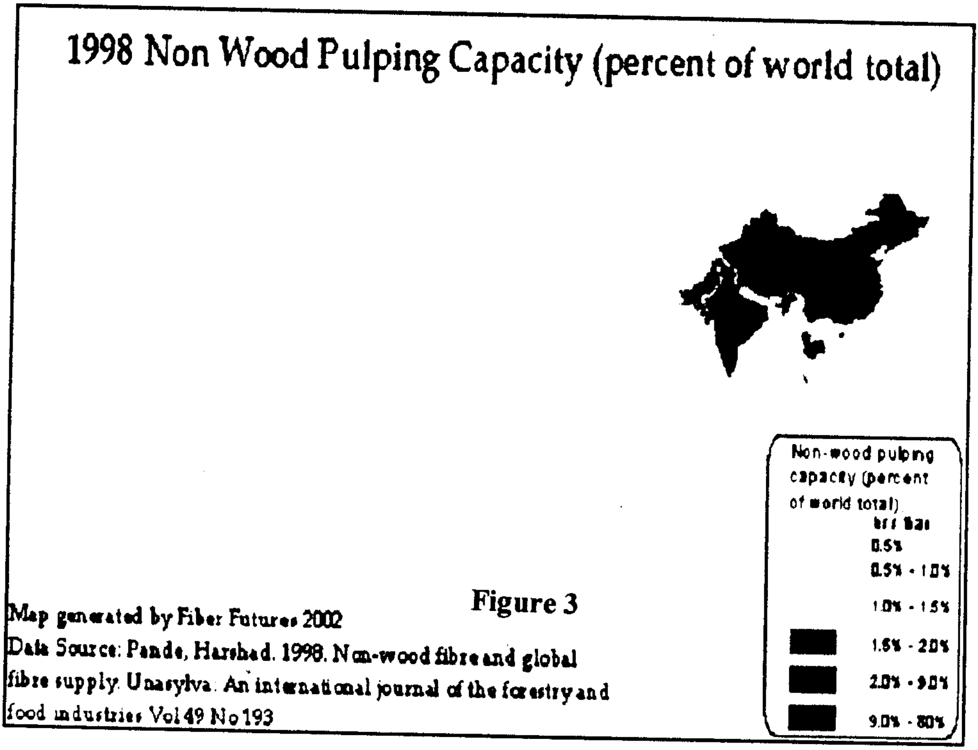
1998 Non Wood Pulping Capacity (percent of world total)
Non-wood pulping capacity (percent of world total)
0.5%
0.5% - 1.0%
1.0% - 1.5%
1.5% - 2.0%
2.0% - 9.0%
9.0% - 80%
Map generated by Fiber Futures 2002
Data Source: Pande, Harshad. 1998. Non-wood fibre and global fibre supply. Unasylva: An international journal of the forestry and food industries Vol 49 No 193

Figure 3

Table 5

India's green and dry fodder availability and projected requirements (million tons)

	Availability	Requirement	Shortfall (%)
Current			
Dry fodder (crop residues)	398.88	583.62	31.0
Green fodder	573.50	74.73	23.0
Concentrates	41.98	79.40	47.1
Required by 2000			
Dry fodder	523.61	632.61	17.3
Green fodder	573.50	830.12	31.0
Concentrates	46.18	88.05	47.6

Source: Draft Report of the Policy Advisory Group on Integrated Grazing Policy, Ministry of Environment and Forest, Govt of India, 19

Table 6

Chemical composition of some common Indian crop residues

Crop residue	Percentage composition			
	Organic matter	Crude protein	Crude fibre	Ash
Rice straw	82.0	4.0	37.0	18.0
Wheat straw	-	3.5	-	7.5
Finger millet straw	90.6	3.7	36.5	7.2
Sorghum stover	90.8	4.2	33.3	7.3
Maize stover	89.0	4.6	32.0	7.1
Sugar cane tops	92.55	5.0	32.0	8.5

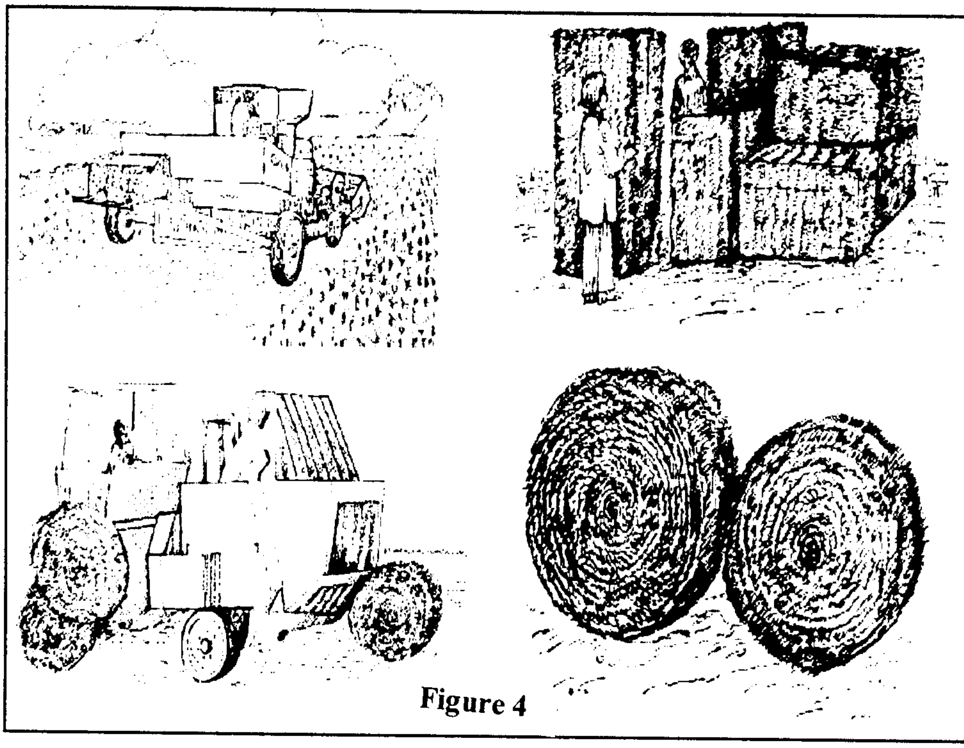

Figure 4

Table 7 Straw Production and End Use in Punjab, India		
Description	Rice straw	Wheat straw
Production ('000 t)	9832	18972
End use (% to total)		
Fodder	6.5	42.6
Manure	0.9	0.2
Burned	81.4	48.2
Sold	4.8	8.1
Miscellaneous	5.8	1.0

United States Policy on Agriculture burning

Under Smoke Management Programme (SMP), The recommended Policy is two-tiered.

Tier One: it is a voluntary program for areas where agricultural burning rarely causes or contributes to air quality problems. The SMP establishes conditions (time of day and year, meteorological conditions, safety parameters, type of burn, maximum number of acres, etc.) under which agricultural burning can occur. It is essentially a permit by rule.

Tier Two: It is designed for areas where agricultural burning contributes to particulate matter exceeding National Ambient Air Quality Standards or visibility impairment in Class I Federal areas (Areas set aside under the Clean Air Act to receive the most stringent protection from air quality degradation.) The SMP would include a process for authorizing/granting approval for agricultural burns and establish criteria for burn/no-burn decisions. Detailed permitting requirements such as a real-time meteorological assessment for burn decisions, air quality monitoring, public notification, and enforcement.

27

Air Pollution and Biomass Burning In India & Abroad Studies carried out so far (References)

✓Venkatraman et.al. (June 2006)- Emissions from open biomass burning in India: Integrating the inventory approach with high-resolution Moderate Resolution Imaging Spectroradiometer (MODIS) active-fire and land cover data;

✓Ferek, R. J., S. Reid, P. V. Hobbs, D. R. Blake, and C. Liousse (1998), Emission factors of hydrocarbons, halocarbons, trace gases and particles from biomass burning in Brazil.

✓Joshi, V. (1991), Biomass burning in India, in Global Biomass Burning: Atmospheric, Climatic, and Biospheric Implications, edited by J. S. Levine.

✓Kaul, O. N. (1993), Forest biomass burning in India, in Global Climate Change: An Indian Perspective, edited by A. N. Achanta. Tata Energy Res. Inst., New Delhi.

✓Kaul, O. N., and V. N. Shah (1993), Grassland biomass burning in India, in Global Climate Change: An Indian Perspective, edited by A. N. Achanta. Tata Energy Res. Inst., New Delhi.

✓Ministry of Environment and Forests (2004), GHG Inventory information, in India's Initial National Communication to the United Nations Framework Convention on Climate Change, Government of India, New Delhi, India. (Available at http://www.natcomindia.org/ pdfs/chapter2.pdf)

✓Ravindranath, N. H., and D. O. Hall (1995), Biomass, Energy and Environment: A Developing Country Perspective from India.

✓ Reddy, M. S., O. Boucher, and C. Venkataraman (2002), Seasonal carbonaceous aerosol emissions from open biomass burning in India.

✓Streets, D. G., K. F. Yarber, J.-H.Woo, and G. R. Carmichael (2003a), Biomass burning in Asia: Annual and seasonal estimates and atmospheric emissions, Global Biogeochem. Cycles.

28

- To undertake more scientific studies in order to estimate the magnitude of the problem. These scientific studies can be dispersion modeling (localized and long-range or air shed), determination of emission factors, development of emission reduction and monitoring techniques, and pollution emission rates; and
- To carry out studies of health impact of residue burning.

Use in Industries: In the paper and pulp industries, India is the second largest user of non-wood raw material for paper manufacturing. Non-wood pulping capacity as a percent of the world total in the Asian countries including India is shown in Fig.3. Bio-ethanol and Rayon and other Fibers can also be commercially manufactured using the agriculture residues, however, manufacturing of these products has not yet been initiated. After pelletization, the material can also be used as fuel for domestic needs as also for electricity generation.

Use as Manure: Agricultural residues can also be effectively used to make Bio-compost, which has more nutrient value. Burying the residues in the fields also works as a soil conditioner. It has been seen that in Rice – Wheat cycle, a yield of 7 T/Ha and 4 T/Ha respectively removes from the soil more than 300 kg/Ha of Nitrogen, 30 kg/Ha of Phosphorus, and 300 kg/Ha of Potash. Out of this the crop residue contains 25% of Nitrogen and Phosphorus, 50% of Sulphur and 75% of Potash.

In the traditional farming practices a major part of the residues were returned back to the fields, but after the introduction of mechanized harvesting this has been discontinued. Crop residues are an obstruction in ploughing and hence are burnt. Manufacturing Bio-compost from the agricultural residues and use of this Bio-compost as manure can help in the recovery of richness of the soil.

Use as a Fodder: Dairy production has increased four fold during the last 30 years, and scarcity of fodder is being felt to a large extent. The availability of green and dry fodder in India at present and the projected requirements in million tones are shown in Table 5. It may be seen from this Table that the requirements have increased sizably over the current availability. Further, although dry Wheat Straw and Rice Straw are used as fodder, however they are poor in nutrients due to the presence of lignin in it. The chemical composition of some of the common Indian crop residues is given in Table 6.

The straws can be used as effective fodders after supplementing them with additional nutrients and improved digestibility (caustic soda treatment). The present position of straw production and its end use in Punjab is shown in Table 7. It is seen from this Table that mostly wheat straw is used as fodder (about 42%), and most of the rice straw (about 61%) is burnt. Nearly half of the wheat straw (48.2%) produced in Punjab is also burnt, and only a nominal quantity of these straws is used for making bio-compost manure.