12 CREMATORIA

The cremation of body is a religious ceremony performed for final disposition of dead body mainly by Sikhs, Jains and Hindus in India. This involves open air funeral pyre made of wood on which dead body is laid and burned. The process results in deforestation and air pollution. In this study, we have estimated the crematoria emissions from wood burning activity only. Earlier studies in India have also reported the emission from the crematorium based on the wood burning activities; however, these studies are mostly based on the city-specific emission inventory, e.g., Delhi, Kanpur. Malik and Sharma (2016) reported less than 1% of total emissions of PM_{10} and $PM_{2.5}$ from the wood burning activities in crematorium. However, TERI (2018) has reported 1% annual PM_{10} and $PM_{2.5}$ emissions in Delhi-NCR from the wood burning in crematoria.

In this study, we calculated the emissions from crematoria at rural-urban level in each district of India. For this we used the 2011 census projected population for 2016 at the rural-urban level of each district. Further, the fraction of Hindus and Sikhs in each district was calculated by using district-wise religious population data of 2011 census. Here the assumption was made that the fraction remained constant from 2011 to 2016. The data of death rate by residence of each state (NITI Ayog, 2017b) was used for each district of respective state in combination with the fraction of Hindu and Sikh population, for estimating the deaths of Hindus and Sikhs in each district in rural-urban areas.

The amount of wood burnt in crematoria of a district is calculated using Eq. 37:

$$TW_d = \sum_{i=1}^{2} P_i \times F_i \times DR_i \times W \qquad (37)$$

where, TW is the total amount of wood burned in kg; P is the total population; F is the fraction of Hindu and Sikhs in the population; DR is the death rate (Table 38); and W is the amount of wood required for each cremation. Different literature has reported the amount of wood required for each cremation in the range of 200 kg to 600 kg (Patel, 2018; Bedge et al., 2016; Sharma, 2016; Kermeliotis, 2011; Sharma, 2010); based on TERI survey during 2016 at fifty crematoria in Delhi, we have taken the value of W as 350 kg in this study; i: Represents rural-urban area of each district.

Table 38 Death rate (percent of total population) by residence for the year 2016

State	Death Rate	State	Death Rate
Andhra Pradesh	6.8	Mizoram	4.2
Arunachal Pradesh	6.2	Nagaland	4.5
Assam	6.7	Odisha	7.8
Bihar	6.0	Punjab	6.0
Chhattisgarh	7.4	Rajasthan	6.1
Delhi	4.0	Sikkim	4.7

State	Death Rate	State	Death Rate
Goa	6.7	Tamil Nadu	6.4
Gujarat	6.1	Telangana	6.1
Haryana	5.9	Tripura	5.5
Himachal Pradesh	6.8	Uttar Pradesh	6.9
Jammu and Kashmir	5.0	Uttarakhand	6.7
Jharkhand	5.5	West Bengal	5.8
Karnataka	6.7	Andaman and Nicobar Islands	5.2
Kerala	7.6	Chandigarh	4.5
Madhya Pradesh	7.1	D&N Haveli	4.0
Maharashtra	5.9	Daman & Diu	4.6
Manipur	4.5	Lakshadweep	6.0
Meghalaya	6.6	Puducherry	7.2

Source: NITI Aayog (2017b)

Further, the emissions were calculated by Eq. 38:

$$E_p = \sum_{s=1}^{n} \sum_{d=1}^{n} TW_d \times EF_p \quad (38)$$

where, EF: Emission factors (Table 39); s: number of states; and d: number of districts.

Table 39 Emission factors of different pollutants due to open burning of wood

Pollutant	PM_{10}	$PM_{2.5}$	SO_2	NO_x	NMVOC
g/kg	18.5	9.1	0.4	2.5	51.9

Source: Malik et al. (2016) and Akagi et al. (2011)

12.1 Emission inventory of different pollutants from crematoria

The resultant values from crematoria burning shows expected results with NMVOCs being emitted most followed by particulate matters (PM_{10} and $PM_{2.5}$) as compared to other pollutants (Table 40). The results show more emission from states with higher population and lower emissions are seen from states where Hindu-Sikh population is less (Figure 16).

Table 40 Emission of different pollutants from the crematoria in different states during 2016

State	PM_{10} (Gg)	$PM_{2.5}$ (Gg)	SO_2 (Gg)	NO_x (Gg)	CO (Gg)	NMVOC (Gg)
Andaman and Nicobar Islands	0.009	0.005	0.000	0.001	0.046	0.026
Andhra Pradesh	2.159	1.062	0.047	0.298	10.853	6.057
Arunachal Pradesh	0.011	0.005	0.000	0.001	0.054	0.030
Assam	0.896	0.441	0.019	0.124	4.505	2.514
Bihar	3.911	1.924	0.085	0.539	19.659	10.971
Chhattisgarh	1.317	0.648	0.028	0.182	6.622	3.696
Goa	0.049	0.024	0.001	0.007	0.245	0.137
Gujarat	2.492	1.226	0.054	0.343	12.526	6.990
Haryana	1.039	0.511	0.022	0.143	5.222	2.914
Himachal Pradesh	0.311	0.153	0.007	0.043	1.562	0.872
Jammu and Kashmir	0.154	0.076	0.003	0.021	0.777	0.433
Jharkhand	0.875	0.430	0.019	0.121	4.400	2.455
Karnataka	2.627	1.292	0.057	0.362	13.207	7.371
Kerala	1.054	0.518	0.023	0.145	5.297	2.956
Lakshadweep	0.000	0.000	0.000	0.000	0.000	0.000
Madhya Pradesh	3.506	1.725	0.076	0.483	17.627	9.837
Maharashtra	4.055	1.995	0.088	0.559	20.387	11.377
Manipur	0.037	0.018	0.001	0.005	0.187	0.104
Meghalaya	0.011	0.006	0.000	0.002	0.057	0.032
Mizoram	0.000	0.000	0.000	0.000	0.002	0.001
Nagaland	0.004	0.002	0.000	0.001	0.020	0.011
NCT of Delhi	0.218	0.107	0.005	0.030	1.096	0.611
Odisha	2.198	1.081	0.048	0.303	11.047	6.165
Puducherry	0.057	0.028	0.001	0.008	0.285	0.159
Punjab	1.122	0.552	0.024	0.155	5.638	3.146
Rajasthan	2.801	1.378	0.061	0.386	14.083	7.859
Sikkim	0.014	0.007	0.000	0.002	0.070	0.039
Tamil Nadu	3.085	1.517	0.067	0.425	15.506	8.653
Telangana	1.379	0.678	0.030	0.190	6.933	3.869
Tripura	0.108	0.053	0.002	0.015	0.544	0.304
Uttar Pradesh	8.388	4.126	0.181	1.156	42.164	23.530
Uttarakhand	0.444	0.218	0.010	0.061	2.231	1.245
West Bengal	2.367	1.165	0.051	0.326	11.901	6.642
Total	47	23	1	6	235	131

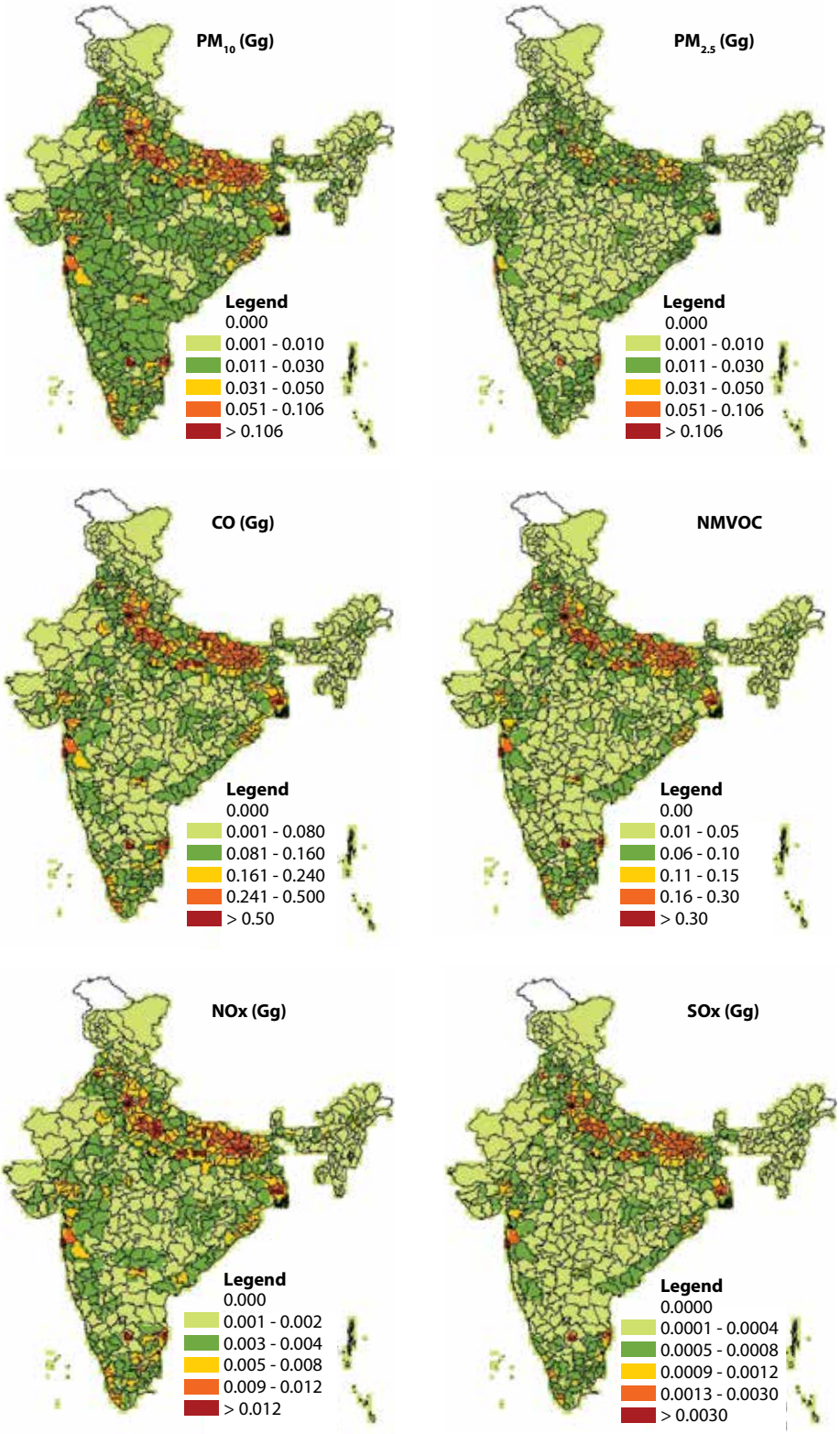

Figure 16 Spatial variations of atmospheric particulate emissions from crematoria during 2016