

Emissions of volatile organic compounds from ritual burning practices

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Worshipping activity is a customary practice related with many religions and cultures in various Asian countries, including India. Smoke from burning in religious and ritual places produces a large number of health-damaging and carcinogenic air pollutants include volatile organic compounds (VOCs) such as formaldehyde, benzene, 1, 3 butadiene, styrene, etc. This study evaluates real-world VOC's emission conditions in contrast to other studies that examined emissions from specific types of incense or biomass material. Sampling was conducted at four different religious places in Raipur city, District Raipur, Chhattisgarh, India: 1) Hindu Temples, 2) Muslim Graveyards (Holy shrines), 3) Buddhist Temples, 4) Marriage Ceremony. Concentrations of selected VOC's, Respirable Particulate Matter (RPM, aerodynamic diameter <5 µm), carbon dioxide (CO₂), and carbon monoxide (CO) were sampled from the smoke plumes. The Emission Factor (EF) has been determined by:

$$EF_j (\text{g.kg}^{-1}) = \frac{\Delta C_j \times 1000 (\text{g.kg}^{-1}) \times C_{\text{Fraction}}}{(\Delta \text{CO}_2\text{-C} + \Delta \text{CO-C} + \Delta \text{THC-C} + \Delta \text{PM-C})}$$

EF_i= Emission Factor of pollutant x in g.kg⁻¹
 ΔC_i = background-corrected concentration of pollutant x in mg.m⁻³
 $\Delta \text{CO}_2\text{-C}$ = mass fraction of C in CO₂ in mg.m⁻³
 $\Delta \text{CO-C}$ = mass fraction of C in CO in mg.m⁻³
 $\Delta \text{THC-C}$ = mass fraction of C in total hydrocarbon in mg.m⁻³

$\Delta \text{PM-C}$ = mass fraction of C in particulate matter in mg.m⁻³

C_{Fraction} = carbon content in dry material

Benzene has shown highest emission factor (EF) among selected volatile organic compounds in all places. All the selected religious and ritual venues have shown different pattern of VOC EF's compared to laboratory based controlled chamber studies.

Table: Emission Factor (g.kg⁻¹) of measured gaseous pollutants and respirable particulate matter for Indian different religious based burning activities

Species Sites	CO ₂	CO	RPM
Marriage Ceremony	2711.70±274.49	190.36±23.76	47.38±5.90
Muslim Graveyards	352.20±6.38	78.78±11.82	30.69±2.64
Buddhist Temple	1240.98±159.88	213.39±26.94	33.09±2.76
Hindu Temple	687.57±98.78	1.72±0.23	18.12±2.05

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