SAFAR -India
(System of Air Quality and Weather Forecasting and Research)
Indian Institute of Tropical Meteorology, Pune
Ministry of Earth Sciences
Government of India

Executive Summary

High Resolution Emission Inventory of Major Air Pollutants of Mega City DELHI for 2018 under SAFAR (System of Air Quality and Weather Forecasting and Research)

*(**Lead Reference**: Gufran Beig et al., SAFAR-High Resolution Emission Inventory of Mega City DELHI for 2018, Special Scientific Report, SAFAR-Delhi-2018-A, ISSN: 0252-1075, Publ.- IITM-Pune, Ministry of Earth Sciences (Govt. of India), 2018.)*
***Note:** For other related emissions inventory references, see peer-reviewed publication given at the end.*

Preamble: Clean air is a basic necessity for human health and well-being. When the local concentrations of air pollutants exceed certain threshold limit, it can have adverse effect on the health of human beings, plants and animals. Most of the mega-cities all over the world are experiencing the deterioration of air quality, including National Capital Territory of Delhi. The pollutants are added to the environment through **emissions** of various natural as well as anthropogenic sources. The anthropogenic emission (man-made.) is on the rise. **Emission Inventory** is a comprehensive listing by local sources of air pollutant emissions and amount of air pollutants released into air as a result of a specific process in a particular geographic region during a specific time period. This is one of the most critical factors required for air pollution forecasting models along with meteorological input to forecast the air quality and frame the mitigation strategy. Quality of forecasting depends on accuracy and reliability of emission estimation. Emission inventories could also be used for air quality management and formulating environmental policy.

Development of emission inventory is a complex process due to numerous, diverse and widely dispersed emission sources in city like Delhi and its adjacent region and requires huge amount of high-resolution activity data, emission factors along with knowledge of fundamental scientific processes. A mega emission inventory campaign involving around 150 students under the supervision of group of scientists mapped all possible local sources of air pollution with around 37,500 hours of work. The main focus of the campaign was to generate missing primary data, validate some uncertain secondary data and to collect the available secondary data. The final product with 400m x 400m high-resolution emission inventory of Delhi and fringe area of eight important air pollutants (PM2.5, PM10, NOx, CO, SO_2, BC, OC, VOCs) is prepared. Emissions are estimated for two specific regions- (a) The geographical area of Delhi city only and (b) Delhi city area along with surrounding regions measuring 70x65 km^2. Ground level activity data about emissions from as many as 26 different sources of pollution were collected. The emission inventory campaign has been led by Indian Institute of Tropical Meteorology (IITM) Pune under the Ministry of Earth Sciences along with experts and researchers from Utkal University, Bhubneshwar, School of Planning and Architecture, Environmental Information System (ENVIS) Resource Partners of MoEFCC, CPCB, IMD and DPCC.

For the development of emission inventory, a bottom up approach has been used for which a Geographical Information System (GIS) based statistical model approach has been developed by our

scientists at IITM to prepare high-resolution gridded emission inventory. During the campaign, information related to following major/minor activities were collected:

No.	Sectors	Important Factors and data
1	Transport	• Category, Fuel Type & Quantity • Vehicle/hour/Road type/VKT
2	Slum	• Type and Fuel used Quantity for cooking
3	Brick Industry	• Type, Technology and Fuel used Quantity
4	Street Vendor	• Type and Fuel Quantity • Coal for Tandoor
5	Hotel (Dhabas)	• Type of Fuel & Quantity used for cooking
6	Construction Sites	• Type of Fuel & Quantity used for cooking activity
7	Speed Breaker	• No. of Speed Breakers per Km • Road Type
8	Major Hospitals	• Number of outdoor patients • Vehicle load and DG sets
9	Tourist places	• Tourist Load, Vehicle load
10	Shopping Malls	• No. of vehicle parked
11	Traffic Junctions	• No. of Traffic Junctions
12	Railway Stations	• Passenger load • Vehicle load in station area
13	Airport	• Vehicle No. (Delhi & Out-side vehicle No.)
14	Industry	• Type, Technology and Fuel used
15	Local Transport (Ola/Uber/Taxi)	• Km run per day and Numbers
16	Household	• Type of fuel used
17	Waste Burning	• Quantity per capita
18	Biomedical Waste	• Quantity generated
19	Power plant	• Technology used, Coal used
20	Crematorium	• Spatial locations, No. of Cases
21	Large hotels	• Fuel used for cooking
22	Large school/college	• Students no. & Travel load
23	Wind Blown Road Dust	• Road condition, vehicle load etc.
24	Diesel Generator	• Fuel used for no. of hours
25	Mobile tower	• Fuel Used & numbers
26	Routine Milk & Vegetable Van	• No of vehicle (outside)

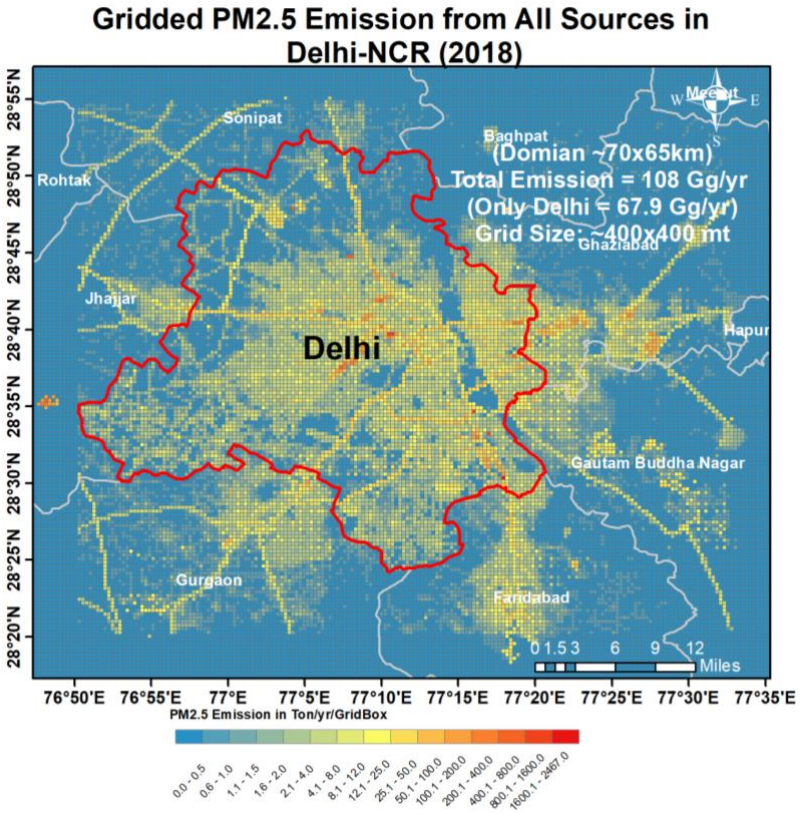
As the vehicular density is remarkably high in NCR region, to find out the exact traffic volume the vehicle numbers were calculated by using click counters in different major and minor roads of the NCR region. Having near about 2250 kms of major roads and 31000kms of minor roads. Major vehicle dense roads contributing to pollution were identified and information were recorded.

Results and Findings**:** The summary of the estimated emission of all 8 pollutants for 2018 for a broader region of Delhi and surrounding areas (70x65 km2) is been given in a table below. Here, brief discussion is done on a specific pollutant $PM_{2.5}$ that would be a case study to describe the similar contribution of other pollutants in this study. The estimated total emission of $PM_{2.5}$ for Delhi-NCR domain is calculated to be around **107.786** Gg/yr in 2018. Transport sector and industrial sector are playing major role in PM2.5 emission by contributing around **42.230** Gg/yr and **24.10** Gg/yr respectively to the total emission. Windblown dust is contributing around **19.50** Gg/yr followed by residential sector **6.2** Gg/yr and thermal power plants (**3.34** Gg/yr). High emission of $PM_{2.5}$ in the range of **10-50** ton/yr is found

over eastern, central, some part of southeastern part of Delhi-NCR, which includes major dense roads network and industrial and residential zones. Emission of the order of 200-1000 ton/yr is found over industrial zone next to major roads. Large Point Sources like thermal power stations and WSM plants are some of other highly emitted zone. Western and northern region of Delhi shows comparatively lower value of $PM_{2.5}$ emission in the range of 0.6-8.0 ton/yr due to large agricultural lands, less number of industries followed by low population density leading to minimum emission. ***The residential emission has reduced drastically due to penetration of LPG connection in slums (95%) and household. The MSW related pollution is emerging as new challenge to tackle air quality issue in Delhi.***

RELATIVE SHARE OF PM2.5 EMISSIONS AMONG ALL SOURCES IN DELHI DURING 2018-19		
SECTORS	Relative Share 2018 DELHI (%)	Percent Growth /decline in 2018 wrt 2010 in Delhi (%)
Transport	41 %	+40 (Increase)
Industry	18.6	+48 (Increase)
Power	4.9	+16 (Increase)
Bio-fuel*	3.0	-64 (Decline)
Re-suspended Dust	21.5	-26 (Decline)
Rest Others#	11.0	Additional (New Sources)
		Overall Change = +15%

***Bio-fuel Sector includes-** Residential cooking, Slum, Trash. burning, Cow Dung, Street Vendor, Household, Wood burning, etc.*
***#Rest Other Sector includes-** MSW Plants, MSW Open Burning, Crematory, Aviation, Incense Stick, Brick Klin, etc.*



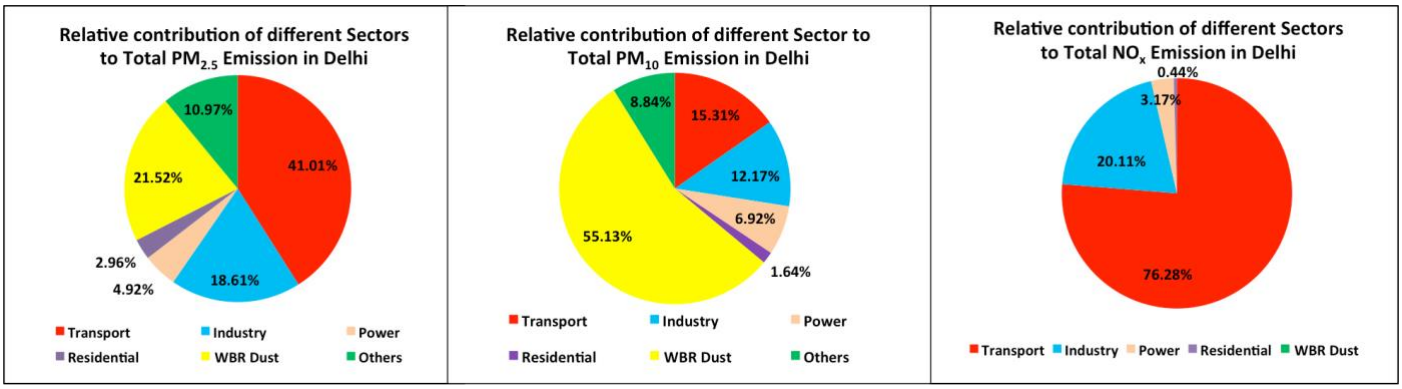


Figure: Relative contribution of various broad categories of local sources of emissions in PM_{10}, $PM_{2.5}$ and NO_x in Delhi NCT. Other includes all those sector not included in top 5 categories and defined above, mainly new one considered in 2018.

More references on Emission Inventory of Delhi

1. *Gufran Beig, S.K. Sahu, V. Singh, S. Tikle, S.B. Shobhna, P. Gargeva, K. Ramakrishna, A. Rathod, and B.S. Murthy, Objective evaluation of stubble emission of North India and quantifying its impact on air quality of Delhi,* ***Science of the Total Environment****, https://doi.org/10.1016/j.scitotenv.2019.136126, 2020.*
2. *Gufran Beig, M.P. George, S. K. Sahu, A. Rathod, S. Singh, S. Dole, B.S. Murthy, R. Latha, S. Tikle and R. Shinde, Towards baseline air pollution under COVID-19: implication to chronic health and policy research for Delhi, India,* ***Current Science,*** *119, 2020.*