DEATH IN EVERY BREATH

Report on Air Quality in Delhi and NCR during November and December 2018
Special report on Air Quality of New Delhi during Diwali 2018

Report by

Lung Care Foundation
http://lcf.org.in/

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Executive Summary

In November and December 2018 residents of New Delhi and Gurugram took seven air samples in and around the city as an exercise to understand the levels of Air Pollution around Diwali and in general in these months. These samples were taken from residential areas of Safdarjung Enclave, Gurugram Sector 67 and DLF Phase 5.

The samples in Safdarjung Enclave were taken over 3 consecutive days around Diwali - a day before, on the day and a day after.

All samples were taken from open balconies of residential homes.
24-hour samples were taken using filters fitted to a low volume air sampler and analysed for PM2.5 (Particulate Matter or dust less than 2.5 micrometres in size) and heavy metals in Chester LabNet at Oregon, USA.

The Results of Analyses revealed that:

1. PM2.5 levels in all the 7 samples were above statutory limits. PM2.5 levels ranged from 90.3 ug/m3 to 563.5 ug/m3 and were between 1.5 and 9.4 times higher than standards prescribed by the Ministry of Environment, Forests and Climate Change (MoEFCC). Levels of PM2.5 are so high for all these 7 samples that if the samples had been taken in the US, the US Environmental Protection Agency would issue an advisory for hazardous air quality in 5 sites and very unhealthy and unhealthy air quality in 1 site each.

2. Levels of manganese in five of the seven samples exceed the U.S. EPA Reference Concentration for exposure to manganese (0.05 ug/m^3) and the WHO annual health-based guidelines value of 0.15 ug/m^3. There are no standards in India for Manganese in ambient air. Manganese is a known neurotoxin and affects the neurobehavioral functions. According to the US EPA, chronic (long-term) exposure to high levels of manganese by inhalation in humans may result in central nervous system (CNS) effects. Visual reaction time, hand steadiness, and eye-hand coordination were affected in chronically exposed worker.

3. Levels of lead in two samples exceeds the Indian NAAQS Annual and WHO annual health-based guidelines value of 0.05 ug/m^3 and in six of the seven samples exceed the U.S. EPA 3 –month average for exposure to lead (0.15 ug/m^3). Lead is a known neurotoxin. Children are particularly vulnerable to the effects of this heavy metal. Exposures to even low levels of lead early in life have been linked to effects on IQ, learning, memory, and behaviour.

4. Nickel levels in all samples exceed the WHO annual health-based guidelines value of 0.0025 ug/m3, which is based on the risk of cancer associated with long-term exposure to nickel. Exposure to nickel in ambient air also affects the respiratory and immune systems in the body.

5. High levels of Barium were found in three samples from New Delhi taken around Diwali. Barium compounds are used in firework to impart yellow, apple green and bright green colour. It is likely that Barium and other chemicals from firework would have contributed to higher PM2.5 levels in the air around Diwali. Based on limited human and animal data, the respiratory tract is the most sensitive target following inhalation exposure.

6. Levels of silicon were seen elevated in all the samples. In most environments, the predominant form or silicon in ambient air is crystalline silica. Both coal ash and construction sand have high levels of crystalline silica and could be prominent contributors. Hence locations that are near coal ash piles or where sand is being processed such as a construction sites might contribute to the elevated levels of crystalline silica in ambient air that can cause respiratory health effects if exposures are prolonged.

7. Substantially elevated levels of iron and calcium particulates in the sample collected on 4 December 2018 at Sector 67, Gurugram, indicate ambient air that is adversely impacted by fugitive emissions of construction materials, which contain high levels of iron and calcium.

Based on these findings and observations the residents of Delhi and Gurugram demand the following:

1. CPCB initiates continuous monitoring heavy metals in dust and publish results periodically along with health advisories.

2. Agencies use the pollution data to apprehend polluters and take corrective action to bring levels of dust and heavy metals in dust to below detection limits in residential areas.

3. Agencies provide for long-term health monitoring by initiating health studies among the residents of Delhi and NCR.

4. Government sets up specialized health care infrastructure operated by the State health departments at polluters' cost to cater to residents in the region of Delhi and NCR

REPORT ON RESULTS OF AIR SAMPLES IN NEW DELHI AND GURUGRAM

Following frequent complaints by residents of air pollution around Diwali and the reports of deteriorating air quality in New Delhi and Gurugram in general, members of Lung Care Foundation in the presence of local residents took seven air samples from New Delhi and Gurugram in November and December of 2018.

Methodology for Air Samples:

Samples of dust in ambient air were taken from residential houses in all locations. The samples in Safdarjung Enclave, New Delhi, were taken over 3 consecutive days around Diwali - a day before, on the day and a day after. Samples from Gurugram Sector 67 and DLF Phase 5 were also from residential neighbourhoods with heavy construction activities going on in the surrounding. All samples were analysed for the PM2.5 levels and the presence of toxic heavy metals in the air.

The equipment used is a low volume air-sampling device called the MiniVol[1]. Five out of seven samples were taken continuously over a period of 24-hour while two samples from DLF Phase 5 and Sector 67 Gurugram were taken over 11.4 and 13.4 hours respectively.

The samples were sent for analysis to the Chester LabNet[2], a laboratory based in Oregon, USA. The laboratory tested the samplers for Particulate Matter ($PM_{2.5}$) using the Gravimetry technique[3] and used the X-ray Fluorsescence (XRF) technique to detect the presence of heavy metals. XRF is a US EPA approved technique.

[1] http://www.airmetrics.com/index.html

[2] http://www.chesterlab.net/index.php

[3] http://www.chesterlab.net/service.php#gra

Location of Air Samples:

Details of the air samples:

S No	Sample Id	Location of Sample	Weather conditions
1.	D 1	Balcony of the 2nd Floor or a park facing house in Safdurjung Enclave	**Day before Diwali**, normal weather conditions
2.	D 2	Balcony of the 2nd Floor or a park facing house in Safdurjung Enclave	**On the day of Diwali**, normal weather conditions
3.	D 3	Balcony of the 2nd Floor or a park facing house in Safdurjung Enclave	A day after Diwali, normal weather conditions
4.	GGN Air Sample 1	Gurugram 4th floor terrace facing construction site, Sector 67	Normal weather conditions
5.	GGN Air Sample 2	Gurugram 6th floor balcony DLF phase 5	Normal weather conditions
6.	GGN Air Sample 3	Gurugram 29th floor balcony DLF phase 5	Normal weather conditions
7.	GGN Air Sample 4	Gurugram 4th floor balcony, Sector 67	Normal weather conditions

Results of the Air Samples:

Location Name	Date	PM2.5	Ba	Si	Fe	Mn	Ni	Pb	Ca	S	Al	Na	Cl	Comments Re PM2.5 level
Delhi - House in Safdarjung Enclave	7-Nov-18	535.1	21.53	18.85	5.71	0.2379	0.0089	0.3975	12.29	27.61	46.03	1.63	10.27	Hazardous
Delhi - House in Safdarjung Enclave	8-Nov-18	481.5	5.84	18.75	5.53	0.1646	0.0077	0.8025	11.78	13.78	17.73	0.59	9.67	Hazardous
Delhi - House in Safdarjung Enclave	9-Nov-18	517.6	2.41	24.91	8.44	0.2433	0.0173	0.4424	15.68	13.35	13.53	1.11	10.90	Hazardous
Gurugram 4th floor terrace facing construction site	4-Dec-18	563.5	0.21	40.87	12.62	0.3428	0.0226	0.2607	31.99	11.17	16.01	1.68	13.08	Hazardous
Gurugram 6th floor balcony DLF phase 5	8-Dec-18	263.7	0.13	12.29	5.14	0.1533	0.0083	0.8729	7.90	7.34	4.81	0.91	7.30	Hazardous
Gurugram 29th floor balcony DLF phase 5	15-Dec-18	166.0	0.03	6.90	2.50	0.0640	0.0067	0.2056	3.74	4.27	2.57	0.63	4.92	Very Unhealthy
Gurugram 4th floor balcony, Sector 67	17-Dec-18	90.3	0.02	3.78	1.51	0.0385	0.0031	0.0469	3.21	1.36	1.43	0.23	1.36	Unhealthy
Health-Based Standards	EPA Air Quality Index, 24-hour	>250.5	Hazardous - This would trigger a health warnings of emergency conditions. The entire population is more likely to be affected.											
	EPA Air Quality Index, 24-hour	150.5–250.4	Very Unhealthy - People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.											
	EPA Air Quality Index, 24-hour	55.5-150.4	Unhealthy - People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion											
	EPA Air Quality Index, 24-hour	35-5-55.4	Unhealthy for Sensitive Groups - People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.											
	WHO 24-hour	25	None	None	None	None	None	None						
	WHO annual	10	None	None	None	0.15	0.0025	0.50						
	EPA 24-hour	35	None	None	None	None	None	None						
	EPA 3-month	None	None	None	None	None	None	0.15						
	EPA annual	12	None	None	None	None	None	None						
	India NAAQS 24-hour	60	None	None	None	None	None	1.00						
	India NAAQS Annual	40	None	None	None	None	0.02	0.50						
	California OEHHA 24-hour	None	None	None	None	None	0.2	None						
	California OEHHA annual*	None	None	3	None	0.09	0.014	None						
	EPA RfC	None	None	None	None	0.05	None	None						
	Comparative Background Urban Levels (Wilmington, USA)	18.5	None	0.08	0.11	0.004	0.004	0.006	0.035	1.82		0.23	0.035	

* Standard for crystalline silica

Italic = conc < 3 times uncertainty

underline = conc < 2 times uncertainty

0.0 = conc < uncertainty = non-detect

http://oehha.ca.gov/air/allrels.html

Sample level exceeds 24-hour standard (directly comparable)

Sample level exceeds annual standard (of significance if reflects generally prevailing air quality)

FINDINGS:

1. PM2.5 levels in all the 7 samples were above statutory limits. PM2.5 levels ranged from 90.3 ug/m3 to 563.5 ug/m3 and were between 1.5 and 9.4 times higher than standards prescribed by the Ministry of Environment, Forests and Climate Change (MoEFCC). Levels of PM2.5 are so high for all these 7 samples that if the samples had been taken in the US, the US Environmental Protection Agency would issue an advisory for hazardous air quality in 5 sites and very unhealthy and unhealthy air quality in 1 site each.

2. Levels of manganese in five of the seven samples exceed the U.S. EPA Reference Concentration for exposure to manganese (0.05 ug/m^3) and the WHO annual health-based guidelines value of 0.15 ug/m^3. There are no standards in India for Manganese in ambient air. Manganese is a known neurotoxin and affects the neurobehavioral functions. According to the US EPA, chronic (long-term) exposure to high levels of manganese by inhalation in humans may result in central nervous system (CNS) effects. Visual reaction time, hand steadiness, and eye-hand coordination were affected in chronically exposed worker.

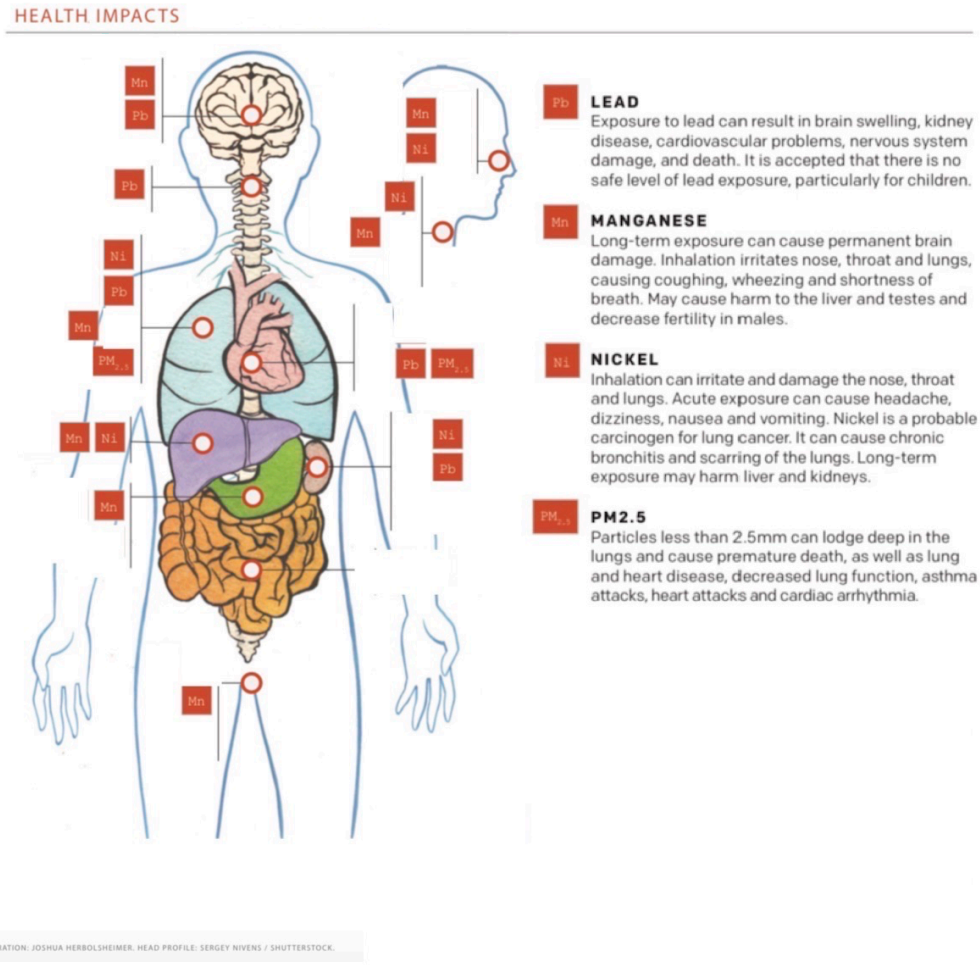
3. Levels of lead in two samples exceeds the Indian NAAQS Annual and WHO annual health-based guidelines value of 0.05 ug/m^3 and in six of the seven samples exceed the U.S. EPA 3 –month average for exposure to lead (0.15 ug/m^3). Lead is a known neurotoxin. Children are particularly vulnerable to the effects of this heavy metal. Exposures to even low levels of lead early in life have been linked to effects on IQ, learning, memory, and behaviour.

4. Nickel levels in all samples exceed the WHO annual health-based guidelines value of 0.0025 ug/m3, which is based on the risk of cancer associated with long-term exposure to nickel. Exposure to nickel in ambient air also affects the respiratory and immune systems in the body.

5. High levels of Barium were found in three samples from New Delhi taken around Diwali. Barium compounds are used in firework to impart yellow, apple green and bright green colour. It is likely that Barium and other chemicals from firework would have contributed to higher PM2.5 levels in the air around Diwali. Based on limited human and animal data, the respiratory tract is the most sensitive target following inhalation exposure.

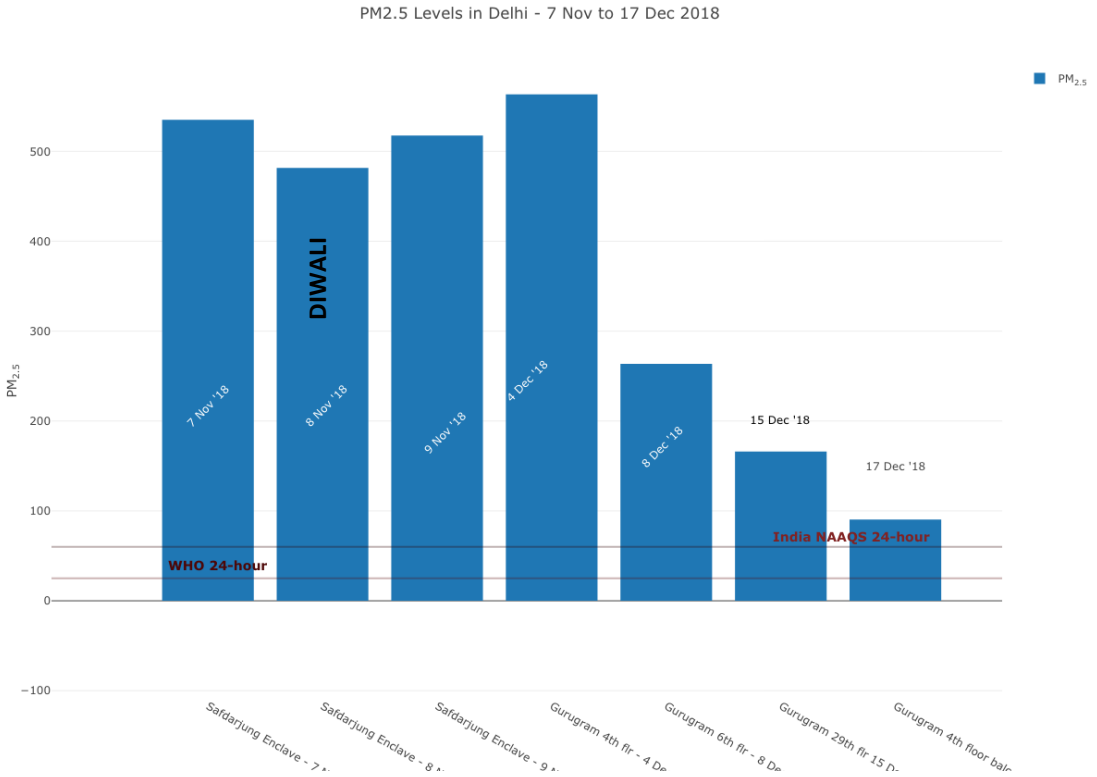
6. Levels of silicon were seen elevated in all the samples. In most environments, the predominant form or silicon in ambient air is crystalline silica. Both coal ash and construction sand have high levels of crystalline silica and could be prominent contributors. Hence locations that are near coal ash piles or where sand is being processed such as a construction sites might contribute to the elevated levels of crystalline silica in ambient air that can cause respiratory health effects if exposures are prolonged.

7. Substantially elevated levels of iron and calcium particulates in the sample collected on 4 December 2018 at Sector 67, Gurugram, indicate ambient air that is adversely impacted by fugitive emissions of construction materials, which contain high levels of iron and calcium.



ANALYSIS:

PM2.5: In all sites, levels of very fine particulate matter in the filtered air sample ($PM_{2.5}$) greatly exceed the 24-hour WHO standard of 25 µg/m^3; the 24-hour USEPA standard of 35 µg/m^3; and the Indian MoEF standard of 60 µg/m^3. These levels exceeded the Indian standards by 1.5 and 9.4 times.



Three samples collected from New Delhi around Diwali contained levels of $PM_{2.5}$ that would be considered by the U.S. EPA as "Hazardous - This would trigger a health warning of emergency conditions. The entire population is more likely to be affected"

Two of the samples [collected at 4th floor balcony of Sector 67, Gurugram and 6th Floor Balcony of DLF Phase 5] contained levels of $PM_{2.5}$ that would be considered by the U.S. EPA as "Hazardous - This would trigger a health warning of emergency conditions. The entire population is more likely to be affected"

One of the samples [29th Floor Balcony of DLF Phase 5, Gurugram] contained levels of $PM_{2.5}$ that would be considered by the U.S. EPA as "Very Unhealthy - People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion"

One of the samples [4th Floor Balcony of Sector 67, Gurugram] contained levels of $PM_{2.5}$ that would be considered by the U.S. EPA as "Unhealthy - People with heart or

lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion"

This would imply that the air quality is such that everyone may begin to experience some adverse health effects, and members of the sensitive groups may experience more serious effects.[4]

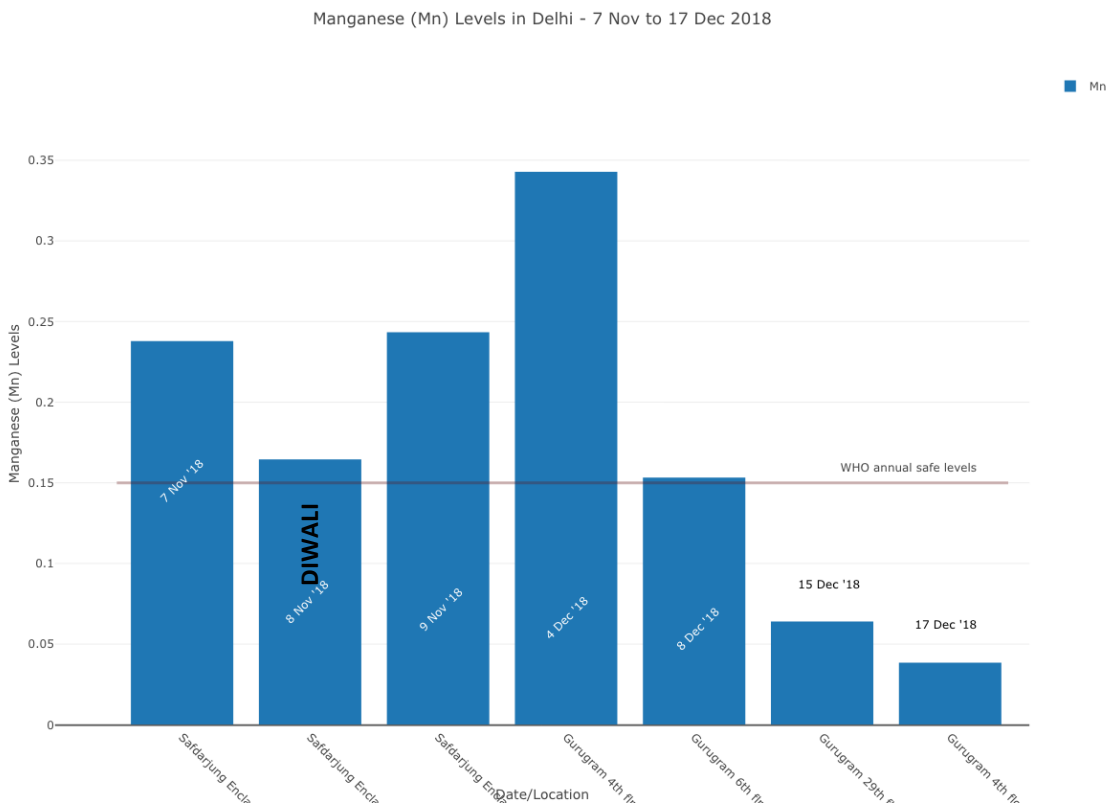
About PM 2.5: Particles less than 2.5 micrometers in diameter (PM2.5) are referred to as "fine" particles and are believed to pose the largest health risks. Because of their small size (less than one-seventh the average width of a human hair), fine particles can lodge deep into the lungs.
"Health studies have shown a significant association between exposure to fine particles and premature mortality. Other important effects include aggravation of respiratory and cardiovascular disease (as indicated by increased hospital admissions, emergency room visits, absences from school or work, and restricted activity days), lung disease, decreased lung function, asthma attacks, and certain cardiovascular problems such as heart attacks and cardiac arrhythmia. Individuals particularly sensitive to fine particle exposure include older adults, people with heart and lung disease, and children."[5]

The Indian Ministry of Environment and Forests (MoEF), the U.S. EPA and the World Health Organization have all adopted health-based air quality standards for exposure to fine particulate matter. They have also adopted short-term (24-hour) and long-term (annual average) standards for exposure to fine particulate matter in order to prevent both acute and chronic effects of exposure to particulates.

[4] https://airnow.gov/index.cfm?action=aqibasics.aqihttps://www3.epa.gov/pm/2012/decfsstandards.pdf
[5] http://www.epa.gov/ttn/naaqs/pm/pm25_index.html

Manganese Results: Levels of manganese in five of the seven samples exceed the U.S. EPA Reference Concentration for exposure to manganese (0.05 ug/m^3) and the WHO annual health-based guidelines value of 0.15 ug/m^3. However, these standards for manganese are for long-term exposures of one year (or longer). These results indicate unhealthy levels of manganese only if they reflect ambient levels of manganese that generally prevail at these locations. Additional testing (over several months) would be necessary to determine long-term average ambient levels of manganese at these locations.

There are no standards in India for Manganese in ambient air.

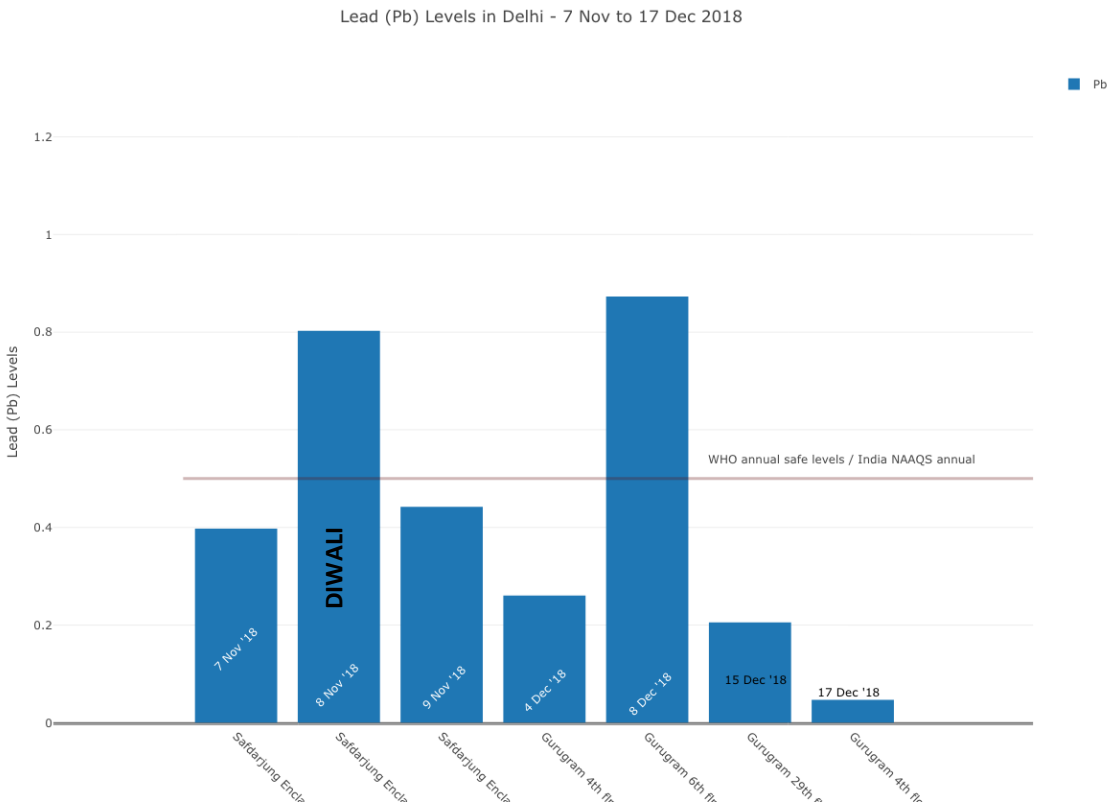


Manganese is a neurotoxin. With regards to its health impacts, the U.S.EPA has observed that:

"Chronic (long-term) exposure to high levels of manganese by inhalation in humans may result in central nervous system (CNS) effects. Visual reaction time, hand steadiness, and eye-hand coordination were affected in chronically-exposed workers. A syndrome named *manganism* may result from chronic exposure to higher levels; *manganism* is characterized by feelings of weakness and lethargy, tremors, a mask-like face, and psychological disturbances."[6]

[6] http://www.epa.gov/ttn/atw/hlthef/manganes.html

Lead results: Levels of lead in two samples exceeds the Indian NAAQS Annual and WHO annual health-based guidelines value of 0.05 ug/m^3 and in six of the seven samples exceed the U.S. EPA 3 –month average for exposure to lead (0.15 ug/m^3).

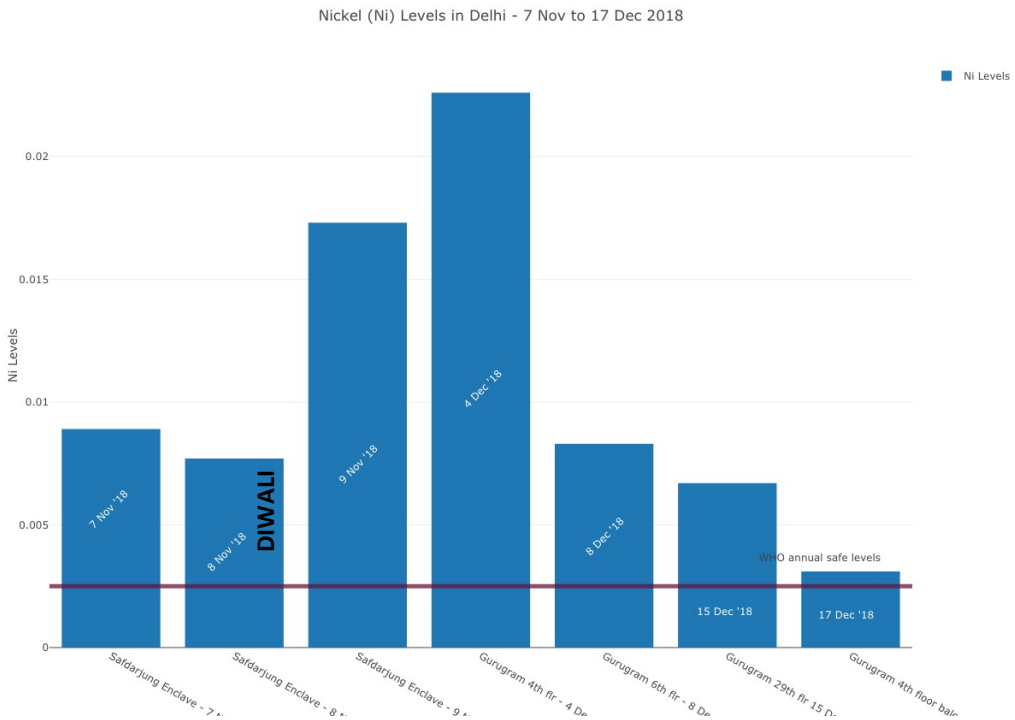


The U.S.EPA has observed that: "Lead is particularly dangerous to children because their growing bodies absorb more lead than adults do and their brains and nervous systems are more sensitive to the damaging effects of lead. Babies and young children can also be more highly exposed to lead because they often put their hands and other objects that can have lead from dust or soil on them into their mouths. Children may also be exposed to lead by eating and drinking food or water containing lead or from dishes or glasses that contain lead, inhaling lead dust from lead-based paint or lead-contaminated soil or from playing with toys with lead paint."[7]

It is a known fact that children are particularly vulnerable to the effects of lead. Exposures to low levels of lead early in life have been linked to effects on IQ, learning, memory, and behavior. There is no known safe level of lead in the body

[7] https://www.epa.gov/lead/learn-about-lead#effects

Nickel results: Nickel levels in all samples exceed the WHO annual health-based guidelines value of 0.0025 ug/m^3.



The WHO air quality guidelines state the following:

"Nickel compounds are human carcinogens by inhalation exposure. The present data are derived from studies in occupationally exposed human populations. Assuming a linear dose–response, no safe level for nickel compounds can be recommended.

On the basis of the most recent information of exposure and risk estimated in industrial populations, an incremental risk of 3.8 × 10–4 can be given for a concentration of nickel in air of 1 µg/m3. The concentrations corresponding to an excess lifetime risk of 1:10 000, 1:100 000 and 1: 1 000 000 are about 250, 25 and 2.5 ng/m3, respectively."[8]

Hence, if nickel levels in the 7 filtered air samples from New Delhi and Gurugram in November and December 2018, reflect conditions that generally prevail over the long-term, then persons in these areas would suffer an excess lifetime risk of cancer of 4 per 1 million (compared to 1.6 per 1 million for typical levels of nickel in urban air).

[8] See: Air quality guidelines for Europe; second edition (2000)

http://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf

Barium results: The Barium level in the sample a day before Diwali is 21.5 µg/m3, on the day of Diwali the sample has Barium level of 5.8 µg/m3, and a day after Diwali, the Barium level in the sample is 2.4 µg/m3.

According to Dr. Mark Chernaik, Staff Scientist at Environment Law Alliance Worlwide (ELAW), US, "These levels are extremely high and unheard of. Typically, Barium levels are <0.05 µg/m3."

Based on limited human and animal data, the respiratory tract is the most sensitive target following inhalation exposure[9].

According to research, "Barium, typically as barium nitrate imparts a yellow or "apple" green color to fireworks; for brilliant green barium mono chloride is used.[10]"

Dr. Mark Chernaik adds, "given that Barium was found in samples around Diwali it is quite likely that the fireworks caused this and Barium along with other chemicals contributed to high levels of PM2.5 on those days."

Impact of Construction on Air Quality:

Levels of silicon were seen elevated in all the samples. In most environments, the predominant form or silicon in ambient air is crystalline silica. Construction sand and coal ash have high levels of crystalline silica and could be prominent contributors. Hence locations that are near areas where sand is being processed such as a construction sites or coal ash site might contribute to the elevated levels of crystalline silica in ambient air that can cause respiratory health effects if exposures are prolonged.

Substantially elevated levels of iron and calcium particulates in the sample collected on 4 December 2018 at Sector 67, Gurugram, indicate ambient air that is adversely impacted by fugitive emissions of construction materials, which contain high levels of iron and calcium.

Health Implications of the results:

According to, Dr Arvind Kumar, Chest Surgeon and Founder Trustee at Lung Care Foundation:

"The air sampling results show a very concerning level of harmful substances that adversely effect health. Their presence at such high levels shows that there is a significant possibility of chronic health effects. Studies have shown that there are linkages between PM2.5 and respiratory diseases and cardiovascular problems. In addition, manganese and nickel are well known toxins and their effects on human health have been well documented. Manganese is predominantly neuro toxin while

[9] https://www.atsdr.cdc.gov/toxguides/toxguide-24.pdf

[10] Russell, Michael S. & Svrcula, Kurt (2008). Chemistry of Fireworks. Royal Society of Chemistry. p. 110. ISBN 0-85404-127-3.

nickel is a carcinogen. The measurement of such toxic substances from the rooftops of human settlements is indeed a cause for concern.

There is an urgent need not only to take immediate steps to reduce the presence of such toxins in the air, but also to institute a comprehensive health survey to assess what damage has already been done, and institute follow up of the population for detecting long term harm from the exposure till now. Further the health system needs to take these chemicals into account and develop a plan on how to provide relevant and adequate care to those who have been so exposed."

Discussions:

The current exercise of air sampling is to understand not only the PM2.5 composition of the air, but also to document the presence of toxic heavy metals in the air. The results have clearly demonstrated that during Diwali there the PM2.5 levels exceeded the statutory regulations and despite the regulation of the bursting of firecrackers by Hon'ble Supreme Court, there was no improvement in the air quality of the region. Presence of toxic chemicals like Barium indicate that threat to air quality and health is not just from PM2.5 but from toxic heavy metals that most of the time do not get accounted for. The presence of Barium also indicated the direct connection of fireworks on the air quality of the region.

It is quite clear that the construction activities in the Gurugram region have negative impact on the air quality and threatening public health. The constructions sites are not just aggravating the already poor air quality in the region but also contributing toxic metal like silica, iron, manganese, nickel and lead to the air.

Conclusion:

Based on the findings, Lung Care Foundation demands:

1. CPCB initiates continuous monitoring heavy metals in dust and publish results periodically along with health advisories.

2. Agencies use the pollution data to apprehend polluters and take corrective action to bring levels of dust and heavy metals in dust to below detection limits in residential areas.

3. Agencies provide for long-term health monitoring by initiating health studies among the residents of Delhi and NCR.

4. Government sets up specialized health care infrastructure operated by the State health departments at polluters' cost to cater to residents in the region of Delhi and NCR