Air Pollution Control Solutions for MSMEs in Delhi for Non-point and Process Emissions

Clean Air Asia, India

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Clean Air Asia, India

ABOUT CLEAN AIR ASIA

Clean Air Asia was established in 2001 by the Asian Development Bank, the World Bank, and USAID. Today, we are registered as an international non-governmental organization that leads the regional mission for better air quality and healthier, more livable cities in Asia. We aim to reduce air pollution and greenhouse gas emissions in 1000+ cities in Asia through policies and programs that cover air quality, transport, industrial emissions, and energy use. We work with ministries (energy, urban development, environment, health, and transport), cities in Asia, the private sector and development agencies to provide leadership and technical knowledge for Air Quality Management. Clean Air Asia is headquartered in Manila and has offices in Beijing and New Delhi.

Clean Air Asia (CAA)'s work in India involves engaging with Indian cities for better air quality management (AQM). This aligns with the overall CAA work program on broad air quality (AQ) interventions. Our expertise lies in providing scientific inputs to city governments for better air quality management, sustainable transport, low emissions, urban development, and education/communication for clean air in India. The focus of our work in India is in cities with high impact potential, as well as potential for leveraging wider change.

We are supporting Indian cities in improving air quality management through capacity building and direct support to preparing air action plans. We have also launched the Clean Air Knowledge Network (cities4cleanair.com), a forum that connects AQ experts and practitioners from across India and city officials with an objective to promote knowledge sharing across cities on AQ issues and share best practices. A major component of our India Program is education for better air quality. Our Youth Clean Air Network (YCAN) is volunteer program in which youth can passionately work together for better air quality. In past, the Indian team has worked green freight and sustainable mobility projects, conducting walkability studies in Indian cities, developing the Walkability App, the National Bus Fuel Efficiency Framework, the Green Trucks Toolkits for India, and an online freight brokerage platform.

EXECUTIVE SUMMARY

The Clean Air Asia, India, sponsored a study to the Indian Institute of Technology (IIT) Kanpur to prepare a knowledge product for MSMEs that will showcase the potential solutions that MSMEs could adopt. The solutions would also include a focus on marginalised/ vulnerable communities and policy recommendations for MSMEs.

There are thirteen air pollution hotspots in Delhi: Jahangirpuri, Anand Vihar, Ashok Vihar, Wazirpur, Punjabi Bagh, Dwarka Sector 8, Rohini Sector 16, RK Puram, Bawana, Mundka, Narela, Okhla Phase II and Vivek Vihar based on high concentrations of pollutants at these locations. These hotspots are densely populated residential areas with a sizeable population of the economically weaker section. The population-weighted concentration will be even higher than that reflected by air quality measurements.

Most of the industries in Delhi are in the Micro, Small, and Medium Enterprises (MSMEs) sectors. The notable decision by the Government is that all industries are now on Piped Natural Gas (PNG) supply for their combustion and energy needs. The total PNG uses are 170000 SCM (standard cubic metre) per month. On the other side, the pollution problems from MSMEs are compounded by old technologies, untrained manpower, casual attitude, poor housekeeping, and nonpoint fugitive emissions. Therefore, there is a need and scope to find technological and policy solutions to reduce emissions.

This report specifically examined the processes in different industries, housekeeping, sources of fugitive emissions, sectors not covered for emission control, civic amenities, and road and infrastructure conditions responsible for indirect emissions in the industrial areas. Nine industrial areas (Okhla, Narela, Bawana, Wazirpur, Kirtinagar, Mayapuri, Mundka, Najafgarh, and Jahngirpuri) were physically visited, and some industries were studied from the beginning of the raw material to the finished product. A greater emphasis was also given to road conditions having high silt load (paved and unpaved), waste collection and disposal, drainage adequacy, construction activities, and indoor environment. Assistance was taken from Delhi Pollution Control Committee for visiting industries, but most industries hesitated to show their processes and pollution control devices.

The immediate common requirements in all industrial areas are better roads fully paved (carpeted beyond shoulders), better drainage facilities, improved power supply, solid waste collection and removal of all encroachments, and preventing any industrial or manufacturing activities and construction on the roadside.

A set of policy recommendations was made so that MSMEs perform better environmentally and reduce emissions. The potential strategies to develop the MSME sector were focused on; skill development, environmental technology resources, decarbonization, preventing waste burning, use of bio-mass-based fuel, small-scale units and small boilers, and future energy. Financial constraints and availability of loans were also discussed for the growth and emission control for MSMEs. It was also pointed out that the MSMEs should be aware of the new technologies of the future and keep abreast with government policies. The policies on green energy should be inclusive for MSMEs not only for their uses but also for their production and storage.

Control Technologies and appropriate solutions for air pollution control are vital for MSMEs as they lack understanding of the right technology and regulatory compliance. The suggested solutions are general and specific to industries. The industries which are more significant in number are targeted explicitly for technology and solutions. The specific sectors include plastic granules, tyre re-treading, dry cleaning, pulse and wheat mills, metal casting, construction and demolition, road dust, auto service centre, and loading and unloading. Technologies and current practices, collection and arresting the fugitive emissions, and recovery of solvent and volatiles are presented so that the industries can explore these options.

Secondary pollutants, both organic and inorganics, including ozone and secondary particles, are not understood by most persons not conversant with atmospheric chemistry. A complete section is devoted to secondary pollutants, their formation and control. While the MSMEs have a role in controlling secondary pollutants, it is not recommended other than solvent recovery because of the small size and high cost involved. However, it is suggested large units like power plants must control precursor gases to prevent the formation of secondary particles and ozone.

A section on pollution effects on marginalized and vulnerable communities has been devoted to better air quality for this group. The current locations of the industrial areas in densely populated regions of Delhi expose the marginalized groups to higher cumulative air pollution. The marginalized communities reside close to the industrial areas, mostly in the shanty and congested dwelling units. These communities face double burdens from industrial emissions, road dust, the movement of heavy-duty trucks, and poor indoor conditions due to the burning of solid fuels like coal and firewood. Most of the analysis and research concerning exposure and air pollution health has focused on the entire Delhi as a single entity. Thus, the current studies do not show the suffering and higher exposure to the vulnerable community. A methodology to keep the right perspectives of marginalized and economically weaker communities impacted by pollution is argued to minimize existing air pollution exposure inequities.

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1. BACKGROUND AND CONTEXT

In metropolises like Delhi, localized areas of high pollutant concentrations are caused by industries, congested traffic and burning of fossil fuels. In some cases, this is seasonal. Known as air pollution hotspots, pollution levels in these areas are often higher than the background concentrations in the region. In 2019 the Central Pollution Control Board (CPCB) identified 13 main hotspot areas within Delhi's city borders based on data from monitoring stations situated either in the area or around, not scientific studies. Most air pollution studies in India monitor average ambient pollutant concentrations at a city or regional level. However, management at this level alone does not allow proper protection of vulnerable communities in highly polluted areas. For this reason, hotspot action is becoming a global regulatory trend. Governments are using it not only to reduce peak and overall pollution, but also to ensure the protection of the poorest and most vulnerable communities, who are most often located in the worst affected areas. Increased monitoring of hotspot air quality should therefore be a priority in Delhi, particularly in high exposure locations where large numbers of people spend significant amounts of time outdoors.

In January 2019, the Ministry of Environment, Forest and Climate Change launched National Clean Air Program (NCAP) as a strategy to reduce air pollution levels in regional and urban areas. To align with NCAP's objectives and approaches, Clean Air Asia focused on preparation and implementation of Clean Air Action Plans, technology solutions across different sectors, air quality management etc. However, it became clear that a major gap in the NCAP is that MSMEs are not explicitly included (except Brick kilns) and thus provides a huge opportunity to discuss this sector's impact on air pollution and provide support to explore solutions towards sustainable and environment-friendly production activities. Clean Air Asia began adding a sector-specific approach with a focus on MSME's to support industries and MSMEs with knowledge about technologies, build their capacity and lead the discussion about challenges and solutions in terms of finances and governing regulations/policies. At this inflection point Clean Air Asia, with the Clean Air Fund, developed and embarked on the project 'Addressing air pollution through a hotspot approach in Delhi NCR'

As a first deliverable, Clean Air Asia completed the study of the industrial zones located in the air pollution hotspots, identified by CPCB, in Delhi, to determine the industrial emissions and challenges faced by the Micro, Small and Medium Enterprises (MSMEs) in the implementation of clean air schemes, policies and technologies & analysed MSMEs in the six identified hotspots and stakeholder mapping completed for these areas. Now, after the Department of Environment, Govt. of NCT of Delhi regulated a mandated closure of all industries in Delhi that have not switched to cleaner fuels in industrial areas (order issued November 2021), which is a major step to reduce the air pollution from industries/ MSMEs, the thrust of the project will be broadened beyond 'clean energy transition' to also focus on other sources of ambient air pollution including those from MSME's production processes.

In the above context, the Clean Air Asia, India sponsored a study to the Indian Institute of Technology (IIT) Kanpur to prepare a knowledge product for MSMEs that will showcase the potential solutions that MSMEs could adopt. The solutions would also include a focus on marginalised/ vulnerable communities & Policy recommendations for MSMEs. The current document constitutes the final report of the study, 'Air Pollution Control Solutions for MSMEs in Delhi for Non-point and Process Emissions' by IIT Kanpur.

The 13 air pollution hotspots have been identified in Delhi: Jahangirpuri, Anand Vihar, Ashok Vihar, Wazirpur, Punjabi Bagh, Dwarka Sector 8, Rohini Sector 16, RK Puram, Bawana, Mundka, Narela, Okhla Phase II and Vivek Vihar. These were identified by the Central Pollution Control Board (CPCB) Delhi and Delhi

Pollution Control Committee (DPCC) based on high concentrations of pollutants at these locations. It may be noted that in these areas, pollution levels are high as they are densely populated residential areas and have a sizeable population of economically weaker section using fuels other than liquid petroleum gas (LPG). In other words, population-weighted concentration can even be higher than that reflected by air quality measurements. It is further seen that in the above-identified hotspots, there are moderate to large industrial areas.

Most of the industries in Delhi are in the Micro, Small, and Medium Enterprises (MSMEs) sectors. The Government has taken several actions, including setting up a robust network of Piped Natural Gas (PNG) supplies to the industry. The PNG has a highly efficient (combustion efficiency of 90% as compared to coal, having combustion efficiency of around 65%) clean fuel and burns almost completely, leaving no residues and insignificant Particulate Matter (PM) emissions. In addition, the issue of fly ash generation, handling and storage facility requirements, etc. do not arise in the case of PNG as it does in the case of coal. It is now well-recognized that combustion-related emissions are taken care of in most industries in Delhi.

The pollution problems from MSMEs are compounded by old technologies, untrained manpower, casual attitude, poor housekeeping, low heights of emission releases (mostly less than 10 m), and nonpoint fugitive emissions, which are not tractable and can be very significant. Therefore, there is a need to find technical solutions to nonpoint fugitive emissions emanating from loading, unloading, storage of raw material and finished product, grinding and crushing operations, transportation, material transfer points, process emissions, leakages of gases, raw material/product losses, and maintenance of flanges, joints, and safety valves. Other industries, especially electric arc and induction furnaces and electroplating (acidic emissions), have no combustion yet produce high air pollution of PM, acidic vapours, and VOCs.

2. SCOPE OF WORK

The scope of work for this study includes the following:

- Research on the MSMEs in Industrial hotspots
- Review the practices followed in material handling and processes in MSMEs
- Review the effect of emissions from secondary pollutants on marginalized/ vulnerable communities. Identify potential solutions that MSMEs could easily adopt.
- Prepare policy recommendations for MSMEs to reduce emissions
- A review may include a field study also for better understanding of the output and work on inputs/ recommendations from Clean Air Asia or its donor(s).

3. NUMBER AND TYPE OF INDUSTRIES AND PNG USES

Detailed information is collected from Central Pollution Control Board and other agencies on the number and types of polluting industries operating in Delhi. Since all industries requiring combustion have shifted to PNG, the overall emission would reduce significantly. However, some industrial areas are densely located and cumulative emissions from PNG can be significant.

The industries were categorized based on location in the industrial clusters. There are 11 major industrial areas (Figure 1), but overall, there are 32 industrial clusters (Table 1, Figure 2). Bawana is the largest industrial cluster, followed by Narela and Mandoli. On the other side, PNG consumption in the Friend's Colony cluster is much higher than in other industrial areas, where iron and other castings are common types of industries. The average monthly consumption of PNG by each industrial cluster is given in Table 1 and Figure 3.

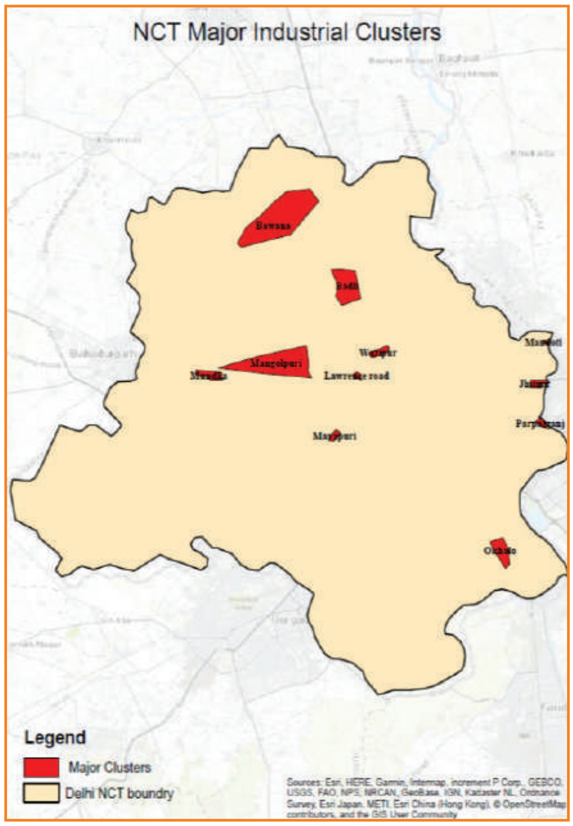


Figure 1: Major Industrial Areas in Delhi

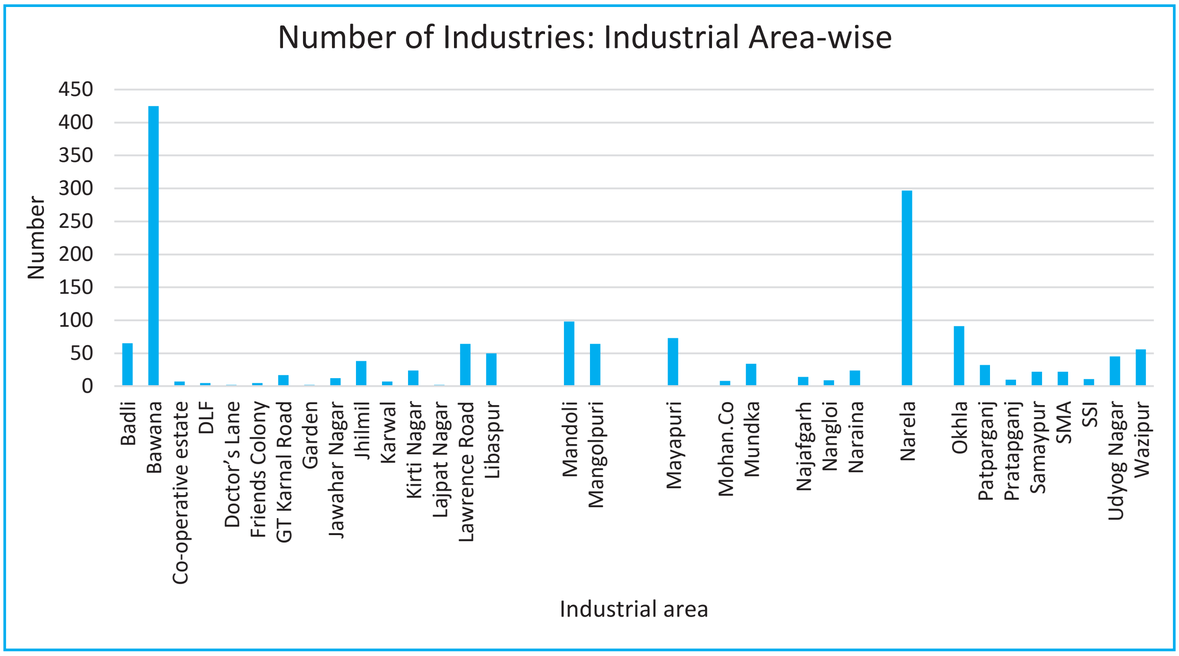


Figure 2: Number of Industries in different Industrial Areas

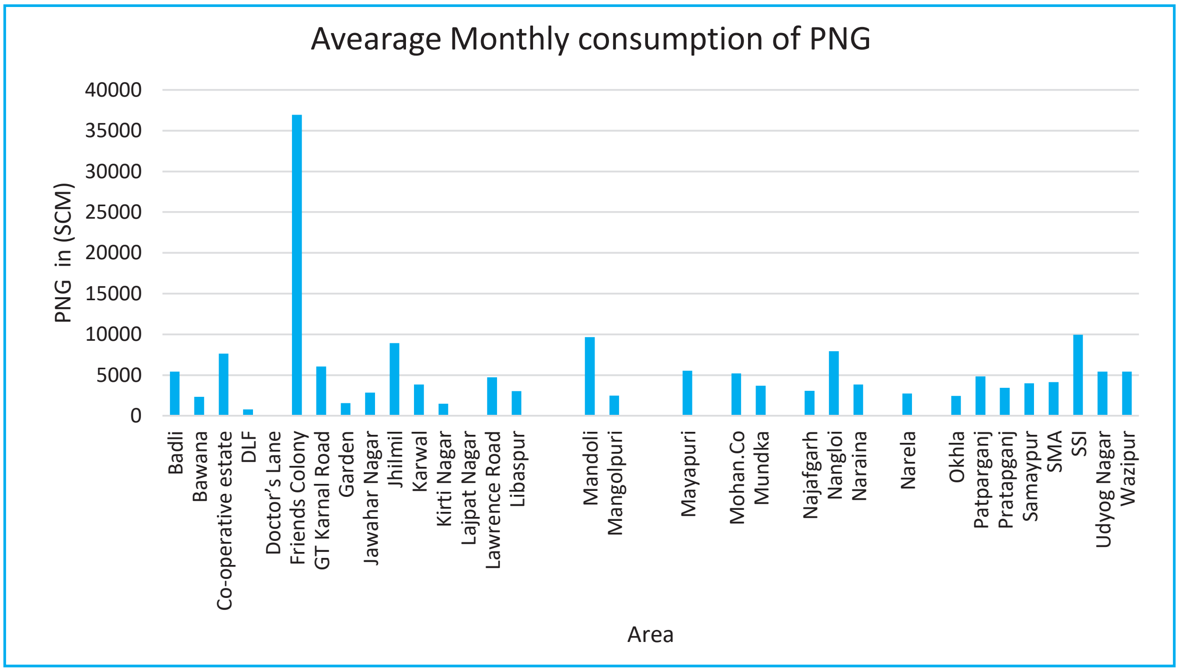


Figure 3: Average Monthly consumption of PNG (SCM; standard cubic metre)
(SCM: absolute dry volume in cubic metre at a temperature of 15° C and absolute pressure of 1.01325 bar)

Table 1: Industrial Clusters, Types of Industries and PNG Consumption

S.No	Cluster name	Category	Total MSMEs	No. of Industries using PNG	Monthly PNG use (SCM)
1	Badli	Food processing and plastic		65	5432
2	Bawana	Dying, Casting Metal Processing	12000	425	2327
3	Cooperative estate	Metal processing Electro plating		7	7621
4	DLF	Plastic, Engineering work		5	790
5	Doctor's Lane	Catering		2	69
6	Friends Colony	Casting		5	36956
7	GT Karnal Road	Washing, Metal Processing		17	6038
8	Garden	Aluminium wire drawing		2	1574
9	Jawahar Nagar	Metal processing, Rubber		12	2865
10	Jhilmil	Ferrous work and Casting	378	38	8933
11	Karwal	Casting		7	3833
12	Kirti Nagar	Metalizing, Ferrous, Paint & Polish	926	24	1491
13	Lajpat Nagar	Hotel, IT Company		2	25
14	Lawrence Road	Dall Mills	90	64	4743
15	Libaspur	Jean, metals, food & beverages		50	3032
16	Mandoli	Casting ferrous and nonferrous items		98	9650
17	Mangolpuri	Rubber, Plastic, EVA Sheets	1249	64	2497
18	Mayapuri	Engineering, Automobile, Metal, forging	330	73	5546
19	Mohan.Co	Automobile Repair		8	5195
20	Mundka	Engineering, Food, Plastic manufacturing		34	3708
21	Najafgarh	Automobile repair, Washing, Rubber		14	3078
22	Nangloi	Plastic, PVC and Rexene clothes.		9	7927
23	Naraina	Powder coating, Metal processing		24	3842
24	Narela	Adhesive, EVA Sheet, Plastic		297	2742
25	Okhla	Engineering, Coating, Painting	294	91	2438
26	Patparganj	Food, Casting, Automobile, Medicine.	603	32	4850
27	Pratapganj	Food, Garments, Automobile		10	3448
28	Samaypur	Casting, Painting		22	3981
29	SMA	Metal processing, Textile, Automobile.		22	4131
30	SSI	PVC, Casting		11	9969
31	Udyog Nagar	Footwear, Plastic coating		45	5409
32	Wazirpur	Rolling sheets		56	5409

4. VISITS TO INDUSTRIAL AREAS AND CURRENT SITUATION

Jahangirpuri, Wazirpur, Alipur, Bawana and Mundka topped the list of most polluted areas among 33 localities in Delhi, where air quality is monitored regularly by the Delhi Pollution Control Committee (DPCC). Jahangirpuri, Wazirpur and Alipur, located in north Delhi, recorded five severe air days of Air Quality Index (AQI) - in the first two weeks of November. Bawana, Mundka, Narela, recorded four severe air quality days.

Physical surveys of industrial areas of Okhla, Narela, Bawana, Wazirpur, Kirtinagar, Mayapuri, Mundka, Najafgarh, and Jahngirpuri were undertaken. Although Kirtinagar, and Mayapuri were not identified as the hotspots for air quality by DPCC, these industrial areas are situated in the centre of the city in densely populated areas and commercial places. Kirti Nagar industrial area has large showrooms and attracts many common citizens. The Kirti Nagar area is considered the largest furniture market in the country. The Mayapuri area has a large number of industries consuming 5546 SCM of PNG, one of the largest PNG users. For the completeness of the study, these two areas were included for field visits. The findings from the areas visited are presented in sections 4.1 - 4.7.

4.1. OKHLA INDUSTRIAL AREA (OIA)

OIA has three phases, I, II, and III. OIA has 294 SMEs and 94 are on PNG, using a total quantity of 2438 SCM per month. The industry types are packaging, garments, stainless steel, leather products, electronics and electrical fittings, pharmaceuticals (formulation), auto service centres and machining works. Although the power supply is adequate and insignificant events of load-shedding, most industries have diesel generator (DG) sets.

There are significant movements of heavy-duty vehicles (HDV), trucks, loaders, cranes and light commercial vehicles (LCV), etc. for transporting raw material and finished products. The area is congested with other traffic movements of man and material. The construction activities held in open space and the materials were stored on the main road causing emissions and traffic congestion (Figure 4).

The collection and management of municipal and industrial wastes (non-hazardous) were inadequate, and they were thrown and scattered indiscriminately. The drainage system was very poor, mostly non-functional, buried under soil and dust. The road condition was also poor and had a high silt load causing significant dust emissions due to the movement of vehicles.

Figure 4: Construction material on roads, inadequate solid waste collection and unpaved and poor roads

Many small and service industries are not fully regulated or do not get attention; for example, automobile service centres (typical example Figure 5) cater to over 12 million vehicles in Delhi. The closed environments of automobile centres cause fugitive emissions, and denting and painting of the vehicles can also lead to air pollution. DG sets are used for captive electricity generation in most industries, including hospitals, banks, and the hospitality industry. These DG sets should be minimized with quality and uninterrupted power supply, and emergency power generation should be on PNG or through solar means.

Figure 5: Auto service centre, painting, and tailpipe emissions in OIA

4.2. NARELA INDUSTRIAL AREA (NIA)

The important source of pollution in this industrial area was traffic congestion, poor road infrastructure, and partially or unpaved roads for transporting raw materials and finished products from industries (Figures 6 -7), including the main road in the area leading to Karnal. The other important source was silt load on the roads in the industrial area, storage of construction material on the road, abandoned construction and demolition waste on the road and encroachments on the road, affecting the smooth traffic flow.

Figure 6: Traffic congestion and poor road condition in and around NIA

Figure 7: High Silt Load, Poor Road condition and improper disposal of muck from excavation (NIA to Karnal road)

4.3. WAZIRPUR INDUSTRIAL AREA (WIA)

WIA is situated in the northern part of Delhi and most factories are engaged in the stainless-steel business making steel utensils. There are exporters of domestic steel utensils and commercial steel vessels. Steel containers like boiler vessels and other big steel pots are also manufactured. Some industries are involved in engineering and metal works, hosiery and garments, engine parts (piston and rings) and a few units of tyre re-treading.

Until some years ago, pickling and electroplating were common practices causing the fumes of HF and HCl. Such operations have now been stopped and industries are involved in metal sheet cutting. Only PNG as a fuel is used as a robust network of PNG supply to all industries is available. The area's general roads, garbage collection and sanitation conditions are very poor (Figure 8). The loading and unloading of raw materials of the products from the trucks are in open areas, and some dusts can be seen from such operations. It was seen that some industries undertake re-treading of tyres (Figure 9). Re-treading of tyres is also done in Mayapuri Industrial Area, and specific issues of emission and pollution control measures are discussed in the section on Mayapuri Industrial Area. The same will be applicable in any industry undertaking tyre re-treading.

Figure 8: Poor sanitation, drainage and garbage collection and road congestion in WIA

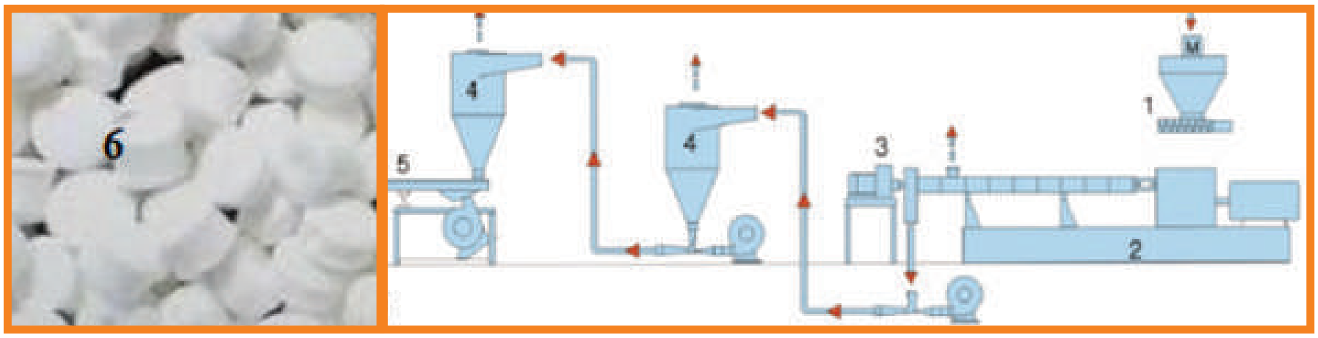
Figure 9: Tyre re-treading, encroachments and open loading and unloading operation in WIA

4.4. BAWANA INDUSTRIAL AREA (BIA)

BIA is spread over an area of 778.17 Ha (1922.10 Acres). It is divided into five sectors and further divided into 7 clusters each. Bawana has 12000 SMEs and 425 are on PNG. The direct employment in the industrial areas is about 14,000 persons and the total user population, including the floating population in the industrial areas, is approximately 18,600 persons.

Plastic recycling industries are common in BIA. Plastic recycling produces fumes as plastic pieces are melted and converted into plastic granules. The fumes can be organic vapours and some HCl. These emissions require special attention as no control device except chimney exhaust is installed, and the number of such industries are large and cumulatively have significant emissions.

Reprocessed plastic granules produce packing covers, carry bags, buckets, mugs, etc. Hence there is an excellent scope to recycle used plastic scrap to make plastic granules. Waste plastic materials are collected from various sources, segregated as per grade, colour and quality, and washed with water before further processing. The cleaned plastic materials are put in a cutting machine and converted into small pieces. The cut pieces are put in an extruder, where plastic is melted to give granule lumps (Figure 10). These lumps are put in a grinding machine to obtain granules of the required size and packed in 50 kg and 100 kg bags for despatch to plastic processing units.



1 Feeder 2. Screw extruder 3. Aircooling 4. Cyclone separator 5. Vibrating Sieve 6: Granules

Figure 10: Schematic manufacturing procedure of plastic granules

Some industries are engaged in coloured plastic like bottles and bottle covers (Figure 11). This requires the use of paints and solvents. The industry seems to have an adequate arrangement for suction and exhaust from the pipe, but there is no control device for VOCs and solvents emissions. Unlike other industrial areas, the roads were well maintained, with proper waste collection and drainage systems. However, some loading and unloading operations of raw material are done in the open, outside the industry premises (Figure 11).

Figure 11: Platic work, bottle covers, paints and roadside disposal and encroachment

4.5. KIRTI NAGAR INDUSTRIAL AREA

Kirti Nagar is home to one of the largest furniture markets, housing showrooms of multi-national home remodelling and fittings, interior design boutiques, imported kitchen and bath brands, and traditional carpentry furniture makers. Kirti Nagar has 926 SMEs and 24 are on PNG. These industries use a PNG of a total quantity 1492 SCM per month. The more significant problem is the storage of wood and carpentry work in the open, leading to encroachment and hindrance to traffic.

On the front side, the industrial area looks neat and clean with huge showrooms for furniture, but as one goes inside the market or at the backside, one can see heavy-duty trucks and trollies with tonnes of wood on the road. Roads are unpaved, and residences are at the roadside with industrial and commercial activities (Figure 12).

There is significant movement of heavy-duty vehicles (HDV), trucks, loaders, cranes and light commercial vehicles (LCV), etc. for transportation of raw material and finished products (Figure 12). The area is congested with other traffic movements of man and material. The construction activities were in the open and materials were stored on the main road causing traffic congestion (Figure 12).

Figure 12: Roadside storage of material, industrial activities, saw dust and encroachments

Figure 12: Roadside storage of material, industrial activities, saw dust and encroachments

4.6. MUNDKA INDUSTRIAL AREA (MIA)

MIA has 34 industries using PNG, with total use of 3708 SCM per month. The industry types are steel and metal cutting, PCC (precipitated calcium carbonate) manufacturers, biomass pellets, and cables and wires manufacturers. Most industries are engineering units. These units have large DG sets for use during power cuts. The major problem of the area is that it is very dusty as many of the roads are unpaved and poorly maintained, and poor air quality was observed inside the industries (Figure 13).

Figure 13: Unpaved Roads, roadside storage of raw material, industrial activities, poor indoor air quality

4.7. MAYAPURI INDUSTRIAL AREA

Mayapuri industrial area is located in West Delhi. It is a major hub of heavy metal and small-scale industries. The place combines residential areas, light metal factories, scrap markets, and automobile service stations. It has 330 SMEs and 73 are on PNG, with total use of 5546 SCM per month. The industry types are auto spare parts manufacturer, gearbox, repairing large DG sets, tyre re-treading cables and wires, electronic control panel, hose pipe, steel conduit pipe, footwear and plastic manufacturers. Most industries have their captive DG sets. There is significant movement of heavy-duty vehicles (HDV) trucks, loaders, cranes and light commercial vehicles (LCV), etc. for transportation of old and scrap vehicles. The area is congested with other traffic movement of man and material. The construction activities were in the open, and the material was stored on the main causing traffic congestion (Figure 14). Also, some industries are manufacturing and servicing DG sets on main road, causing encroachment and traffic congestion.

Figure 14: Roadside storage of raw material, industrial activities, saw dust emissions, encroachments and construction

5. CONTROL TECHNOLOGIES AND SOLUTIONS FOR AIR POLLUTION CONTROL

The industries in Delhi are on PNG for their combustion needs. Since PNG is the clean fuel, we focus on non-combustion but significant emissions from MSMEs and small business houses, including DG sets. Once the proposed actions are taken, there will be a substantial improvement in air quality in Delhi, adding overall cleanliness and better housekeeping in MSMEs.

5.1. CONTROL OF EMISSIONS FROM PLASTIC GRANULES

Adsorbers: Vapour-phase adsorption process use the property of large surface area of solids to adsorb and concentrate some pollutants (mostly VOCs) preferentially. The gas phase VOCs (from the melting of plastic) are passed through a packed bed of adsorbent where VOCs are captured on a solid surface, mostly by physical adsorption because of intermolecular or Van-der-Waals forces. The adsorbed organics can be recovered and the adsorbent can be regenerated. The most common adsorbent is activated carbon made from natural materials (wood, coal, nut shells, etc.). The system maintains a minimum of one active bed while another is regenerated (Figure 15). The collected VOCs must be recaptured and used for fuel and other applications.

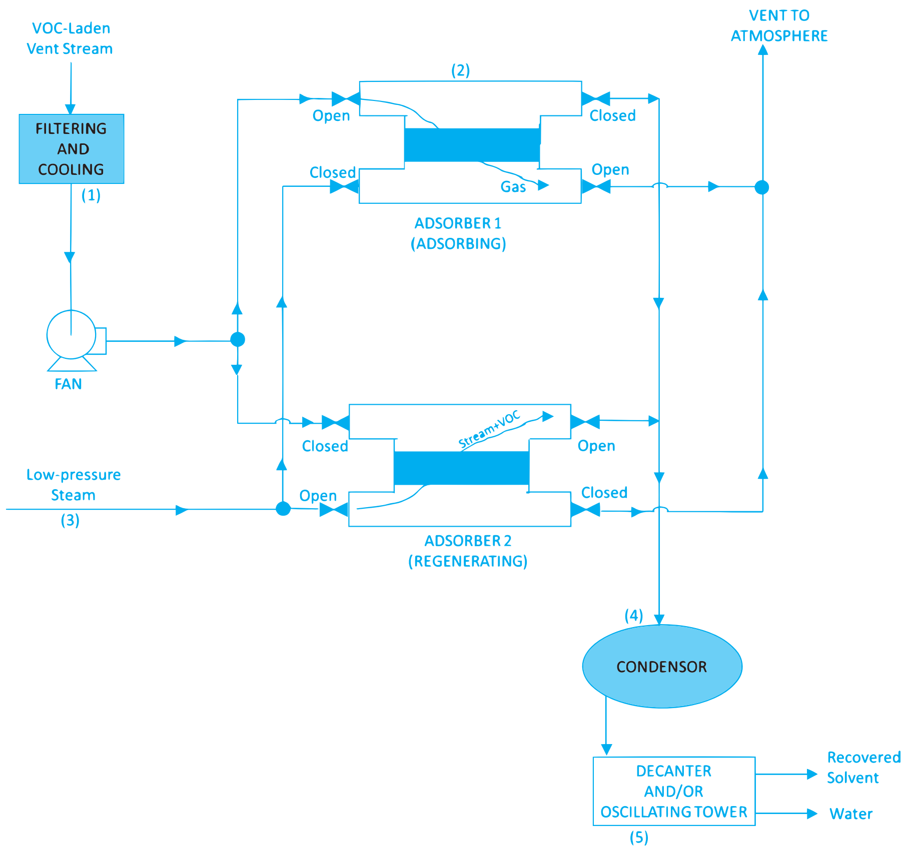


Figure 15: Two-stage regenerative VOC adsorption system for VOC Control (USEPA 1983)

5.2. EMISSION CONTROL FROM TYRE RE-TREADING

1. The re-treading of one tyre generates 1 to 1.5 kg of scrap rubber. The scrap shall be properly collected and disposed to recyclers. It should not be dumped in nearby areas unscientifically.

2. Firewood or PNG and adhesive are used for re-treading operations and smoke generated by gaseous pollution should be vented off using a chimney/stack with adequate height.

The system operates within a temperature range of 250 °C to 500 °C. At a temperature above 250°C, shredded tyres release more liquid oil products and gases. The pyrolysis process produces an excess of energy. In this process, oil, carbon black, and gases in the form of energy are generated.

Pollution control measures

1. The tyre, during the process of pyrolysis at a temperature above approximately 250 °C, releases liquid oil, it shall be stored in a suitable tank in a safe condition.

2. Carbon black shall be conveyed through a hydraulic/ screw conveyor in closed conditions. It can also be conveyed, collected, and handled using any advanced technology like bag filters. The carbon black shall be bagged in HPPE/leakproof bags with proper sealing.

3. The excess uncondensed gases from the reactor shall be stored under compressed conditions in a tank of suitable design. The collected gases can be used as fuel instead of wood during the start-up of the reactor. The excess uncondensed gases can be flared in a scientifically designed flaring system if the quantity is large and cannot be used as fuel.

5.3. DRY CLEANING UNITS

Dry cleaning are small businesses generally undergo unnoticed from an emission point of view. More than 90 percent of drycleaners are unorganized and perhaps not registered. However, cumulatively, the emissions from such units of solvents and non-methane volatile organic compounds are very high. As per the estimates of TERI, the NMVOC (non-methane volatile organic compound) emission from Delhi alone is about 63 kt/year based on USEPA's per capita emission factor. Most of this emission is expected from dry cleaning units and businesses.

Dry cleaning involves the cleaning of fabrics with organic solvents comprising three basic steps: (1) washing the fabric in a solvent, (2) spinning to extract excess solvent, and (3) drying in a hot air stream. Two general types of cleaning fluids are used in the industry, petroleum solvents and synthetic solvents. Perchloroethylene (PCE) and trichloro trifluoroethane are the two synthetic drycleaning solvents presently in use. Operations using these synthetic solvents are respectively called "perc" plants and fluorocarbon plants.

Emissions and Control

The drying exhausts are expelled into the atmosphere contributing to VOC emissions. However, there is a need for stricter controls on solvent emissions to be applied to all drycleaning machines, and no solvent fumes are vented to the atmosphere. In enclosed machines, solvent recovered during the drying process is returned, condensed and distilled, so it can be reused to clean further loads or safely disposed of. The solvent itself is the primary emission from dry cleaning operations. The solvent is given off by a washer, dryer, filter muck storage, leaky pipes, joints and flanges (USEPA 1995).

Solvent recovery is necessary in perc plants from emission and cost points of view. The solvent must be desorbed once a day from carbon adsorbent, condensed, separated from water and returned to a pure solvent tank. Residual solvent after treatment, distillation bottoms and muck is not recovered. Reasonable emission control is possible through good housekeeping by maintaining all equipment and good operating practices. All fluorocarbon machines on the dry-to-dry basis to save solvent vapours should have a built-in solvent recovery system. Refrigeration systems can also be installed to recover solvent from washers and dryers' exhaust gases.

Working solvent from the washing chamber passes through several filtration steps before it is returned to the washing chamber. The first step is a button trap, which prevents small objects such as lint, fasteners, buttons, and coins from entering the solvent pump.

Over time, a thin layer of filter cake (called "muck") accumulates on the lint filter. The muck is removed regularly (commonly once per day) and then processed to recover solvent trapped in the muck (USEPA 1995). After the filter, the solvent passes through a porous cartridge filter. This filter, which contains activated clays and charcoal, removes the solvents fine insoluble soil, non-volatile residues, and dyes. Finally, the solvent passes through a polishing filter, which removes any soil not previously removed. The clean solvent is then returned to the working solvent tank Figure 16).

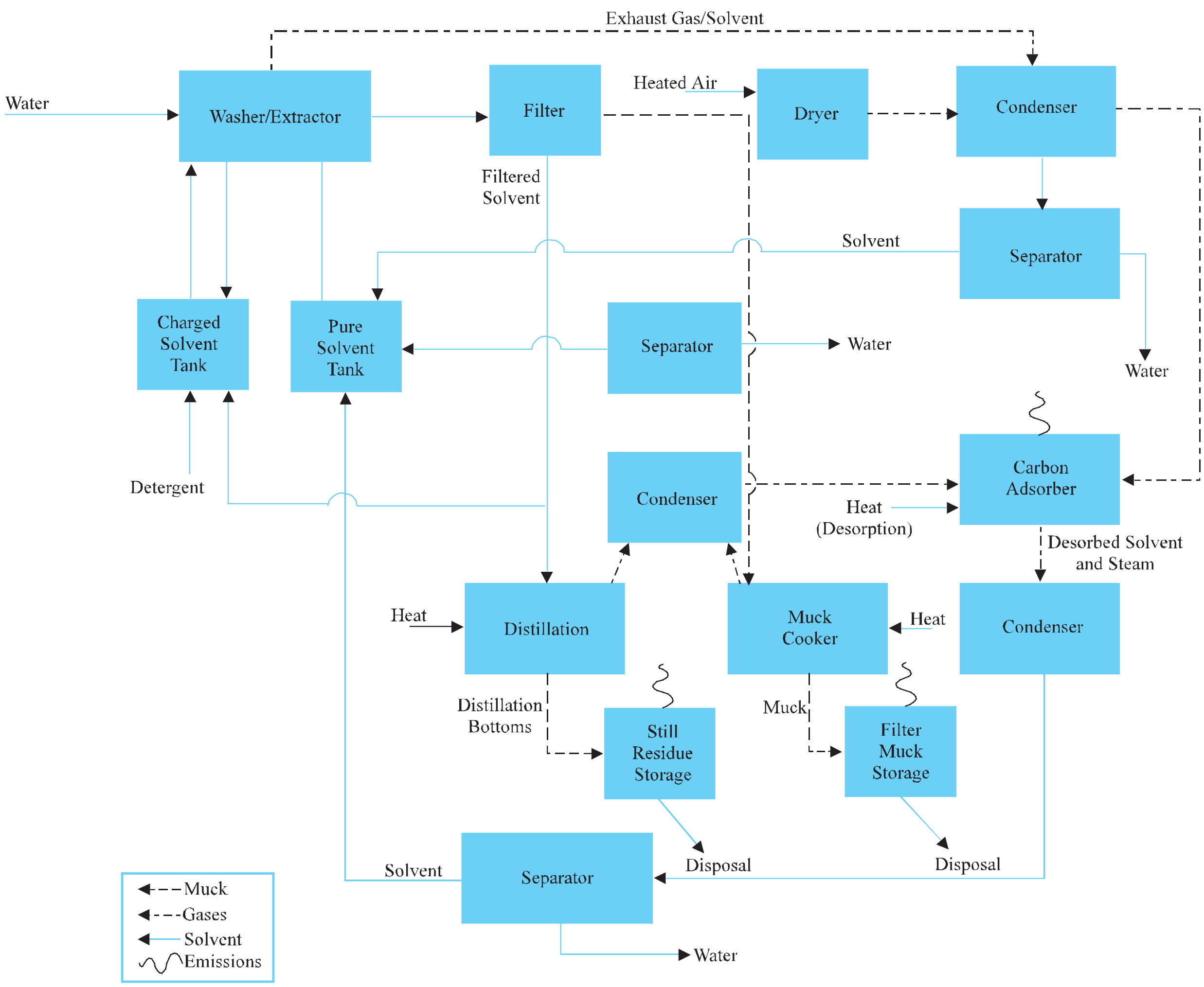


Figure 16: Emission Control at Dry cleaning units and recovery of Solvents (USEPA 1995)

5.4. PULSE AND WHEAT MILLS

Primary milling of rice, wheat and pulses is one of the essential activities in food grains. Today, due to industrialization and globally competitive market trend, it has emerged as a major industrial activity in the small, medium-scale sector to cater to the needs of the increasing population. Delhi has over 80 pulse (called "Dal") and 18 wheat mills. The technologies used for processing and milling are mostly indigenous and conventional and are not oriented towards minimizing pollution. These units generate a substantial amount of pollution, especially air pollution, due to fugitive emissions from various operations and pollution aspects remain primarily unsatisfactory (CPCB 2008).

Cleaning Process: The cleaning process starts with raw material (whole pulses) unloading from gunny bags to the plant site unloading area. The pulses are elevated continuously with the help of a bucket elevator and fed to a cleaning screen. The cleaning screen comprises a perforated cylindrical metal sheet with holes of various sizes. The impurities, such as dirt, dust, plant waste remains, shells of pulses, etc., are cleaned either by screening through the screen or by blowing away the impurities with the help of axial fans. The pulses are then passed through a set of rubber rollers (called "reel machine") to scour adhered dust etc. and to break the tips of pulses which are again passed through a 2nd or 3rd set of rotary screens for screening the impurities.

The cleaned pulses are conditioned using water or oil by soaking for desired hours and sun-drying or hot air drying. After proper conditioning, the pulses are sent for milling, involving the application of abrasive force in various rollers to remove the outer shell of pulses, followed by shearing of pulses in two halves in grinders (Figure 17).

Emissions and Control

Research shows feed grain dust's harmful or toxic effects; many individuals experience bronchial or allergic disturbances after exposure to feed and grain process dusts (CPCB 2008). During pulse making, dust is generated/emitted from various points, which spreads into the surrounding areas and pollutes the shop floor and ambient air.

In the cleaning section, fine dust is generated at various points as detailed below (CPCB 2008):

1. While unloading the pulses
2. At different stages of lifting and discharging pulses through bucket elevators and pipes.
3. Rotary screening
4. Scratching of pulses for breaking of tips roller machine
5. At discharge points of the rotary screens
6. Blown away dust (bhussi)

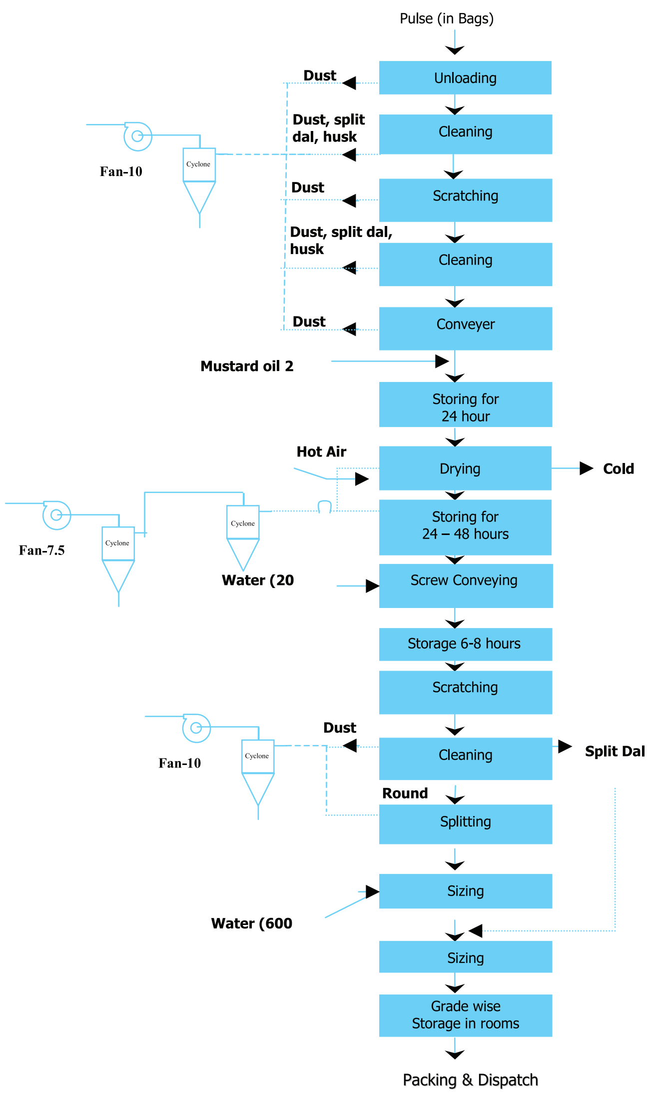


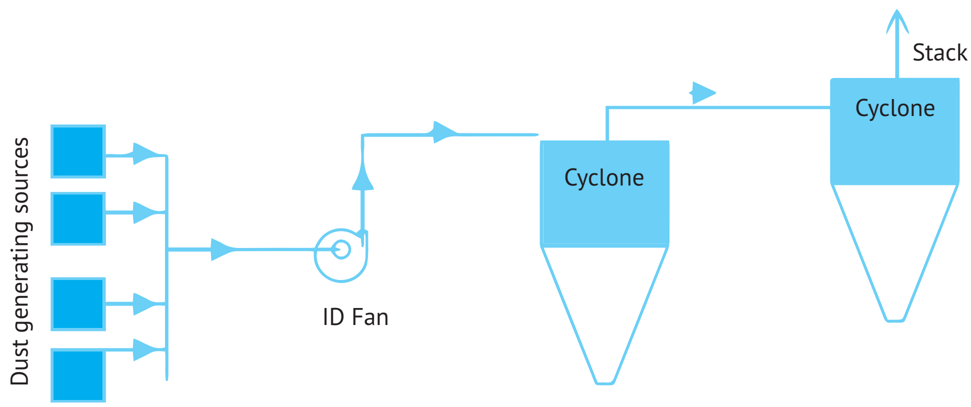
Figure 17: Typical Pulse Mill Showing Pollution Sources & Control Systems (CPCB 2008)

The dust and powder emitted from the cleaning and milling sections must be separately extracted and captured in separate air pollution control systems. The dust collected from the cleaning section primarily contains impurities like soil, silica, stones, etc., which must be disposed of, whereas the powder collected from the milling section is a by-product that can be sold as animal feed.

The uncontrolled emission concentration to the control device can be very high, exceeding 30000 mg/Nm3 (CPCB 2008). Most units employ the colle ction of emissions through fans and hoods (Figure 17). The critical aspect of air pollution control is the proper collection of over 98% of emissions then only the role of control devices will come into being. Fugitive emissions are reported in various mills, which may be due to inadequate provision of the dust extraction system. The suspended particulate matter (SPM) measurements were conducted at the shop floor of the Pulse-making units primarily to estimate the fugitive emissions arising from the ineffectiveness of dust extraction systems (CPCB 2008). It was reported that an inefficient dust extraction arrangement would lead to higher SPM concentration at the shop floor can vary from 7000 to 79000 µg/m3 in the shop floor area (CPCB 2008). The standard devices are cyclones alone and or along with bag filters of over 99% efficiency.

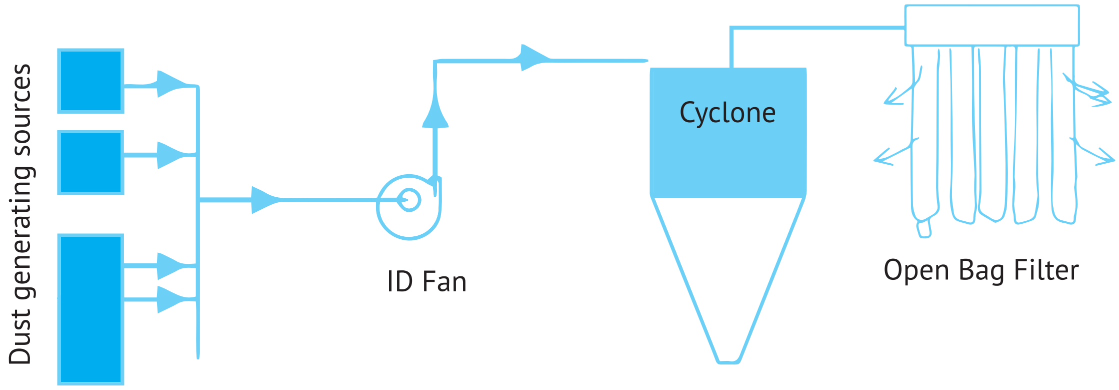
Double cyclones in series

Post extraction of dust, the industry can deploy double cyclones in series. In this type of system, shown schematically below, dust is extracted from various dust generating points with the help of an ID (induced draft) fan and it is passed through a set of two cyclones in series. Generally, most mills install the second cyclone as an add-on item, thinking that more dust would be collected which was not collected in the first cyclone. However, technically, the dust that could not be collected in the first cyclone contains a maximum percentage of fine particles below 10-micron size, which cannot be collected efficiently in any number of subsequent cyclones in series but it would only increase the system pressure drop and would ultimately reduce the volume extracted by the fan which would lead to fugitive emissions from the dust sources (CPCB 2008).



Open Hanging type Bag Filter (without cleaning arrangement and stack)

A far more efficient technology to adopt that series of cyclone is the big filters. This is most pre-dominantly adopted type of dust control system, particularly in pulse making and wheat flour mills. In this system, dust is extracted from various dust generating points with the help of an ID fan and the dust-laden air is passed through a cyclone and the cyclone outlet is connected to a ring type enclosure with holes in the bottom and on these holes loose cloth bags are tied, as shown below. In such systems, the heavier particles get collected in the cyclone and the finer particles, escaping cyclone, get deposited on the filter bag cloth. In the absence of any periodical bag cleaning mechanism, the dust deposits on filter bags keep building, eventually leading to blinding of the cloth and choking after a few hours of operation. This leads to high pressure drop across the filter bags, which results in either puncturing the bags or a reduction in the suction capacity of the fan. Any puncturing in the filter bags gives rise to the spreading of fine dust through the hole into the shop floor area. On the other hand, the fan's reduced suction capacity leads to reduced volume, which leads to fugitive emissions from the dust-generating sources.



5.5 METAL CASTING INDUSTRY

Air pollution is a major environmental problem for metal casting industries, especially foundries. Delhi has over 250 small-scale metal (ferrous and non-ferrous) casting industries and is cumulatively a major industrial emission source despite uses of PNG. The raw materials handling operations emit fugitive particulates generated from receiving, unloading, storing, and conveying all raw materials for the foundry. These emissions are controlled by enclosing the major emission points and routing the air from the enclosures through fabric filters.

Emissions from scrap preparation consist of hydrocarbons if solvent degreasing is used and consist of smoke, organics, and carbon monoxide (CO) if heating is used. Catalytic incinerators and afterburners of approximately 95% control efficiency for carbon monoxide and organics can be applied to these sources (USEPA 1995).

Emissions from melting furnaces are particulates, carbon monoxide, organics, sulphur dioxide, nitrogen oxides, and small quantities of chlorides and fluorides. The flux generates the particulates, chlorides, and fluorides. Scrap contains volatile organic compounds (VOCs), dirt particles, and oxidized phosphorus, silicon, and manganese (USEPA 1995). In addition, organics on the scrap and the carbon additives increase CO emissions. There are also trace constituents such as nickel, hexavalent chromium, lead, cadmium, and arsenic.

The highest concentrations of furnace emissions occur when the furnace lids and doors are opened during charging, back charging, alloying, oxygen lancing (in some industries), slag removal, and tapping operations. These emissions escape into the furnace building and are vented through roof vents. Controls for emissions during the smelting and refining operations focus on venting the furnace gases and fumes directly to an emission collection duct and control system. Controls for fugitive furnace emissions involve using building roof hoods or special hoods near the furnace doors at the side (Figure 18), to collect emissions and route them to emission control systems. Emission control systems commonly used to control particulate emissions are bag filters, cyclones, and venturi scrubbers.

The major pollutant from mould and core production are particulates from sand reclaiming, sand preparation, sand mixing with binders and additives, and mould and core forming. Particulate, VOC, and CO emissions result from core baking and VOC emissions occur during mould drying. Bag filters and scrubbers can be used to control particulates from mould and core production. Afterburners and catalytic incinerators can be used to control VOC and CO emissions (USEPA 1995). During casting operations, large quantities of particulates can be generated in the steps before pouring. Emissions from pouring consist of fumes, CO, VOCs, and particulates from the mould and core materials when contacted by the molten steel.

Figure 18: Sideways collection of fumes from melting and casting operation

Used foundry sand (UFS) Sand is the primary constituent of moulds and cores used in the production of both ferrous and non-ferrous castings. In most foundries, the majority of UFS is disposed to landfill. Depending on the binding agents used to make the moulds and cores, a number of sand reclamation and internal recycling options exist. These options should be considered where feasible. Similarly, options for recycling used foundry sand for external applications, such as a component of road base or other suitable means of reuse, should also be considered.

5.6 CONSTRUCTION AND DEMOLITION

It is a common site in the industrial areas of Delhi where some construction and demolition activities are ongoing. These activities are open and no specific pollution control measures are adopted (Figure 19). The control measures for emission include:

1. Wet suppression (Figure 20)
2. wind speed reduction (for large construction site) (Figure 21)
3. Waste should be disposed of appropriately. It should not be kept lying near the roads as it may contribute to road dust emissions.
4. Proper handling and storage of raw material: covered the storage and provide the windbreakers
5. vehicle cleaning and specific fixed wheel washing on leaving the site and damping down of haul routes
6. The actual construction area is covered by fine screen
7. No storage (no matter how small) of construction material near the roadside (up to 10 m from the edge of road).
8. The haul roads shout be stone brick-path roads to minimize the emissions
9. Use water cannons (Figure 22) to create a fine mist using jet nozzles with a strong air flow generated

Figure 19: Unpaved Road and Construction dust

The suggested control measures will reduce the emission by 50%. These measures will also reduce the road dust and fly ash contribution to ambient air concentration.

5.7 ROAD DUST

Road dust and dust from soil, construction and demolition (C&D) are the largest sources in industrial areas. The source apportionment report of IIT Kanpur for Delhi, indicates dust as the major contributor to air pollution, specifically in the summer season, going up to 50% for PM_{10}. Thus, the clean and well-maintained roads, paved shoulders, stabilized soil (to the extent possible) at all levels of urban roads, state and national highways will positively impact air quality. A new policy is to be formulated for the condition of the road, types of shoulder paving including interlocking blocks, regular dust cleaning, especially washing of urban roads and occasionally highways, and stabilization of soil through growing shrubs and/ or grasses or chemicals.

Figure 20: Dust Suppression System; Sprays are used to capture airborne dust

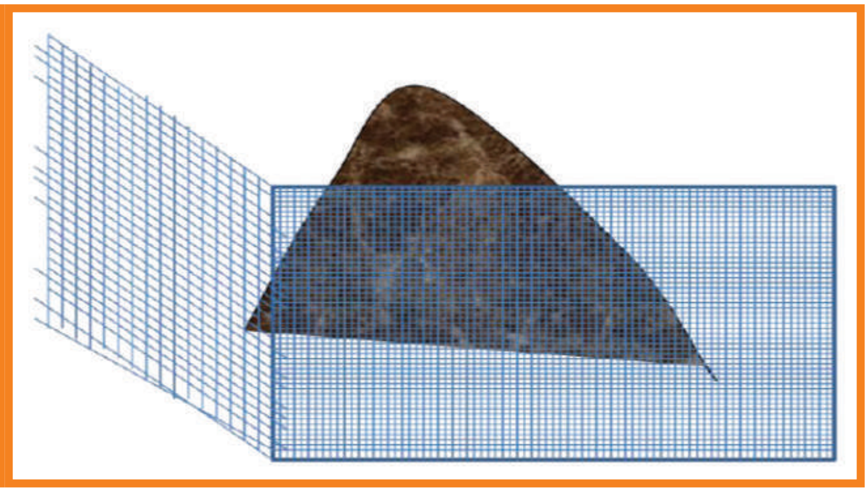


Figure 21: Windscreen for dust control from storage area

Figure 22: Water cannon to suppress dust emissions

There should be a regulation on the condition and a regular maintenance framework. One of the effective ways to reduce the dust is to set the limit on silt loading on the road as less than 2.0 g/m2, which regulatory authorities should enforce. The following control measures are evaluated and suggested to reduce the dust emissions on major roads and should become a national policy/norm:

1. **Mechanical sweeping with water wash:** The estimated road dust PM_{10} emission is 20 million tons annually, accounting for about 55% of total national emission. This emission will be maximum in summer and least in monsoon. The efficiency of mechanical sweeping has been reported as 55% (Amato et al., 2010). If the sweeping of the main roads is done twice a month, the road dust emission will be reduced by 23% and if the frequency is increased to four times a month, then the road dust emission will be reduced by 52%. This reduction is likely to reduce the ambient air concentration of PM_{10} by one-fourth of PM_{10} levels contributed by this source.
2. **Vacuum-assisted Sweeping:** The efficiency of vacuum-assisted sweeping followed by washing is taken as 90% (Amato et al., 2010). If the sweeping is done twice a month, the road dust emission will be reduced by 42%. If the frequency of sweeping is increased to four times in a month, then the road dust emission will be reduced by 71% i.e., road dust emission at the end of the month will be 24 ton/day. This reduction is likely to reduce the ambient air concentration of PM_{10} by one-third in summer.
3. **Maintenance of Roads:** It is more important that the condition of the roads is adequately maintained and paved wall to wall. Broken roads are a source of silt accumulation and particle generation.

Road Shoulders, footpaths, and parking lots

Since PM_{10} is the subset of $PM_{2.5}$, all action taken for $PM_{2.5}$ control will also bring the PM_{10} levels. However, the exclusive controls of PM_{10} should include better road conditions, paved shoulders, stabilization of soil surface, sidewalks and unpaved portions (e.g., parking lots) to have Interlocking Concrete Block Pavement (ICBP). ICBP technology is internationally adopted for specific requirements of footpaths, parking areas, etc. It should be the priority that all existing unpaved shoulders, sidewalks, and parking lots are suitably handled (see above), and in the future, all new road constructions incorporate these measures.

5.8 AUTOMOBILE SERVICE CENTRES

The city of Delhi caters to over 12 million vehicles in Delhi. The closed environments of automobile centres cause fugitive emissions, and denting and painting of the vehicles can also lead to air pollution. The European Garage Equipment Association (EGEA, 2011) has published the following general guidelines recommendations:

1. Ordinary citizens should avoid exposure to the indoor air environment of automobile service centre.
2. The workspace should be equipped with an exhaust extraction system to protect the workers against the high air pollution level.
3. Exhaust emissions should be captured as close to the tailpipe of the activity likely to cause emissions.
4. The extraction system specification should accommodate the largest engine that could be serviced at the workshop in use at the workplace.

The EGEA recommends the following exhaust rates: 450 m3/h is needed for cars with up to 4 litres engines; 900 m3/h is required for cars with up to 4 litre engines when exhaust tests are carried out; 1000 m3/h is needed for trucks with up to 16 litre engines that are being serviced; 1800 m3/h is needed for trucks with up to 16 litre engines when exhaust tests are carried out. Ventilating or air conditioning systems are controlled by the value of indoor temperature or relative humidity.

5.9 LOADING AND UNLOADING

It was observed that loading and loading operations of raw material and finished products are carried out casually, causing fugitive emissions – this is a common issue in all industries. As the truck enters the loading and unloading areas, it should be covered with flexible plastic sheets and the fogging nozzles should come into operation from the sides and top to suppress the dust (Figure 23). It will save the wastage of raw material and add moisture content to the material, preventing further emissions from material handling and transfer points. The fogging should not be used for cement-like material. Instead, pneumatic dust suction should be employed.

Figure 23: Covering loading and unloading areas with flexible plastic sheets (with hopper)

5.10 DG SETS

DG (captive power generation) sets are installed to account for power outages and unreliable supply for industrial/commercial areas. Regulatory compliance with emissions standards and shifting to gas-based generators should be mandatory to reduce emissions. There is a need to understand the power deficit and inadequacy of transmission and distribution systems for immediate remedial action. Power supply infrastructure must be updated to prevent power cuts.

A per the Commission for Air Quality Management in NCR & Adjoining Areas (caqm.nic.in): Strategy will have to be aligned with the renewable energy programmes – grid scale and rooftop solar — in the region. Rooftop solar power with enhanced grid capacity needs to be encouraged and supported. This needs targeted expansion to support clean air action. Sub-region-wise plans need to be created with targets for deployment that is measurable and monitorable for implementation.

All efforts should be made to minimize uses of DG sets and to strengthen the regular power supply. Some small DG sets are used at the ground level, creating noise and high pollution. It is recommended that all DG sets of size 2 KVA or less should not be allowed to operate; solar-powered generation, storage, and inverter should be promoted.

5.11 READY MIX CONCRETE BATCHING

The ready-mix concrete is used for construction activities. These activities are frequent in a city like Delhi, which is high in urban agglomeration. This source is the third most contributor to total PM_{10} emission (Sharma and Dikshit 2016). A large amount of fly ash generation is also expected from this source because pozzolana cement is used in the process and has about 35 percent fly ash in it. The control measures include:

1. Wet suppression
2. Wind speed reduction
3. The transfer of pozzolana cement and other material to silos is one of the plant's primary emission sources, and fabric filter installation should be compulsory.
4. Waste should be disposed appropriately. It should not be kept lying near the roads as it may contribute to road dust emission.
5. Proper handling of raw material (loading, unloading, storage, etc).
6. Vehicle cleaning and specific fixed wheel washing on leaving site and damping down of haul routes.
7. All transfer points and conveyer belts should be covered
8. Telescopic chute should be used for dropping the raw material

6. SECONDARY POLLUTANTS AND CONTROL

Primary pollutants are directly emitted from the emitting source. This section focuses on secondary air pollutants formed in the lower atmosphere by chemical reactions driven mainly by the Sun's radiation. Primary pollutants, especially particulate matter, have been controlled extensively from the major sources. However, control of secondary pollutants requires control of percussor gases from industries and nonpoint sources. Nothing much has been done to control precursors except coal-based power plant emissions. Therefore, the focus of this section is on understanding and control of secondary pollutants.

The two examples are ozone and secondary aerosols (haze). Secondary pollutants are harder to control because they have different ways of synthesizing and the formation is not well understood. Secondary pollutants form naturally in the environment and cause problems like photochemical smog (Figure 24).

The major problem in the Delhi air environment is secondary aerosols (SA). A significant portion of PM originated in the atmosphere is from the secondary transformation of precursor gases (e.g., nitrogen oxides (NOx), sulphur dioxide (SO2), ammonia (NH3), volatile organic compounds (VOCs)) through gas-to-particle conversion. Primary particles can be controlled at the source; however, assessment and control of secondary particles pose a greater challenge as these are formed in the atmosphere and require control of precursor gases.

Components of secondary PM can broadly be classified into two groups: (i) secondary organic aerosols (SOA), (Figure 25 and (ii) secondary inorganic aerosols (SIA). Detections and quantification of SIA are straightforward, as it consists of ions of sulfate (SO42-), nitrates (NO3-), ammonium (NH4+) and chlorides (Cl-) (Figure 26). However, the polar nature of SOA and its many species pose challenges in their detection and analysis. Therefore, organic aerosols are often represented by a group referred to as organic carbon (OC), which contains both primary and secondary components. Assessment of the secondary component of OC poses an even greater challenge, as part of OC (representing SOA) is an outcome of several hundreds of reactions occurring concurrently in the atmosphere.

Gas-to-particle transformation processes in the atmosphere (both organic and inorganic), leading to the formation of secondary $PM_{2.5}$, account for the remaining 50–60% (Russell et al., 2004). NH3 gas neutralizes sulfuric acid (H2SO4), nitric acid (HNO3) and hydrochloric acid (HCl) to form ammonium sulfate (NH4)2SO4, ammonium bisulfate (NH4HSO4), ammonium nitrate (NH4NO3) and ammonium chloride (NH4Cl), which are the major components of $PM_{2.5}$ (Aneja et al., 2008; Baek and Aneja, 2005). This neutralization produces ionic species of these compounds (SO42–, NO3–, NH4+ and Cl-) and these constitute SIA, which could be 20–40% of $PM_{2.5}$ (Lin and Cheng, 2007). These reactions are strongly influenced by ambient air temperature, relative humidity, solar radiation, the concentration of precursor gases, and concentration levels of existing PM (Figure 26).

PM levels have been shown to be very high in Indian cities (PM10: 50–600 μgm-3; $PM_{2.5}$: 25–200 μgm-3; Sharma and Maloo, 2005). Recent studies (Sharma and Dikshit, 2016) have focused on the chemical characterization of $PM_{2.5}$ in Delhi. For any control strategy to be effective, it is essential to understand the chemical characteristics of aerosols, their sources, and mechanisms of formation. A study at Kanpur (Sharma, 2010) has suggested that NH3 plays a significant role in the formation of secondary inorganic aerosols (NH4+, SO42- and NO3–); the study was based on the chemical characterization of PM10. However, consistent hazy conditions in the Indian atmosphere are significant because of fine particulates and efforts are needed to discern the sources and formation of $PM_{2.5}$.

6.1. CONTROL OF SECONDARY PARTICLES

What are the sources of secondary particles, the major and consistent contributors to Delhi's PM? These particles source from precursor gases (SO2 and NOx), chemically 276 transformed into particles in the atmosphere. Mostly, the precursor gases are emitted from far distances from large sources. For sulfate, the major contribution can be attributed to large power plants and refineries. The prevalent wind from the northwest and southeast can bring in secondary sulfate and nitrates from large power plants and refineries almost from all sides of Delhi. However, the contribution of NO2 from local sources, especially vehicles and power plants, can also contribute to nitrates. Behera and Sharma (2010) for Kanpur have concluded that secondary inorganic aerosol accounted for the significant mass of $PM_{2.5}$ (about 34%) and any particulate control strategy should also include control of primary precursor gases. In Delhi, the estimated contribution of secondary particles in $PM_{2.5}$ is 30% and requires strict controls. Even more significant is that controlling secondary particles through SO2 and NOx will benefit the entire NCR (national capital region) and not just Delhi.

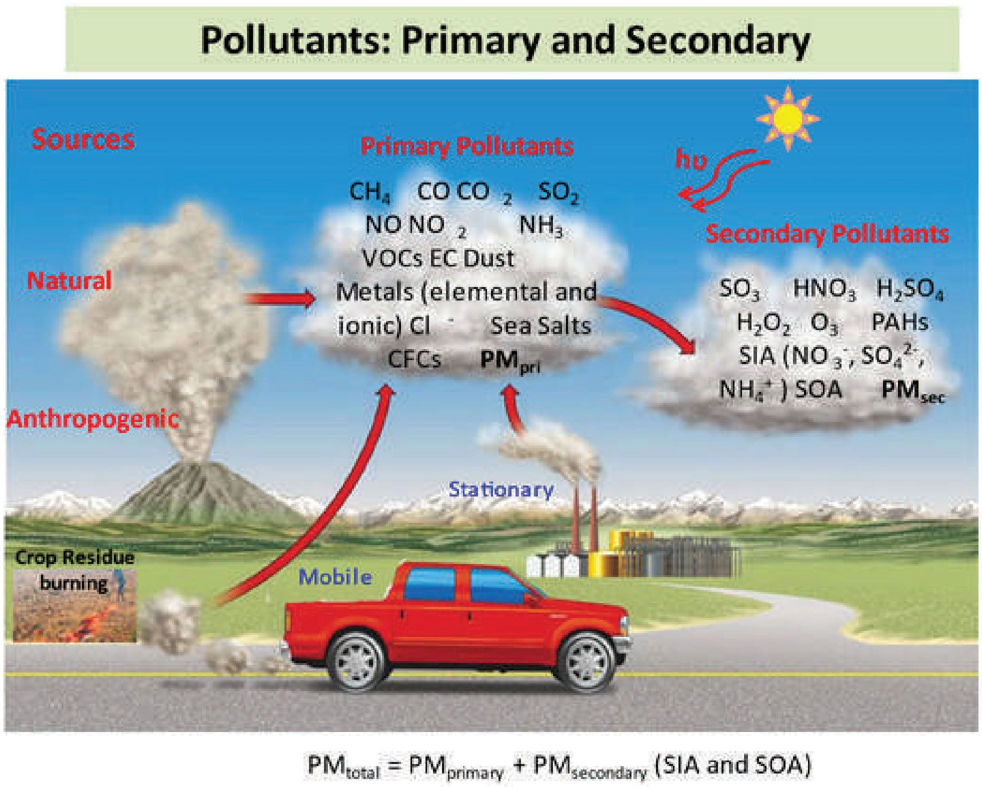


Figure 24: Emissions of Primary Pollutants and Formation of Secondary Pollutants

There are many thermal power plants (TPPs) with a total capacity of over 11000 MW within a radius of 300 km from Delhi, which is expected to contribute to secondary particles. Based on the study done by Quazi (2013), it was shown that power plants contribute nearly 80% of sulfate and 50% of nitrates to the receptor concentration. A calculation assuming 90% reduction in SO2 from these plants can reduce 72% of sulphates. This will reduce PM10 and $PM_{2.5}$ concentrations by about 62 µg/m3 and 35 µg/m3, respectively. Similarly, 90% reduction in NOx can reduce the nitrates by 45%. This will reduce PM10 and $PM_{2.5}$ concentrations by about 37 µg/m3 and 23 µg/m3, respectively. It implies that control of SO2 and NOx from power plants can reduce PM10 concentration by approximately 99 µg/m3; for $PM_{2.5}$ the reduction could be about 57 µg/m3. SO2 removal technologies include wet flue gas desulfurization (FGD), dry FGD utilizing a spray dryer absorber and dry adsorbent (lime and limestone) injection. Most SO2 removal processes are engineered oxidation systems that transform calcium sulphite (CaSO3) formed by the SO2 removal process to calcium sulfate (CaSO4: gypsum). In a De-NOx-ing (removal of NO2) system, NO2 is reduced by ammonia (NH3) or urea to nitrogen and water. Based on economic considerations, a suitable reducing agent can be selected from ammonia-like materials. This process is called Selective Catalytic Reduction (SCR). SCR De-NOx-ing system consists of a reactor, injection system, and catalyst.

Secondary Organic Aerosols

The contribution of secondary organic aerosols (SOA) in an urban environment in India is estimated as 20% of $PM_{2.5}$. This implies that VOC emissions need to be controlled both in and outside Delhi, as SOA can be formed from VOC sources far from the receptor. It is recommended that all petrol pumps in Delhi should install a vapour recovery system to reduce VOC emissions when dispensing petrol/diesel and filling a storage tank at the petrol pump. In addition, Delhi's VOC sources should be controlled in all industries producing, handling and using solvents (e.g., dry cleaning units). It is also recommended that VOC-free paints be used in painting works.

The estimated global SOA (20–70 Tg/year) results from NMVOC emitted by many anthropogenic and natural sources (burning fossil fuels, wood and biomass, solvent uses, and emissions from vegetation and the oceans). Black Carbon and Organic Carbon emissions serve as a site for condensation of SVOC. Primary organic aerosol (POA) emissions provide a surface for the formation of SOA.   In other words, to control SOA, the control of primary of particles and NOx and SO2 will be helpful.

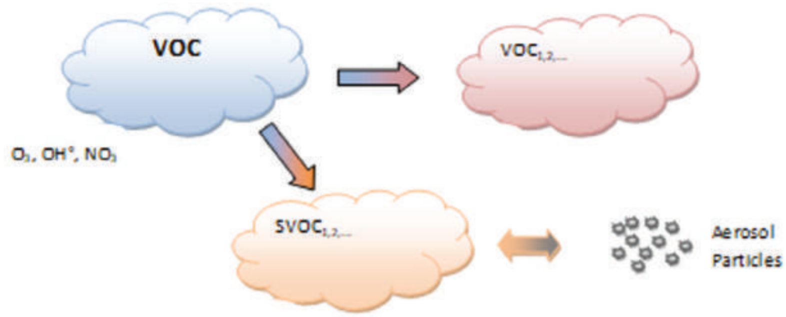


Figure 25: Role of VOCs and formation of Secondary Organic Aerosol

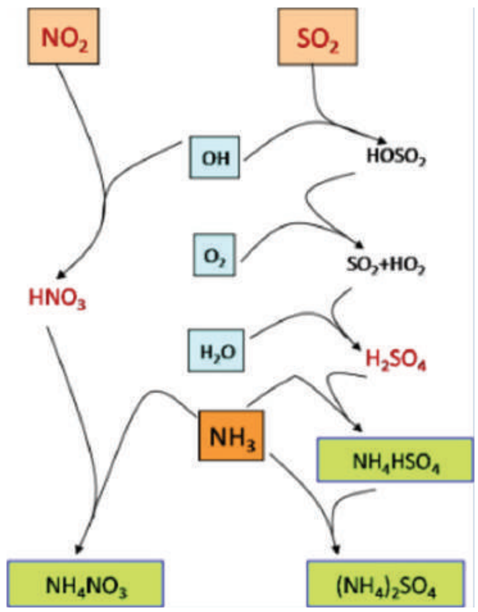


Figure 26: Chemistry of Secondary Inorganic Aerosol

7. POLICY ISSUES AND INTERVENTIONS FOR BETTER AIR QUALITY

The role of micro, small and medium enterprises (MSMEs) in the economic and social development of the country is well established. The MSME sector is a nursery of entrepreneurship, often driven by individual creativity and innovation. This sector contributes 8 percent of the country's GDP, 45 percent of the manufactured output and 40 percent of its exports. The MSMEs employ about 60 million persons through over 26 million enterprises producing over six thousand products (Strategic Action Plan of Ministry of Micro, Small and Medium Enterprises; https://msme.gov.in/sites/default/files/MSME-Strategic-Action-Plan.pdf).

MSMEs produce a wide-ranging variety of goods for exports and for within the domestic consumption. A level playing field for MSME sector is essential, despite the reluctance of banks/financial institutions to provide loans, modern technology, marketing capabilities, etc.

The potential strategies to develop the MSME sector and do better for environmental control would mainly rest on the following points:

1. Skill development
2. Environmental technology resources
3. Decarbonization
4. Preventing waste burning
5. Used of bio-mass based fuel
6. Small-scale units and small boilers

7.1 SKILL DEVELOPMENT

The workforce and owners of MSMEs lack the training and are unaware of air pollution control measures, including environmental regulations, obligations and rights. They cannot operate air pollution control devices, including preventing their own exposure. A systematic approach is required for skill development that should include on-field training. To cover the larger subject areas, a Centre for Excellence can be set up at the national and state level to standardize training curriculum, training of trainers, etc. The centre should provide advisory services for better technology and efficiency for a competitive edge. Better efficiency means more profit and helps the environment. A database of the trained persons in managing air pollution control equipment, their maintenance and ensuring regulatory compliance could be maintained and be available to the MSMEs.

7.2 ENVIRONMENTAL TECHNOLOGY RESOURCES

The key factor that moves growth in MSME sector is technology, which can change rapidly. The technology issue is equally important for air pollution control devices and measures. The environmental laws change routinely, demanding higher levels of control. The MSME sometimes is unaware of new regulations that require the upgradation of emission standards and faces legal notices from the pollution control boards. A resource on technology-linked emissions achievements and multiple technology options and vendors (with the cost) linked to different levels of control be available from national and state level ministries; however, standards should be attained with the industry.

7.3 DECARBONIZATION

With the commitment pledged in Paris Agreement and in the Glassgow meeting of 26th UN Climate Change Conference, the MSMEs need to share the responsibility for better efficiency and reduction in carbon emissions. However, it does not imply that growth and profits may be compromised. In simple words, climate finance should be routed to the MSME sector and they should be aware of it. This financing will be available for longer periods, and MSMEs should be connected formally with the financial credit system. Climate finance will open new avenues for technology transfer and expertise from developed nations and MSMEs can participate in climate change mitigation. The major focus should be cleaner energy and energy and product efficiency.

7.4 NEED FOR A UNIFORM NATURAL GAS PRICING POLICY

It is common knowledge that despite the availability of PNG, many MSMEs, even households, do not adopt gas on a large scale, mainly due to economic considerations and loss of profit. Given the current fuel taxation policies, PNG is more expensive than other competing solid fuels like coal. Natural gas currently does not attract GST; however, state VAT (value added tax) and central sales tax continue to be applicable on PNG, making it difficult to use economically. It must be considered that the tax structure is rationalized for the NCR sub-regions so that there is product cost competitiveness and also the gas companies get a return on their investment.

7.5 PREVENTING WASTE BURNING

Nearly all industrial areas are prone to open burning of industrial waste, including plastic, packaging, rubber, textile, ceramic, slag, etc. For both non-hazardous and hazardous waste, industrial waste management has emerged as an important issue in Delhi and the NCR states. There is an urgent need to streamline the collection and disposal of such waste to prevent burning. Make industries and industry associations liable for safe collection and disposal. There have been some initiatives in Bhiwadi Industrial Area, Rajasthan where authorities have tied up with an organization named 'Saarthak' to collect industrial waste and recycle and reuse it using a material recovery facility. Such initiatives need to be scaled up for all industrial areas, including Delhi.

7.6 USE OF BIOMASS-BASED FUELS

Industrial use of agro residues is growing in NCR, which has a co-benefit of lowering pollution in relation to coal combustion and also absorbing the biomass waste from agriculture that would otherwise burn in the open to cause enormous pollution. Pollution emergency action during winter that requires closure of industry on dirty fuel and the pressure to implement the comprehensive action plan is pushing this change. There is an increasing trend towards the adoption of biomass fuels in the region. There is also considerable policy thrust at the central level to use biomass for cofiring in power plants. It is expected to lower particulate and gaseous emissions and nearly eliminate SOx emissions through the use of biomass fuels in lieu of conventional fossil fuels for industrial applications.

7.7 SMALL-SCALE UNITS AND SMALL BOILERS

MSMEs dominate the industrial areas and many have boilers for producing steam. Small scale multiple generations of steam or use of boilers are inefficient and often based on dirty solid fuel. The Centre for Environment and Science (CSE 2020) has examined the feasibility of replacing small boilers with common steam boilers in industrial areas replacement of small boilers with common steam boilers in industrial areas feasibility assessment. As per the CSE report, there are a large number of small boilers in several industrial clusters in Ghaziabad, Loni, Faridabad, Bhiwandi and Panipat, among other towns. Replace small boilers with common boilers for steam generation in a cluster of industrial units is a meaningful way forward. Community boilers are centralized systems that meet the collective demand for steam by a group of industrial units through a steam pipeline network in the industrial area. This approach can considerably reduce particulate and gaseous NOx and SO2 emissions (CSE 2020).

The emission standards are relaxed for small boilers; the PM emissions standards for less than 2 t/hr capacity boilers are 1,200 mg/Nm3; 2 to <10 t/hr capacity 800 mg/Nm3 10 to <15 t/hr capacity 600 mg/Nm3 and 15 and above t/hr capacity 150 mg/Nm respectively appear to be lenient and warrant a review by the CPCB and MoEFCC (Ministry of Environment, Forest and Climate Change).

Use of diesel generator (DG) sets for captive power generation in industrial areas is a major source of pollution. To discourage use of DG sets the key focus has to be on uninterrupted power supply in the region and replacing DG sets with gas-based sets. The DG sets should be restricted for emergency applications.

7.8 FUTURE ENERGY

The efforts by all governments will slowly move towards green energy, including solar, hydrogen, and ammonia. The MSMEs should be aware of the new technologies of future and keep themselves abreast with government policies. The policies on green energy should be inclusive for MSMEs not only for their uses but also for their production and storage.

8. AIR POLLUTION EFFECTS ON MARGINALIZED AND VULNERABLE COMMUNITIES

The current locations of the industrial areas in densely populated regions of Delhi expose the marginalized groups to higher cumulative air pollution. It is evident that for economic regions and employment opportunities, the marginalized communities that reside close to the industrial are mostly in shanty and congested dwelling units. These communities face double burdens from industrial emissions, road dust movement of heavy-duty trucks and poor indoor conditions and solid fuel like coal and firewood. Thus, the higher pollutant exposure burden falls on immigrants, laborours and low-income residents. Many industrial areas, especially in the north, east and west of Delhi, are seen in areas where population density may exceed 25000 persons per sq. km. For instance, in the city of Delhi, rich and well-off communities live in clean area with better sanitation and civic amenities. They are not experiencing higher cumulative air pollution burdens than labourers, migrants and their families (elderly and children).

The most analysis and research concerning exposure, and air pollution health studies have focused on the entire Delhi as a single entity and thus, the current research does not show the suffering and higher exposure to the vulnerable community. The bulk data on air pollution hazards, fine particulate matter, nitrous oxide, sulphur dioxide and ozone are linked to the entire city. There are hardly any studies considering the pollution levels from different microenvironments and indoor environments of the poor and marginalized communities.

Unfortunately, inequity is part of the system. Arguably, air quality policy-making should centre around equity by considering multiple aspects of social vulnerability and air pollution hazard using cumulative indicators, location and population-based methodology. This methodology keeps the right perspectives of communities impacted by pollution to minimize existing inequities.

8.1. FIELD VISITS AND INTERVIEWS

A consented survey through personal visits and interviews was undertaken to assess air pollution-related health and its general impact on marginalized and vulnerable communities in the industrial areas (Questionnaire in Hindi – Annexure 1). The industrial areas included Najafgarh, Bawana and Narela. The main focus of the survey was based on a questionnaire covering the health of workers and residents, exposure to dust and gaseous pollutants, type of fuel used in industrial work (like PNG, LPG, Electric, Diesel, Coal or any other kind of fuel) and at home, ventilation at work place, plastic burning, and disposal of garbage.

The percentage distribution of the age group of 25-40 years was 60%, above 40 years 35% and rest others. Generally, the education level was the same from grade eight to intermediate. The occupational exposure to dust and gaseous was significantly higher in the Kirti Nagar, Okhla, Wazirpur and Mayapuri industrial areas as most of the activities were in closed rooms. Annexure 1 shows sample surveys and a summary of the consented respondents.

At all the survey locations, more than 90% of workers had expressed weakness or fatigue as common problem. The number of workers with symptoms of cough and sputum production was higher in the industrial areas with plastic and PVC works, aluminium sheet cutting, casting metal processing, and painting and polishing. It was observed that the workers were not wearing face masks to avoid exposure.

The residents living near the industrial areas experience respiratory and atopic symptoms such as cough and sputum production. During the survey, it was also observed that most of the workers who have resided in the industry's backyard or adjacent areas are vulnerable to much greater exposure to air pollutants not only during working but also during non-working hours. The specific complaints of pollution exposure were much higher during winters.

At all survey location industry uses LPG, PNG or Electricity for industrial processes. Most households use LPG, but some (about 10%) use dung cake or wood as cooking fuel. Almost at every survey location,

The residents also complained about dust and emissions from roadside, vehicle congestion, and construction and demolition activities that seemed unabated for a long time. Emissions from ground level DG set were also a source of pollutant exposure and nuisance for most residents.

It may be stated that many residents and workers were not forthcoming to participate in survey; however, the area looked polluted and general civic conditions and ventilation at workplace was inadequate.

Although there is a need to segregate the effects of primary and secondary pollutants on vulnerable and marginalized communities, it is not easy without a chemical characterization of pollutants. The secondary pollutants of concern are ozone and secondary particles of inorganic and organic origins. Secondary particles constitute more than 50 percent of PM2.5.

The secondary inorganic particles (NO_3- + SO_4-^{2} + NH_4+) account for 26 percent of total PM10 and 28 percent of total PM2.5 of 375 ug/m3 in winter (Sharma and Dikshit 2016). In addition, high levels of NO2 are expected to undergo chemical transformation to form fine secondary particles in the form of nitrates, adding to high levels of existing PM10 and PM2.5.

It is recommended that all petrol pumps in Delhi should install vapour recovery system to reduce VOC emissions. The other sources outlined in this report include emissions from MSMES like dry cleaning units, PVC and plastic industry and tyre re-treading; their emissions control have been discussed in sections 5.1 and 5.3. The adoption of BS6 and the introduction of electric vehicles (EV) are expected to reduce NOx emissions, reducing both secondary PM2.5 levels and formation of ozone.

9. CONCLUDING REMARKS

The hotspots for air pollution in Delhi are densely populated residential areas with a sizeable population of the economically weaker section in the close vicinity of the industrial regions. Most Delhi's industries are in the Micro, Small, and Medium Enterprises (MSMEs) sectors. The notable decision to supply Piped Natural Gas (PNG) to the industry is a welcome step. The total PNG uses are at 170000 SCM (standard cubic metre) per month. However, the pollution problems from MSMEs are compounded by old technologies, untrained manpower, casual attitude, poor housekeeping, and nonpoint fugitive emissions.

The MSMEs suffer from poor housekeeping, sources of fugitive emissions, poor civic amenities, and inadequate road and infrastructure, causing indirect emissions in the industrial areas. The immediate common requirements in all industrial regions are better roads fully paved (carpeted beyond shoulders), better drainage facilities, improved power supply, solid waste collection and removal of all encroachments, and pre venting any industrial or manufacturing activities and construction on the roadside.

There is a need to amend and bring new policies to support the MSMEs; skill development, environmental technology resources, decarbonization, preventing waste burning, use of bio-mass-based fuel, small-scale units and small boilers, and future energy. Financial constraints and the availability of loans are significant issues for MSMEs. The policies on green energy should be introduced to MSMEs not only for their uses but also for their production and storage.

The industries which are more significant in number should be targeted explicitly for technology and solutions. The sectors include plastic granules, tyre re-treading, dry cleaning, pulse and wheat mills, metal casting, construction and demolition, road dust, auto service centre, and loading and unloading. Technologies and current practices, collection and arresting the fugitive emissions, and recovery of solvent and volatiles are inadequate and should be introduced in a time-bound manner.

Marginalized and vulnerable communities should get special attention for better air quality. The current locations of the industrial areas in densely populated regions of Delhi expose the marginalized groups to higher cumulative air pollution. These communities face double burdens from industrial emissions and poor indoor conditions due to burning solid fuels like coal and firewood.

The specific pollutants and their remediations pertaining to an industrial area have been discussed. The immediate common requirements in all industrial areas are better roa ds fully paved (carpeted beyond shoulders), better drainage facilities, improved power supply, solid waste collection and removal of all encroachments, and preventing any industrial or manufacturing activities on the roadside. The roads must be swept with sweeping machines and washed regularly for dust control. Better roads will reduce the time for the movement of materials and final products, reduce air pollution, improve aesthetics, and increase profitability. Better drainage will prevent inundation during rains and ensure a longer life for roads and other infrastructure.

Although the focus of this study was emissions and air pollution control, the field visits showed that many of the industries are not safe from potential fires. It appears adequate measures such as fire exit, clear escape routes, fire extinguishers, etc. not provided in some industries. For example, in some industries there was indiscriminate multi-stacked storage of inflammable raw material (plastics) with no space to escape for the workers and they could be trapped in case of fire. It is strongly suggested that all fire control measures as per the regulation must be enforced, including training workers to deal with minor fires.

10. REFERENCES

Amato, F., Querol, X., Johansson, C., Nagl, C. and Alastuey, A (2010). A review on the effectiveness of street sweeping, washing and dust suppressants as urban PM control methods. Science of the Total Environment 408, 3070–3084

Aneja VP, Schlesinger W, Erisman JW (2008). Farming pollution. Nature Geosci 1:409–411

Baek BH, Aneja VP (2004). Measurement and analysis of the relationship between ammonia, acid gases, and fine particles in Eastern North Carolina. J Air and Waste Manag Assoc 54:623–633

Behera S.N. and Sham M (2010). Reconstructing Primary and Secondary Components of PM2.5 Composition for an Urban Atmosphere. Aerosol Science and Technology, Volume: 44 Issue: 11 Pages: 983-992

CPCB (2008). Comprehensive Industry Document on Pulse, Wheat, Rice Mills. COINDS, Central Pollution Control Board, Delhi

CSE (2020). Replacement of Small Boilers with Common Steam Boilers in Industrial Areas. Centre for Science and Environment, New Delhi

EGEA (2011). Guidelines for the Reduction of Exposure to Hazardous Vehicle Exhaust Emissions, European Garage Equipment Association. Available online: https://www.egea-association.eu/wpcontent/uploads/guidelines-vehicle-emissions-egea-2011.pdf.

Quazi, Z. R. (2013). Air Quality Modeling of Kanpur at Higher Resolution: Application of WRF-CMAQ Modeling Framework. Master Thesis, IIT Kanpur, India

Russell AG, McRae GJ, Cass GR (1983). Mathematical modeling of the formation and transport of ammonium nitrate aerosol. Atmos Environ 17:949–964

Sharma M. and Maloo Shaily (2005). Assessment and Characterization of Ambient Air PM10 and PM2.5 in the City of Kanpur, India. Atmospheric Environment Vol 39 6015-6026.

Sharma M (2010). Air Quality, Emission Inventory and Source Apportionment Studies for Kanpur City. An IIT Kanpur Report Submitted to Central Pollution Control Board, Delhi.

Sharma M and Dikshit O (2016). Comprehensive study on air pollution and greenhouse gases (GHGs) in Delhi. A report submitted to Government of NCT Delhi and DPCC Delhi, 1-334

USEPA (1983). Control of Volatiles Organic Compund Emissions from Manufacture of High Density Polyethylene, Polypropylene and Poly strene Resins. Report No. EPA-400/3-83-008 U.S. Environmental Protection Agency

USEPA (1995). Air Emissions Factors / AP-42. 4.1 Dry Cleaning; https://www.epa.gov/sites/default/files/2020-10/documents/c4s01.pdf

ANNEXURE 1- HEALTH AND ENVIRONMENT SURVEY FOR VULNERABLE COMMUNITY

औद्योगिक श्रमिकों के लिए सर्वेक्षण प्रश्नावली

औद्योगिक कार्यकर्ता की जानकारी: **दिनांक:**

नाम:

आयु:

लिंग:

पता:

1) 1 से 10 के पैमाने पर आप खुद को कितना स्वस्थ मानते हैं?
2) सांस की कोई बीमारी? यदि हां, तो कृपया नाम दें।
3) उद्योग के प्रकार?
4) कार्यस्थल का वातावरण:

   (a) बहुत प्रदूषित (बी) मध्यम प्रदूषित (सी) स्वच्छ (डी) कोई अन्य
5) कार्यस्थल पर गैस एक्सपोजर

   (a) नगण्य (बी) मध्यम (सी) गंभीर
6) कार्यस्थल पर धूल का एक्सपोजर

   (b) नगण्य (बी) मध्यम (सी) गंभीर
7) क्या आपने कभी निम्न में से किसी भी लक्षण का अनुभव किया है जो किसी विशिष्ट बीमारी (यानी फ्लू या सर्दी) से जुड़ा नहीं है और 3 सप्ताह या उससे अधिक समय तक रहता है?

   (a) बुरी खांसी जो 3 सप्ताह या उससे अधिक समय तक रहती है
   (b) सीने में दर्द
   (c) कमजोरी या थकान
   (d) ठंड लगना
   (e) बुखार
8) आपके कार्यस्थल स्थान में किस प्रकार के ईंधन का उपयोग किया जाता है:

   (a) पीएनजी (बी) एलपीजी (सी) इलेक्ट्रिक (डी) डीजल (ई) कोयला (एफ) कोई अन्य
9) आपके कार्यस्थल पर गैसीय धुएं से बाहर निकलने के लिए चिमनी: (ए) हां (बी) नहीं
10) आपके कार्यस्थल पर उचित वेंटिलेशन? (ए) हां (बी) नहीं
11) आपके कार्यस्थल पर प्लास्टिक जलाना: (ए) हां (बी) नहीं (सी) यदि हां, तो कितनी बार ____
12) क्या आपके उद्योग में कचरा जलाने की उचित सुविधा है: (ए) हां (बी) नहीं
13) आप अपने घर में किस प्रकार के खाना पकाने के ईंधन का उपयोग करते हैं?

    (a) एलपीजी/गैस (बी) केरोसिन (सी) जलाऊ लकड़ी (डी) गोबर गैस/जैव ईंधन (ई) अन्य: निर्दिष्ट करें: ________

सुझाव:

सूचित सहमति:उपरोक्त सर्वेक्षण का उपयोग डेटा व्याख्या और शोध कार्य के लिए किया जा सकता है। एक साक्षात्कारकर्ता प्रतिभागी को आश्वस्त करता है कि उसकी पहचान का खुलासा नहीं किया जाएगा और इस अध्ययन में भाग लेने वाला पूरी तरह से स्वैच्छिक है।

हस्ताक्षर:

Questionnaire survey in Industrial area with vulnerable population (Nazafgarh)

औद्योगिक श्रमिकों के लिए सर्वेक्षण प्रश्नावली

औद्योगिक कार्यकर्ता की जानकारी: **दिनांक:** 13/9/22

नाम: Pankaj Jangid

आयु: 27

लिंग: Male

पता: Palam

1) 1 से 10 के पैमाने पर आप खुद को कितना स्वस्थ मानते हैं? 08
2) सांस की कोई बीमारी? यदि हां, तो कृपया नाम दें। NO
3) उद्योग के प्रकार? Plywood, board making
4) कार्यस्थल का वातावरण:
   (a) बहुत प्रदूषित (बी) मध्यम प्रदूषित (सी) स्वच्छ (डी) कोई अन्य
5) कार्यस्थल पर गैस एक्सपोजर
   (a) नगण्य (बी) मध्यम (सी) गंभीर
6) कार्यस्थल पर धूल का एक्सपोजर
   (b) नगण्य (बी) मध्यम (सी) गंभीर
7) क्या आपने कभी निम्न में से किसी भी लक्षण का अनुभव किया है जो किसी विशिष्ट बीमारी (यानी फ्लू या सर्दी) से जुड़ा नहीं है और 3 सप्ताह या उससे अधिक समय तक रहता है?
   (a) बुरी खांसी जो 3 सप्ताह या उससे अधिक समय तक रहती है
   (b) सीने में दर्द
   (c) कमजोरी या थकान
   (d) ठंड लगना
   (e) बुखार
8) आपके कार्यस्थल स्थान में किस प्रकार के ईंधन का उपयोग किया जाता है:
   (a) पीएनजी (बी) एलपीजी (सी) इलेक्ट्रिक (डी) डीजल (ई) कोयला (एफ) कोई अन्य Electric
9) आपके कार्यस्थल पर गैसीय धुएं से बाहर निकलने के लिए चिमनी: (ए) हां (बी) नहीं
10) आपके कार्यस्थल पर उचित वेंटिलेशन? (ए) हां (बी) नहीं
11) आपके कार्यस्थल पर प्लास्टिक जलाना: (ए) हां (बी) नहीं (सी) यदि हां, तो कितनी बार ____
12) क्या आपके उद्योग में कचरा जलाने की उचित सुविधा है: (ए) हां (बी) नहीं
13) आप अपने घर में किस प्रकार के खाना पकाने के ईंधन का उपयोग करते हैं?
   (a) एलपीजी/गैस (बी) केरोसिन (सी) जलाऊ लकड़ी (डी) गोबर गैस/जैव ईंधन (ई) अन्य: निर्दिष्ट करें: ____

सुझाव:

सूचित सहमति: उपरोक्त सर्वेक्षण का उपयोग डेटा व्याख्या और शोध कार्य के लिए किया जा सकता है। एक साक्षात्कारकर्ता प्रतिभागी को आश्वस्त करता है कि उसकी पहचान का खुलासा नहीं किया जाएगा और इस अध्ययन में भाग लेने वाला पूरी तरह से स्वैच्छिक है।

हस्ताक्षर:

औद्योगिक श्रमिकों के लिए सर्वेक्षण प्रश्नावली

औद्योगिक कार्यकर्ता की जानकारी: **दिनांक:** 17/9/22

नाम: Rajesh Kumar

आयु: 46 years

लिंग: M

पता: A-172 N.H.C. Vipin Garden

1) 1 से 10 के पैमाने पर आप खुद को कितना स्वस्थ मानते हैं? 10
2) सांस की कोई बीमारी? यदि हां, तो कृपया नाम दें। Overweight, not related to industry
3) उद्योग के प्रकार? Aluminium; Plywood; board
4) कार्यस्थल का वातावरण:
   (a) बहुत प्रदूषित (बी) मध्यम प्रदूषित (सी) स्वच्छ (डी) कोई अन्य
5) कार्यस्थल पर गैस एक्सपोजर
   (a) नगण्य (बी) मध्यम (सी) गंभीर
6) कार्यस्थल पर धूल का एक्सपोजर
   (b) नगण्य (बी) मध्यम (सी) गंभीर m/c vacuum installed
7) क्या आपने कभी निम्न में से किसी भी लक्षण का अनुभव किया है जो किसी विशिष्ट बीमारी (यानी फ्लू या सर्दी) से जुड़ा नहीं है और 3 सप्ताह या उससे अधिक समय तक रहता है?
   (a) बुरी खांसी जो 3 सप्ताह या उससे अधिक समय तक रहती है
   (b) सीने में दर्द
   (c) कमजोरी या थकान
   (d) ठंड लगना
   (e) बुखार ✓
8) आपके कार्यस्थल स्थान में किस प्रकार के ईंधन का उपयोग किया जाता है:
   (a) पीएनजी (बी) एलपीजी (सी) इलेक्ट्रिक (डी) डीजल (ई) कोयला (एफ) कोई अन्य Electricity
9) आपके कार्यस्थल पर गैसीय धुएं से बाहर निकलने के लिए चिमनी: (ए) हां (बी) नहीं
10) आपके कार्यस्थल पर उचित वेंटिलेशन? (ए) हां (बी) नहीं
11) आपके कार्यस्थल पर प्लास्टिक जलाना: (ए) हां (बी) नहीं (सी) यदि हां, तो कितनी बार ____
12) क्या आपके उद्योग में कचरा जलाने की उचित सुविधा है: (ए) हां (बी) नहीं
13) आप अपने घर में किस प्रकार के खाना पकाने के ईंधन का उपयोग करते हैं?
    (a) एलपीजी/गैस (बी) केरोसिन (सी) जलाऊ लकड़ी (डी) गोबर गैस/जैव ईंधन (ई) अन्य: निर्दिष्ट करें: ____

सुझाव:

सूचित सहमति: उपरोक्त सर्वेक्षण का उपयोग डेटा व्याख्या और शोध कार्य के लिए किया जा सकता है। एक साक्षात्कारकर्ता प्रतिभागी को आश्वस्त करता है कि उसकी पहचान का खुलासा नहीं किया जाएगा और इस अध्ययन में भाग लेने वाला पूरी तरह से स्वैच्छिक है।

हस्ताक्षर:

Survey of vulnerable population (25 Numbers)

1) How healthy do you consider yourself on a scale of 1 to 10?	10-8	7-5	Below 5
	8	12	5

2) Any respiratory disease? If yes, kindly name it.	Yes	No
	8	17

3) Industry type?	Welding	Wooden work	Polishing	Scrap

4) Work place environment:	Very Polluted	Medium Polluted	Clean	Any other
	4	14	7	-

5) Gas exposure at work place	Neglible	Medium	Severe
	6	14	5

6) Dust exposure at work place	Neglible	Medium	Severe
	4	18	3

7) Have you experienced following symptoms NOT associated with an illness (i.e. flu or cold) and lasting 3 weeks?

A bad cough that lasts 3 weeks or longer	Weakness or fatigue	Weight loss	Multiple issues
14	22	16	

8) What type of fuel used in your workplace location:	PNG	LPG	Electric	Diesel	Coal	Any other
	3	14	8	-	-	-

9) Chimney to exit gaseous fumes at your workplace	Yes	No
	10	15

10) Proper ventilation at your workplace?	Yes	No
	12	13

11) Plastic burning at your workplace	Yes	No
	8	17

12) Does your industry has proper garbage burning facility	Yes	No
	16	9

13) What type of cooking fuel do you use in your house?	LPG/Gas	Kerosene	Firewood	Gobar gas	Other
	10	-	8	7	-

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