Dust Management in Urban Regions: Road Map

Dust loading in ambient air, especially in cities is significant. The tropical nature of the country also leads to dry soil and its entrainment. However, the major dust related contribution comes from road side digging/construction, construction/demolition activities combined with transportation of such material. Delhi and NCRare also going through tremendous growth and development in terms of metro constructions, bridges, roads, building constructions, its demolition and many more. According to various literature (CPCB, 2010, IIT – Kanpur, 2015); the various sources of Particulate matter emissions in Delhi are:

- Vehicular exhaust (mainly heavy vehicles)
- Biomass burning including crematoria (open fire, cooking and heating)
- Soil and road side dust
- Industries
- Diesel generators
- Open waste burning
- Power plant
- Regional dust transport

Also, occurrence of various health hazards related to particulate matter is increasing day by day. Some of the diseases like coughing, sneezing, asthma attack, bronchitis, high blood pressure, heart attack, strokes, and even premature death is occurring at greater instances in Delhi. Hence, it is important to design and develop road map to control air pollution, especially particulate matter in Delhi.

A. Street Sweeping

There are various methods to carryout street sweeping and controlling dust:

- **Manual Sweeping** (it require large volume of man power for sweeping and collection of road side dust)
- **Mechanical Sweeping**: These sweepers lift the material from the road onto a conveyer belt, and then discharge the material into a collection hopper. In general, these sweepers are considered to be effective at removing large debris such as branches, leaves, litter, and large quantities of dirt.

Figure 1: Vacuum Sweeper

- **Vacuum Sweeper**: They typically use a gutter broom to loosen dirt and debris from the road and direct it to a vacuum nozzle which sucks it into a hopper. The hopper usually consists of a chamber into which the material is collected by gravitational settling.
- **Regenerative air vacuum sweepers**: It directs all or some of the exhaust air back to one end of the pickup head at high speed or to a nozzle located immediately behind the pickup head. The blast of exhaust air is directed at an angle to the pavement to dislodge dirt.

Figure 2: Regenerative air

B. Street Washing

Mainly, recycled and reused water can be used for street washing. **As per literature, it is recommended to spray 1 litre/ sq.m area.**At Düsseldorf, 2μg/m^3 reduction of dust was observed after application of flushing water on road (two times weekly)[1] and similar results were obtained at Madrid by Karanasiou et al., (2011)[2].At Stockholm, about 6% reduction of dust was observed while applying water spraying for 8 days[3].

Street washing is better in terms of controlling dust pollution than mechanical sweeping, if water is available and cost of transportation is reasonable.

C. Use of Dust Suppressant to Control Road Side dust

Variety of chemical dust suppressant is available to suppress fugitive dust emissions. Compared to water, these are more effective in suppressing dust and need to be applied much less in quantity and less frequently. While the application of water and chemical dust suppressants are proven and effective options for mitigating dust, they have to be applied judiciously.

Their usage, while mitigating dust, must be monitored as also watched for the site specific places so that its quantity is managed properly. It is important to keep these environmental consequences in mind when deciding on the extent to which water and chemical dust suppressants are to be utilized.

While the application of water and chemical dust suppressants are proven and effective options for mitigating dust, they have to be applied judiciously. Their usage, while mitigating dust, can trigger hazardous environmental consequences. It is important to keep these environmental consequences in mind when deciding on the extent to which water and chemical dust suppressants are to be utilized.The most common dust control agents are chlorides,asphalt products, and lignin. The accompanying chartgives details on these products. The general characteristicsof these and other treatments used for dust controlare described here.Moisture causes dust particles to agglomerate into larger entities and to adhere to the surface.Dust can be

Selection Criteria for dust suppressant

- environmentally compatible
- easily applied with common road
- workable and responsive to maintenance
- reasonably effective at controlling dust
- not degrading environment
- relatively harmless to vehicles using road
- posing no hazard or inconvenience residents
- cost competitive

[1]John A., Hugo A., Kaminski H., Kuhlbusch T., 2006. ntersuchung zur Abschätzung der Wirksamkeit von Nassrei-nigungsverfahren zur Minderung der PM10 - Immissionen am Beispiel der Corneliusstraße, Düsseldorf, Institut für Energie und Umwelttechnik e. V., Duisburg (in German).

[2]Karanasiou A., Moreno T., Amato F., Lumbreras J., Narros A., Borge R., Tobías A., Boldo E., Linares C., Peya J., Rechea C., Alastueya A., Querol X., 2011.Road dust contribution to PM levels - evaluation of the effectiveness of street washing activities by means of Positive Matrix Factorization. Atmospheric Environment 45, 2193-220.

[3]Norman M. and Johansson C., 2006. Studies of some measures to reduce road dust emissions from paved roads in Scandinavia. Atmospheric Environment, 40, 6154–6164

suppressed using water but it lasts only until the water evaporates from thesurface. Evaporation can be slowed down by adding dust suppressants to the water.The main dust suppressants that have been tested on paved roads in Europe to reduce PM10 concentrations are:

- magnesium chloride (MgCl2);
- calcium chloride (CaCl2);
- calcium magnesium acetate (CMA); and
- potassium formate (referred to as KF in some publications)

Typically these are combined with lignosulphonates and surfactants in very small quantities. These are tested on different types of surfaces and then applied.

Amato et al. (2010)[4] showed that application of $MgCl_2$at dosage between 20 and 40 g/m^2has resulted in 56% of reduction of PM10 and 70% reduction of PM2.5. They applied it for 10 continuous days to achieve this success.

In order to achieve the maximum effect in terms of dust control and to reduce the environmental and other impacts; CSIR – NEERI evaluated few options of dust suppressant. It has been validated through laboratory studies and field trials under Indian conditions and scenarios. When, it was applied in Delhi for trials, it showed about 6-8 hours of effectiveness from its applications. Hence, dust suppressant can be used to control road side dust.

At Delhi, water sprinkling was effective for 10-15 mins while dust suppressant was effective for more than 6-8 hours after its applications

D. Control of Dust at Construction and Demolition sites

Dust from construction and demolition activities must be controlled using dust suppressants along with water sprinkling.

Action Plan for use of dust suppressant for Storage piles

- For some materials, hard crusts can be built-up on storage piles by application of dust suppressants. Crusts reduce the dust blown off the storage piles. Care is required to avoid application of dust suppressants to a degree that may erode or settle the fines to the bottom of the pile
- Storage piles that are greater than 2.5 m (8 feet) in height and not covered may have a road bladed to the top to allow water truck access or should have operational water irrigation system that is capable of complete stockpile coverage
- Disturbed areas of a construction site, including storage piles of fill dirt and other bulk materials that are not being actively utilized for construction purposes for a period of 7 days or more, should be stabilized with a chemical dust stabilizer or enzymatic dust suppressant

[4]Amato F, A. Karanasiou, P. Cordoba, A. Alastuey, T. Moreno, F. Lucarelli, S. Nava, G. Calzolai, and X. Querol, 2014. Effects of road dust suppressants on PM levels in a Mediterranean urban area. Environmental Science and Technology. 48, 8069-8077.

- A much more effective technique (than applying water to the storage pile) is to apply chemical agents (such as surfactants) directly to the storage pile, which permit more extensive wetting

Other actions must be followed are:

- Developers should avoid the use of long-term stockpiles on-site wherever possible unless it performs the function of visual or noise screening
- Make sure that stockpiles exist for the shortest possible time
- Do not build steep sided stockpiles or mounds or ones which have sharp changes in shape
- Stockpiles should be kept away from the site boundary, sensitive receptors, water courses and surface drains
- Enclose stockpiles or keep them securely sheeted
- Fine or powdery material (under 3mm in size) should be stored inside buildings or enclosures

The covering of stockpile in scientific manner to control dust emission is given in Figure 3.

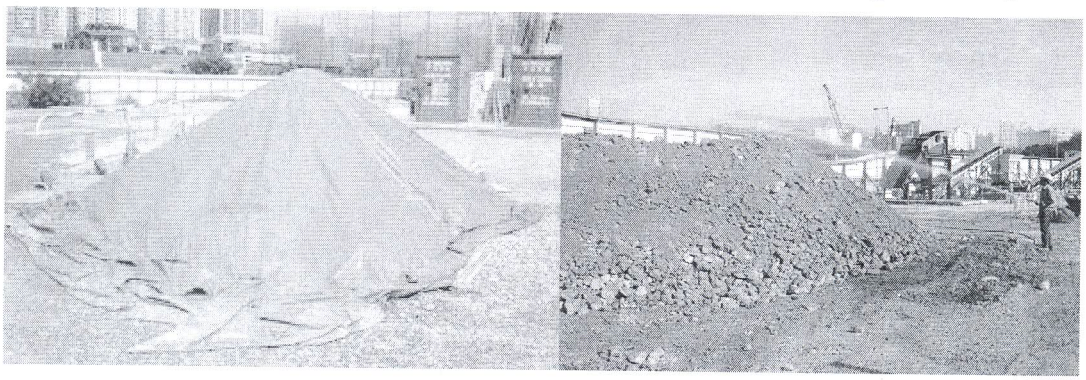

Figure 3: Proper covering and application of dust suppressant on the stockpile

E. Dust Suppression for Road Surfaces

Road surfaces dust loads have also been controlled in many places. However, in Indian city roads dust are primarily laden with local dust from unpaved surfaces or from dust/debris falling from transportation trucks. Over a period of time, these accumulations are too high and mere application of dust suppressant may have limited benefits.

Road surfaces should primarily be controlled through better construction practices and also contracting practices. Application of good road quality surfacing can improved the condition and dust loads from the road alone can get reduced substantially. Road degradation due to poor construction is an another source which can not be easily solved only through dust suppressant.

Action Plan for use of dust suppressant for Road Surfaces

Water can be sprayed on road surfaces to control emission. Control efficiency of water depends on:

(i) Amount (per unit road surface area) of water added during each application

(ii) period of time between applications

(iii) Weight, speed and number of vehicles travelling over the watered road during the period between applications

The control effectiveness of chemical dust suppressants depends on:

(i) the dilution rate used in the mixture

(ii) the application rate (volume of solution per unit road surfaced area)

(iii) the time between applications

(iv) the size, speed and amount of traffic during the period between applications

(v) Meteorological conditions (rainfall, freeze/thaw cycles, etc.) during the period

Diagrammatic representation of chemical dust suppressant application is given in Figure 4.

Figure 4: Application of dust suppressants for unpaved roads

F. Dust Control for Debris and other construction material transportation

Delhi and NCR witnesses huge transportation loads of trucks carrying material as also debris. These numbers vary based on status of construction in residential premises, metro work, roads resurfacing and redevelopment of old structures. The action plans for this sector specific dust control warrants multiple options and careful monitoring of the agencies implementing these projects. There is a need to incorporate some of the best practices in the code of practices of construction.

Action Plan for use of dust suppressant for Transportation of debris

- Closed vehicles like dumpers can be used for this purpose
- The top surface of the material to be transported should be applied with dust suppressant prior to loading and/or the entire surface area
- Materials may be sprayed with dust suppressant, 15 minutes prior to handling and/or at points of transfer
- Dust suppressant may be applied at the feed and/or intermediate points in the conveyor system as needed
- Water or dust suppressant couls be sprayed during unloading of the materials and debris (refer**Figure5 and 6**)

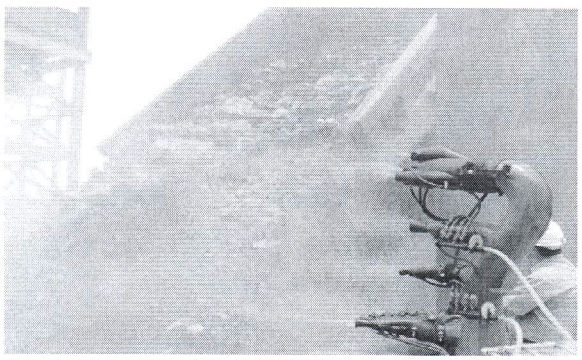

Figure 5: Control of Dust during unloading of materials

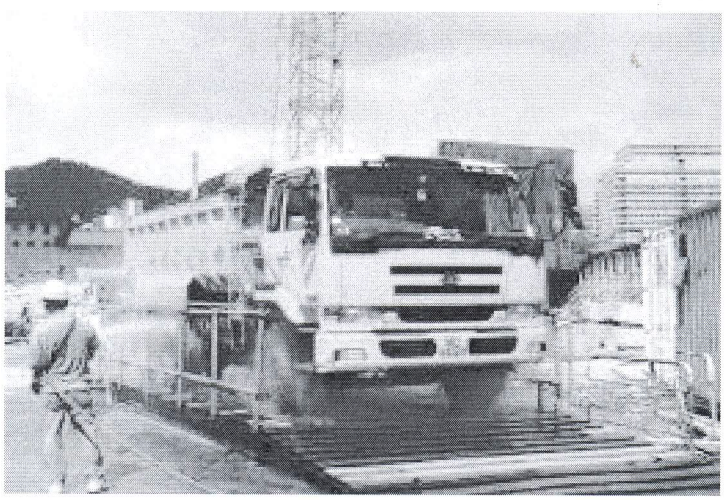

Figure 6: Washing the wheels of vehicles with dust suppressants

G. Demolition Activities

Demolition activities are the main reason for the generation of dust in a very specific region/area. In order to minimize this dust generation, one must use clean technologies or dust suppressant methods. Water is the most commonly used dust suppressant which do not allow the dispersion of dust to greater extent. Thus, suitably, sufficient quantity of water must be sprayed to control dust emission.Spraying should be carried out prior to and during demolition activities. Dust suppressants may be applied during the following situations:

i. unpaved surface areas within 30 meters (100 feet) where materials from demolition will fall;
ii. debris piles immediately following blasting and periodically afterwards
iii. the surrounding area following demolition (distance of minimum 30 metres)
iv. unpaved surface area where equipment will operate.

Diagrammatic representation of dust management during demolition activities are given in Figure 7.

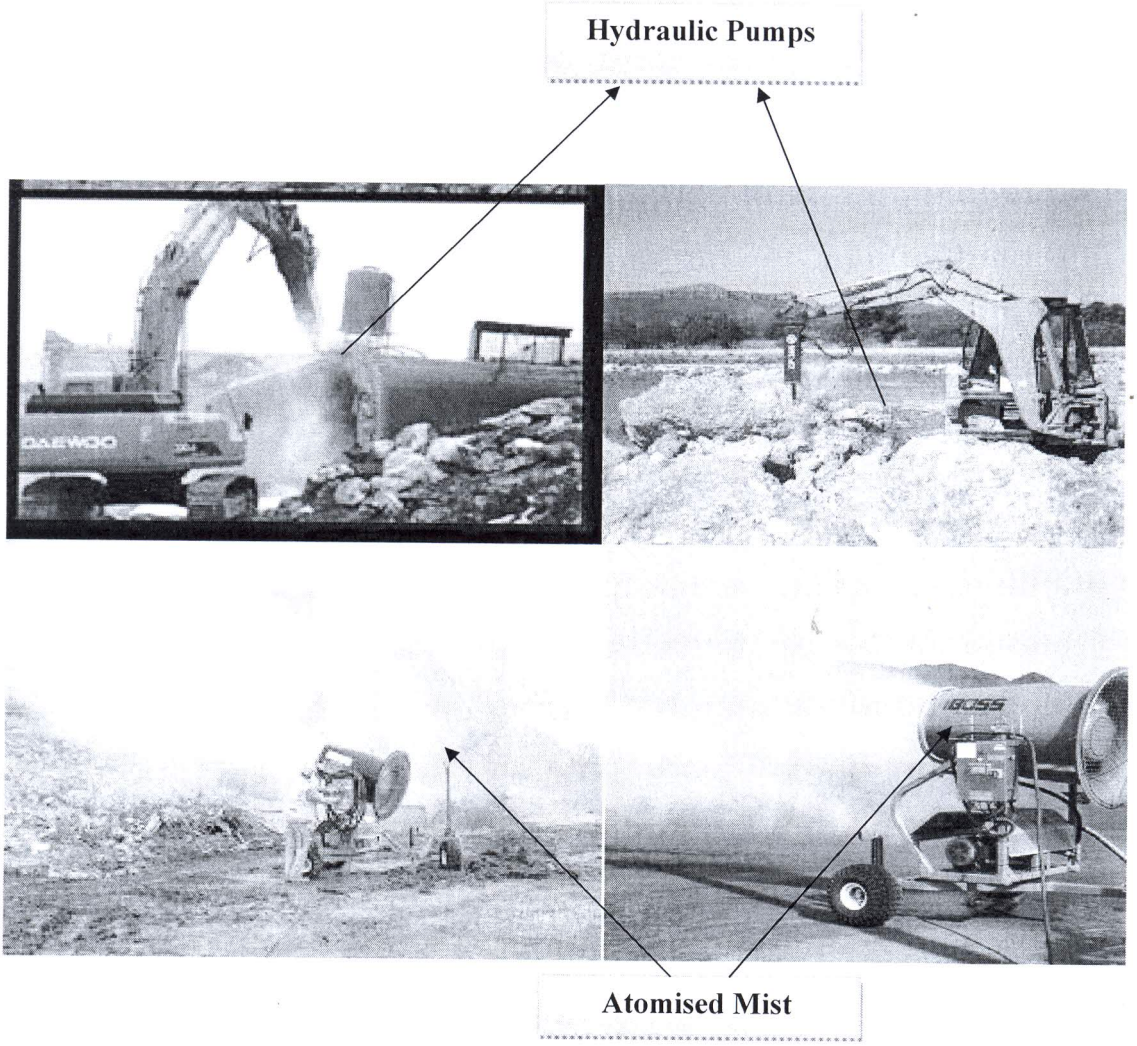

Figure 7: Management plan for dust management from demolition activities

Conclusions and Recommendation

- Dust suppressant must be made compulsory for construction and demolition activities
- They must be used to reduce the dust level at source and at road side as well
- Road side dust must be controlled through better construction practices and later only for construction material piles, dust suppressants can be used.
- Online monitoring system for dust (Particulate Matter) must be made compulsory and it should be displayed at the site and connected to CPCB for record
- Also dust suppressant must be complemented with mechanical sweeping to reduce piling or accumulation of road side dust
- Dust management guidelines of MOEFCC must also include use of dust suppressant for construction, demolition, traffic junctions, along with roles and responsibilities of stakeholders, government bodies, regulatory bodies and citizen
- Environmental monitoring mechanism for dust management

Annexure : Comparison of Water and Dust suppressant costs

Water can be considered as one of the ancient dust palliative, as it is readilyavailable to apply by spraying over the surface of road. Water is used apply moistureto the surface area, but the capacity of dust suppression is less due to evaporation.EPRI which carried out the pilot application last year using Dust Suppressant (hygroscopic liquid compound) helped to reduce 50%- 60%pollutants for 5-6 hours, as compared to water i.e. 25%- 30% which holds moisture for about 15 minutes. Dust suppressant spraying showed more efficiency to reducedparticulate matter emission as compared to water spraying.The cost of EPRI's Dust Suppressant is less i.e. 50 paise/ sq.m with limited maintenanceand suitable for surface area mainly at construction sites as also road side debris and construction material transportation. Some of the mechanized system at construction sites may be more expensive when large scale equipments are deployed for atomization.

The cost comparison of water and a typical dust suppressant indicates that the cost of suppressantis effective as it gives more efficiency and durability with minimal cost as comparedto water/ recycled water.

For Example: (6 Hours)

Water Sprinkling

Water Sprinkling

Area (Sq. m)	Water Requirement	Costing of Water	Application in 6 hrs.	Total Cost in Rupees for 6 hrs.
100	2 Lit. Sq/mt Total Water requirement for 100 Sq. mt = 2 x 100 = 200 Litres	45 paise/lit Total costing of Water for 100 Sq. mt = 45 x 200 = 9000 paise (90 rupees)	24 times	90 x 24 = 2160

Dust Suppressant Sprinkling

Area (Sq. m)	Water Requirement	Costing of Dust Suppressant including water	Application in 6 hrs.	Total Cost in Rupees for 6 hrs.
100	2 Lit. Sq/mt Total Water requirement for 100 Sq. mt = 2 x 100 = 200 Litres	50 paise /sq mt Total costing of Dust suppressant with water for 100 Sq. mt = 50 x 200 = 10,000 paise (100 rupees)	1 times	100 x 1 = 100

Dust suppressant of the varieties which will last longer having lignosulphonates and surfactants will still be cheaper when used for sustained period of 7-10 days.

It is clear from above example the cost of Dust Suppressant is cost effective than single water sprinkling.