# CONTRIBUTION AND ROLE OF OFF-ROAD INDUSTRY TOWARDS BETTER AIR QUALITY

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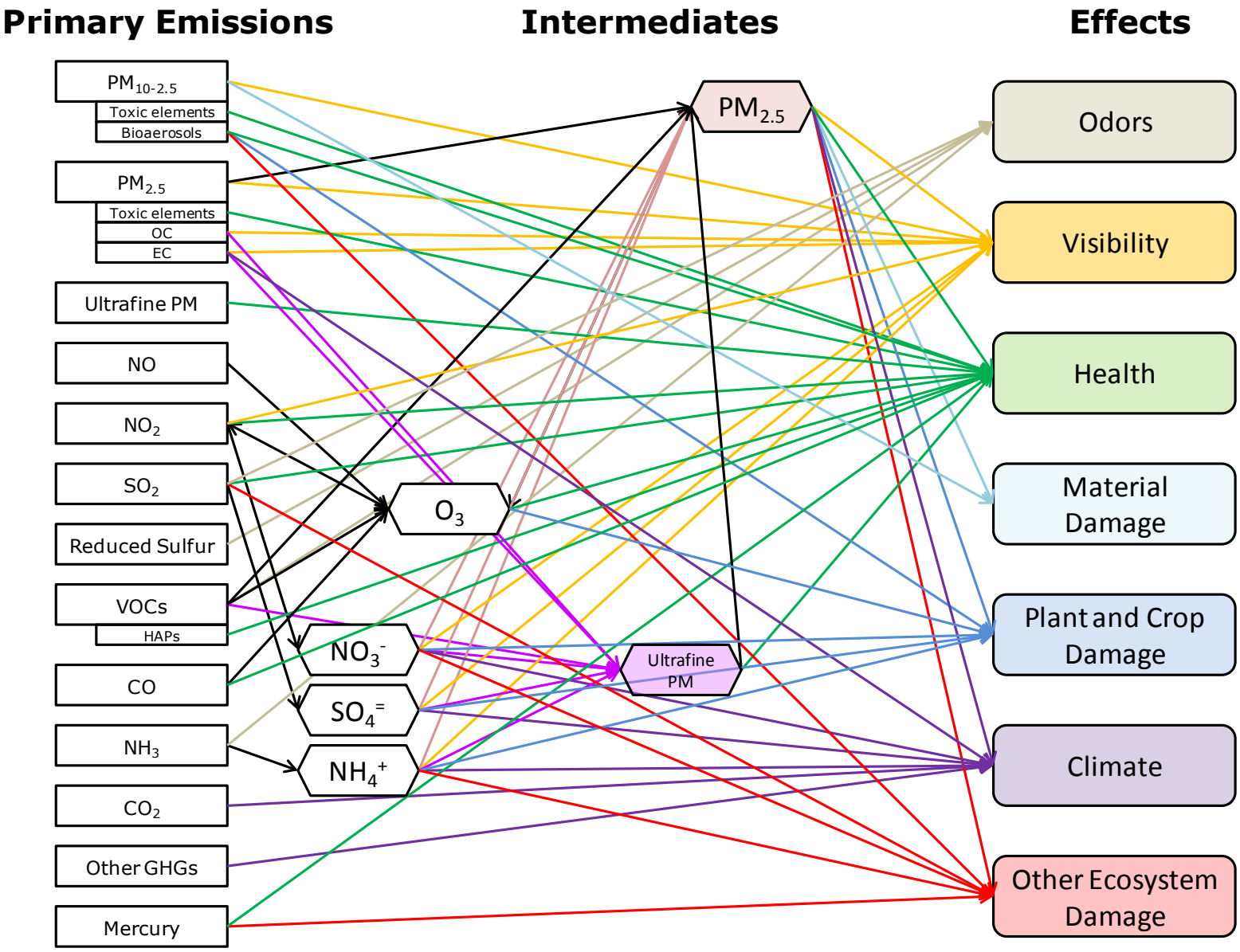
# POLLUTANTS OF CONCERN

| Air Pollutant | Effects |
|---|---|
| • Criteria pollutants (i.e., CO, $SO_2$, $NO_2$, $O_3$, $PM_{2.5}$/$PM_{10,}$ and, Pb) | • Adverse health and ecosystem effects |
| • Light scattering and absorbing PM and gases (e.g., $SO_4^{=}$, $NO_3^{-}$, $NH_4^{+}$, OC, EC, sea salt, soil, and $NO_2$) | • Adverse visibility, health and ecosystem effects |
| • Hazardous Air Pollutants (HAPs, or toxics; e.g., persistent organic pollutants [POPs] and metals [e.g., As, Cd, Cr, Cu, Hg, Ni, Pb, Se, and Zn]) | • Carcinogenic health effects (cancer, reproductive or birth defects)<br>• Adverse environmental effects (bioaccumulation of Hg in fish and lakes) |
| • Oxidizing pollutants (e.g., $H^+$, $SO_4^{=}$, and $O_3$) | • Destruction of forests, crops, and lakes |
| • Depositing pollutants (e.g., $SO_2$, $HNO_3$, $O_3$, soot [BC], and soil dust) | • Soiling and degradation of buildings, antiquities, vehicles, and clothing |
| • Reduced sulfur compounds and certain VOCs | • Unpleasant odors |
| • Climate forcers (e.g., BC, $O_3$, $CO_2$, $CH_4$, and halocarbons [Freon-122]) | • Alter earth's radiation balance (e.g., absorbing electromagnetic radiation, depleting stratospheric $O_3$, and changing cloud cover and water vapor) |

# THE EMPHASIS ON HEALTH OFTEN NEGLECTS OTHER IMPORTANT ADVERSE EFFECTS…BUT IT'S COMPLICATED



# AIR QUALITY CONCERNS

- **METROS CITIES/URBAN AREAS**
  - **93 non-attainment cities**
  - **Dominant Sources: Vehicular Emissions, Small/Medium Scale Industries, Off Road Industry,Gensets, Biomass burning, etc.**
  - **Pollutants: $NO_x$, PM10 & PM2.5 , CO and Benzene**
- **CRITICALLY POLLUTED AREAS**
  - **43 critically polluted areas**
  - **Dominant Sources: Industries-Power Plants, Refineries, Chemical Plants, etc.)**
  - **Pollutants: $NO_x$ ,PM10/PM2.5, $SO_2$ VOCs, PAHs, etc.**
- **RURAL AREAS / INDOOR AIR POLLUTION**
  - **Indoor air pollution: Use of Biomass, Coal, kerosene, etc.**
  - **Outdoor air pollution: Unpaved roads, Biomass burning, Gen-sets etc.**
  - **Pollutants: $PM_{10}$/$PM_{2.5}$, PAH, CO, etc.**

# REASON FOR HIGH AIR POLLUTION IN URBAN AREAS/CITIES

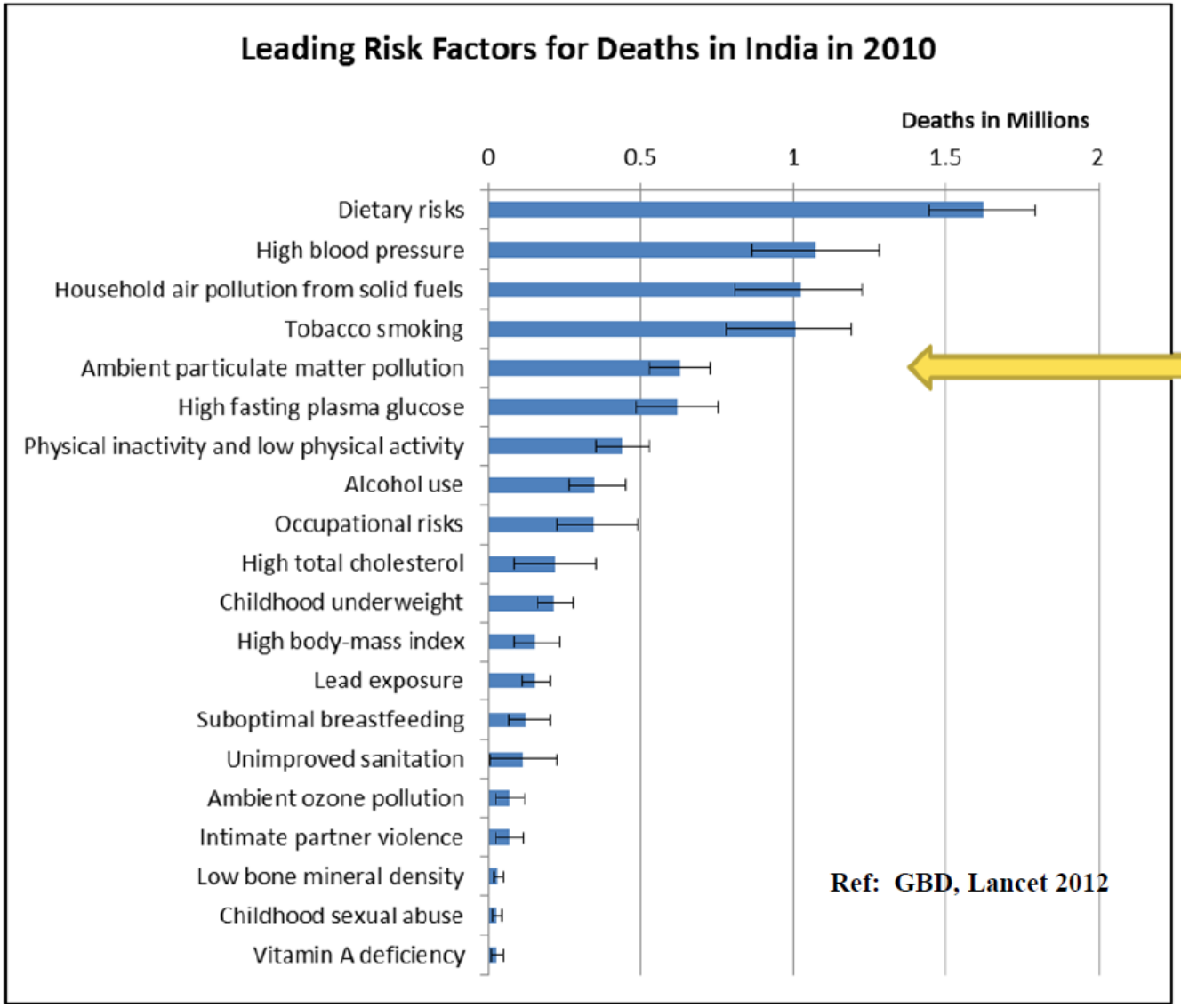
- Uncontrolled growth of vehicular population
- Type of vehicles on road (predominant old vehicles, Bharat Stage – II vehicles, 2W / 3W)
- Fuel quality issues
- Fuel adulteration issues
- Air pollution from SSI units (brick kiln, stone crusher, hotmix plants etc.)
- Large number of DG Sets (small power generating set run on liquid fuel)
- Emission Control from Off Road Engine(Tractor, Construction Vehicles, Earth moving Equipment etc.)
- Coal based power station

# HEALTH EFFECT DUE TO AIR POLLUTION

# WHAT ADVERSE HEALTH EFFECTS HAVE BEEN LINKED TO PM?

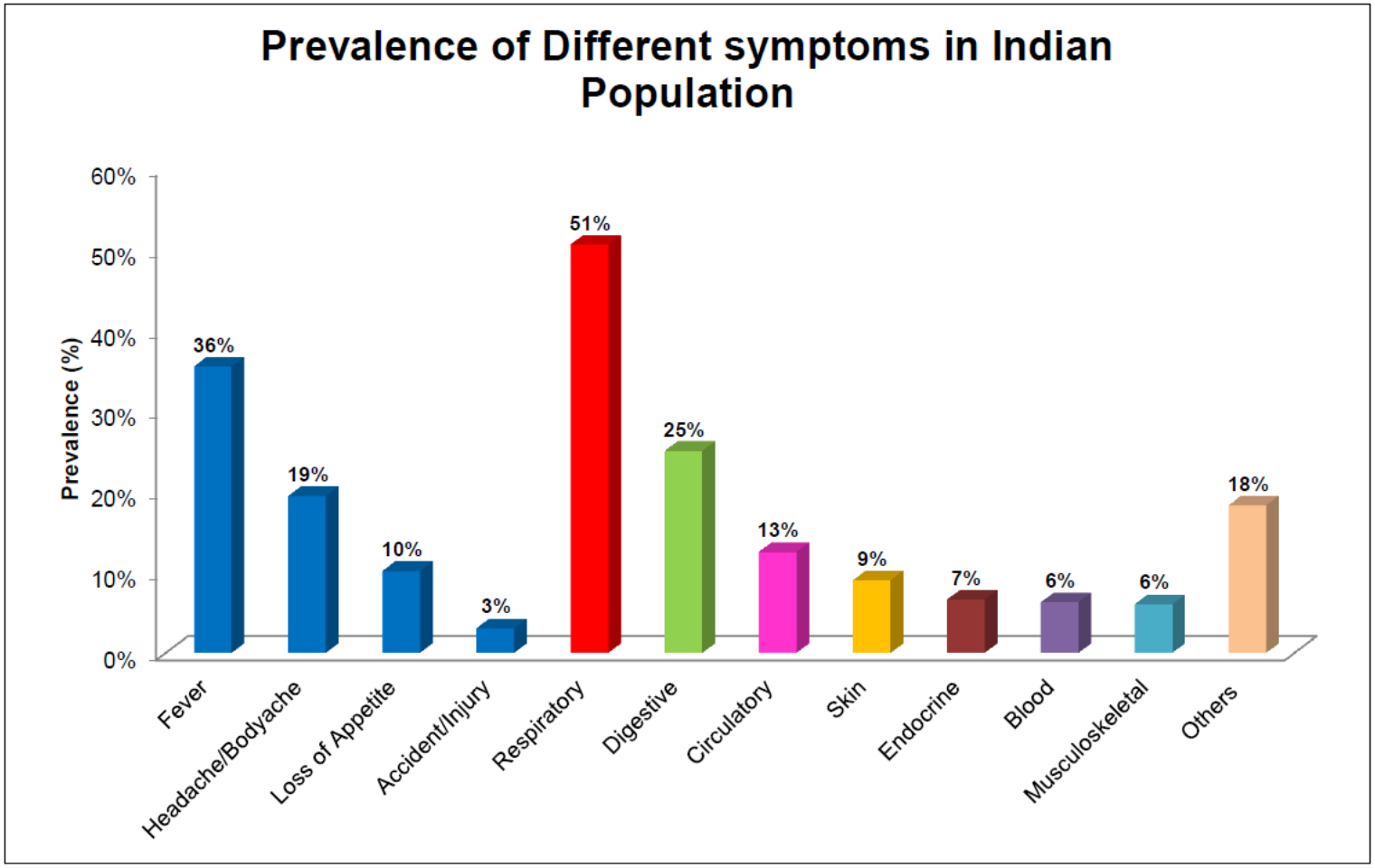
- Premature death
- Lung cancer
- Exacerbation of COPD
- Development of chronic lung disease
- Heart attacks
- Hospital admissions and ER visits for heart and lung disease
- Respiratory symptoms and medication use in people with chronic lung disease and asthma
- Decreased lung function
- Low birth weight

# PM: A MAJOR HEALTH AND CLIMATE CHANGE ISSUE




**Ambient $PM_{2.5}$ caused an estimated 627,000 deaths**

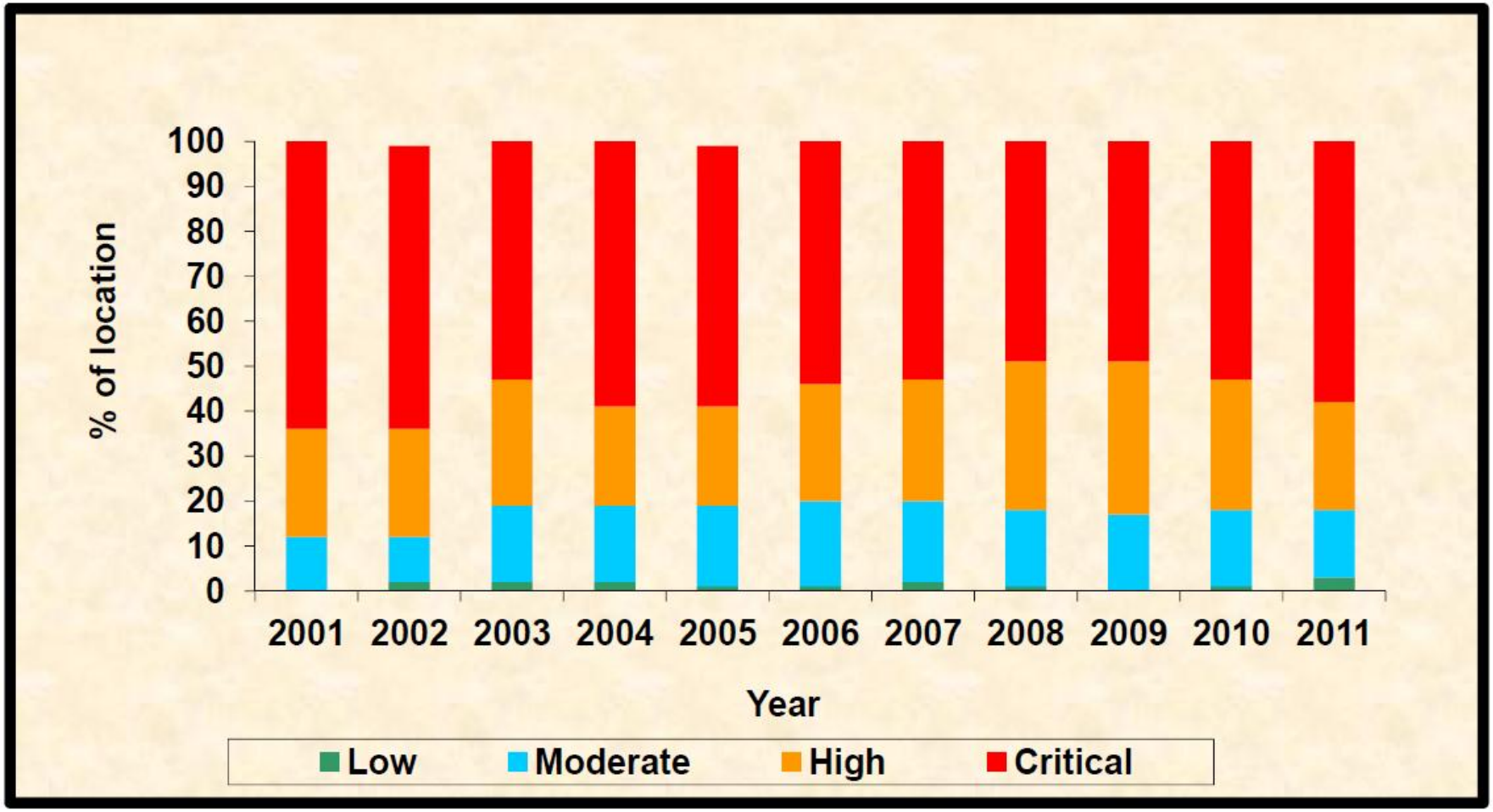
# MOST COMMON SYMPTOMS FOR WHICH A PATIENT VISITS A DOCTOR (NON-SPECIALIST) IN INDIA



# AIR QUALITY MONITORING AND DISSEMINATION SYSTEM

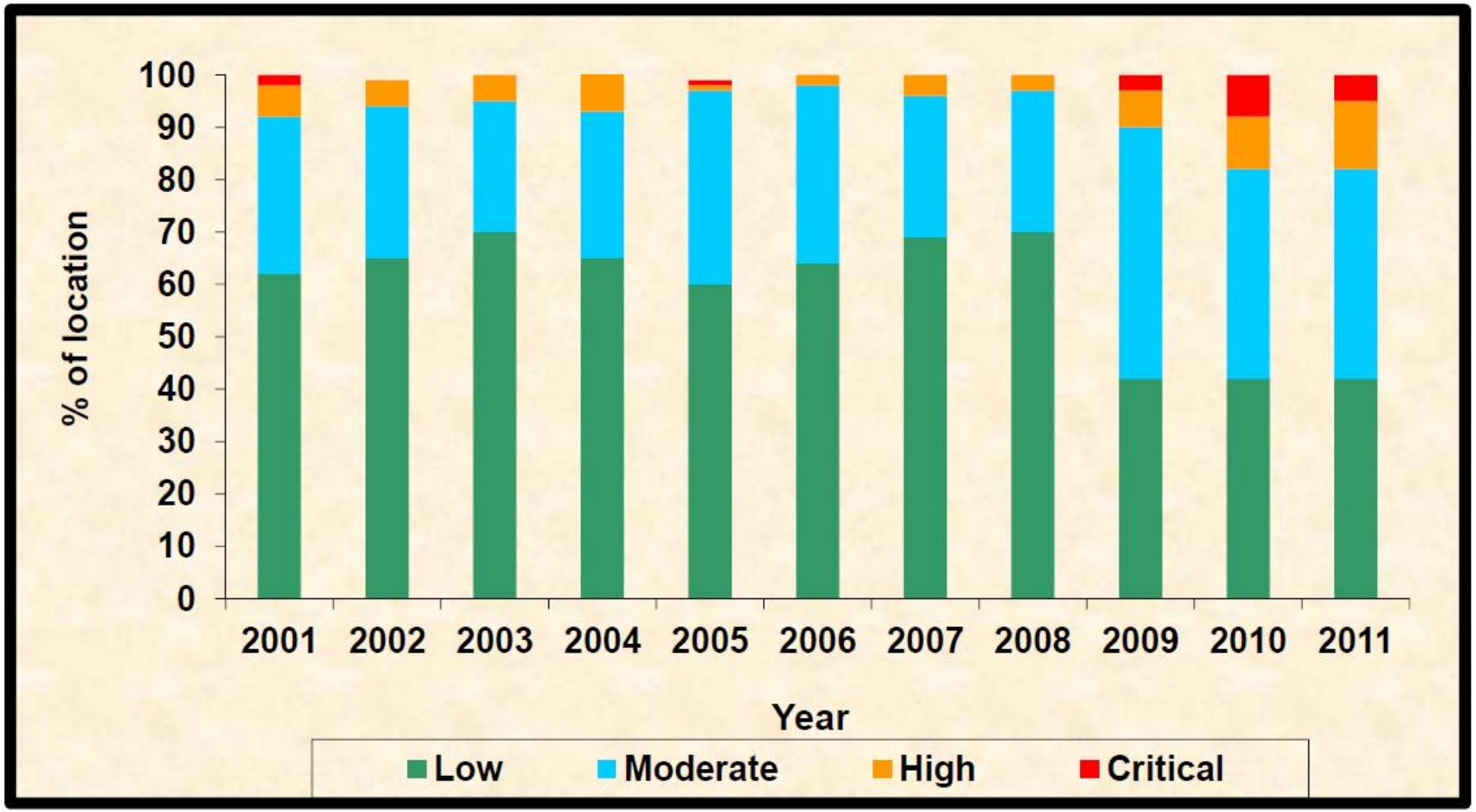
- National Air Quality Monitoring Network
- 573 operating stations covering 240 cities/towns; being expanded to 700 manual stations
- Continuous monitoring stations: 16 operational; 66 stations covering major cities with by 2017
- Parameters monitored – $SO_2$, $NO_2$, $PM_{10}$ (all locations); $PM_{2.5}$, BTX, PAH, $O_3$, CO, $NH_3$ (Select locations)
- NAAQS revised in 2009
  - Independent of activities; health primary focus
  - 12 parameters – $PM_{2.5}$, $PM_{10}$, $SO_2$, $NO_2$, CO, $O_3$, $NH_3$, Benzene, B(a)P, Pb, Ni, As

# NATIONAL TREND FOR PM2.5 LEVELS



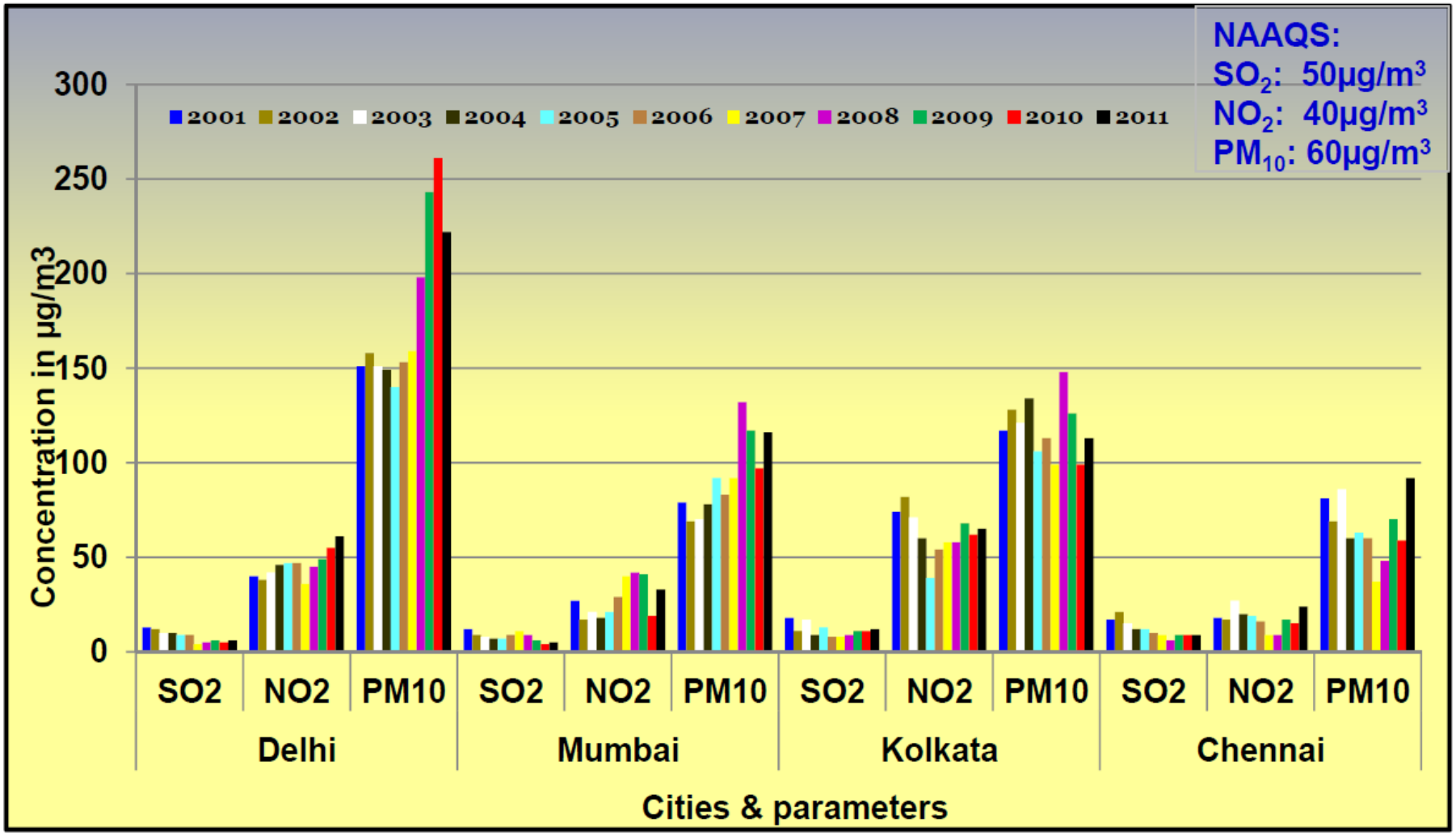

***Source : CPCB***

# NATIONAL TREND FOR NO2 LEVELS




*Source : CPCB*

# AIR QUALITY TRENDS IN FOUR MEGA CITIES




*Source : CPCB*

# CITY WISE MONTHLY AIR QUALITY INDEX VALUES

**NOVEMBER, 2015**

| S.No | Date/Cities | MAX | MIN | AVG |
|---|---|---|---|---|
| 1 | Agra | 423 | 183 | 327 |
| 2 | Bengaluru | 124 | 31 | 61 |
| 3 | Chandrapur | 265 | 59 | 143 |
| 4 | Delhi | 435 | 263 | 360 |
| 5 | Faridabad | 414 | 188 | 350 |
| 6 | Hyderabad | 207 | 55 | 115 |
| 7 | Kanpur | 394 | 222 | 316 |
| 8 | Lucknow | 450 | 241 | 374 |
| 9 | Mumbai | 179 | 63 | 119 |
| 10 | Muzzaffarpur | 449 | 168 | 345 |
| 11 | Navi Mumbai | 151 | 84 | 106 |
| 12 | Patna | 439 | 266 | 366 |
| 13 | Pune | 315 | 86 | 212 |
| 14 | Varanasi | 397 | 183 | 318 |

| Good (0–50) | Satisfactory (51–100) | Moderate (101–200) | Poor (201–300) | Very Poor (301–400) | Severe (>401) |
|---|---|---|---|---|---|

**Source : CPCB website**

## DECEMBER, 2015

| S.No | Cities | MAX | MIN | AVG |
|---|---|---|---|---|
| 1 | Agra | 431 | 207 | 342 |
| 2 | Bengaluru | 156 | 45 | 89 |
| 3 | Chandrapur | 415 | 73 | 139 |
| 4 | Chennai | 390 | 81 | 139 |
| 5 | Delhi | 386 | 140 | 293 |
| 6 | Faridabad | 446 | 234 | 345 |
| 7 | Gaya | 305 | 273 | 289 |
| 8 | Gurgoan | 158 | 136 | 146 |
| 9 | Haldia | 106 | 82 | 97 |
| 10 | Hyderabad | 190 | 52 | 101 |
| 11 | Jaipur | 381 | 41 | 290 |
| 12 | Jodhpur | 374 | 203 | 294 |
| 13 | Kanpur | 431 | 73 | 347 |
| 14 | Lucknow | 489 | 204 | 353 |
| 15 | Mumbai | 211 | 91 | 134 |
| 16 | Muzzaffarpur | 474 | 302 | 400 |
| 17 | Navi Mumbai | 154 | 81 | 109 |
| 18 | Panchkula | 141 | 54 | 92 |
| 19 | Patna | 421 | 245 | 373 |
| 20 | Pune | 320 | 84 | 209 |
| 21 | Varanasi | 466 | 139 | 366 |

| Good (0–50) | Satisfactory (51–100) | Moderate (101–200) | Poor (201–300) | Very Poor (301–400) | Severe (>401) |
|---|---|---|---|---|---|

**Source : CPCB website**

## JANUARY, 2016

| S.No | Cities | Max | Min | Average |
|---|---|---|---|---|
| 1 | Agra | 449 | 262 | 372 |
| 2 | Bengaluru | 210 | 55 | 122 |
| 3 | Chandrapur | 237 | 84 | 141 |
| 4 | Chennai | 314 | 63 | 140 |
| 5 | Delhi | 434 | 269 | 362 |
| 6 | Faridabad | 453 | 276 | 399 |
| 7 | Gaya | 348 | 123 | 278 |
| 8 | Haldia | 113 | 51 | 90 |
| 9 | Hyderabad | 230 | 82 | 142 |
| 10 | Jaipur | 344 | 247 | 294 |
| 11 | Jodhpur | 394 | 147 | 284 |
| 12 | Kanpur | 455 | 60 | 359 |
| 13 | Lucknow | 408 | 183 | 339 |
| 14 | Muzzaffarpur | 474 | 300 | 409 |
| 15 | Navi Mumbai | 116 | 79 | 103 |
| 16 | Panchkula | 283 | 27 | 125 |
| 17 | Patna | 488 | 112 | 388 |
| 18 | Pune | 320 | 92 | 195 |
| 19 | Rohtak | 300 | 82 | 191 |
| 20 | Solapur | 196 | 94 | 133 |
| 21 | Varanasi | 487 | 266 | 409 |

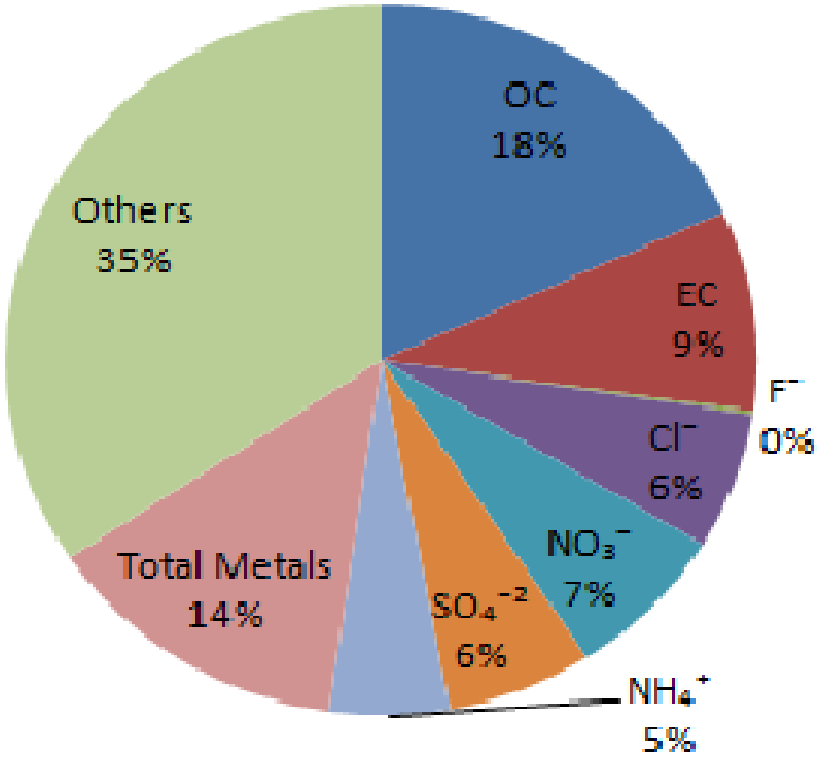
| Good (0–50) | Satisfactory (51–100) | Moderate (101–200) | Poor (201–300) | Very Poor (301–400) | Severe (>401) |
|---|---|---|---|---|---|

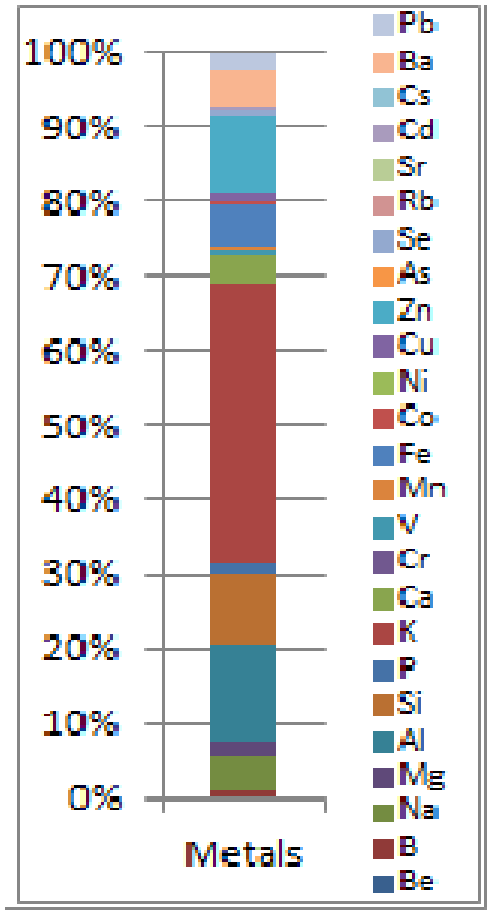
**Source : CPCB website**

# PM2.5 CHEMICAL CHARACTERIZATION DURING WINTER 2015-16 IN DELHI

- PM2.5 ≈ **375 ug/m3** (standard 60 ug/m3)
- Crustal component (Si + Al + Fe + Ca) – **3.5%** (soil, road dust etc.)
- Secondary particles ($NO_3^-$ + $SO_4^{-2}$ + $NH_4^1$) – **28%** (emitted from vehicles + industry)
- Combustion related total carbon (TC=EC+OC) – **23%** (emitted from vehicles and industries)
- Chloride – **7%** (emitted due to MSW burning)

# PERCENTAGE DISTRIBUTION OF SPECIES IN PM2.5 AT DELHI FOR WINTER SEASON




**(Source: IIT Kanpur, 2016)**

# SETTING THE AMBIENT AIR QUALITY GOAL

- The first NAAQS notified in 1984,
- The Second in 1994 which was subsequently revised with the introduction of few new parameters in 1998.
- The NAAQS further revised on November 18, 2009.

# REVISED NATIONAL AMBIENT AIR QUALITY STANDARDS (2009)

| S. No. | Pollutants | Time Weighted Average | Concentration in Ambient Air | | Methods of Measurement |
|---|---|---|---|---|---|
| | | | Industrial, Residential, Rural and other Areas | Ecologically Sensitive Area (notified by Central Government) | |
| 1 | Sulphur Dioxide ($SO_2$), µg/m$^3$ | Annual* | 50 | 20 | 1. Improved West and Gaeke<br>2. Ultraviolet Fluorescence |
| | | 24 Hours** | 80 | 80 | |
| 2 | Nitrogen Dioxide ($NO_2$ ), µg/m$^3$ | Annual* | 40 | 30 | 1. Modified Jacob & Hochheiser (Na-Arsenite)<br>2. Chemiluminescence |
| | | 24 Hours** | 80 | 80 | |
| 3 | Particulate Matter (Size <10µm) or $PM_{10}$ µg/m$^3$ | Annual* | 60 | 60 | 1. Gravimetric<br>2. TOEM<br>3. Beta attenuation |
| | | 24 Hours** | 100 | 100 | |
| 4 | Particulate Matter (Size <2.5 µm) or $PM_{2.5}$ µg/m$^3$ | Annual* | 40 | 40 | 1. Gravimetric<br>2. TOEM<br>3. Beta attenuation |
| | | 24 Hours ** | 60 | 60 | |
| 5 | Ozone ($O_3$), µg/m$^3$ | 8 hours** | 100 | 100 | 1. UV photometric<br>2. Chemiluminescence<br>3. Chemical Method |
| | | 1 hours ** | 180 | 180 | |
| 6 | Lead (Pb), µg/m$^3$ | Annual * | 0.50 | 0.50 | 1. AAS/ICP Method after sampling using EPM 2000 or equivalent filter paper<br>2. ED-XRF using Teflon filter |
| | | 24 Hour** | 1.0 | 1.0 | |
| 7 | Carbon Monoxide (CO), mg/m$^3$ | 8 Hours ** | 02 | 02 | Non dispersive Infra Red (NDIR) Spectroscopy |
| | | 1 Hour** | 04 | 04 | |
| 8 | Ammonia ($NH_3$), µg/m$^3$ | Annual* | 100 | 100 | 1. Chemiluminescence<br>2. Indophernol blue method |
| | | 24 Hour** | 400 | 400 | |
| 9 | Benzene ($C_6H_6$) , µg/m$^3$ | Annual * | 05 | 05 | 1. Gas chromatography based continuous analyzer<br>2. Adsorption and Desorption followed by GC analysis |
| 10 | Benzo(a)Pyrene (BaP)- particulate phase only, ng/m$^3$ | Annual* | 01 | 01 | Solvent extraction followed by HPLC/GC analysis |
| 11 | Arsenic (As), ng/m$^3$ | Annual* | 06 | 06 | AAS/ICP method after sampling on EPM 2000 or equivalent filter paper |
| 12 | Nickel (Ni), ng/m$^3$ | Annual* | 20 | 20 | AAS/ICP method after sampling on EPM 2000 or equivalent filter paper |

** Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform interval.*

*** 24 hourly 08 hourly or 01 hourly monitored values, as applicable shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.*

*NOTE: Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigation*

# OPTIONS FOR URBAN AIR QUALITY IMPROVEMENT BASED PRIMARILY ON VEHICULAR POLLUTION CONTROL

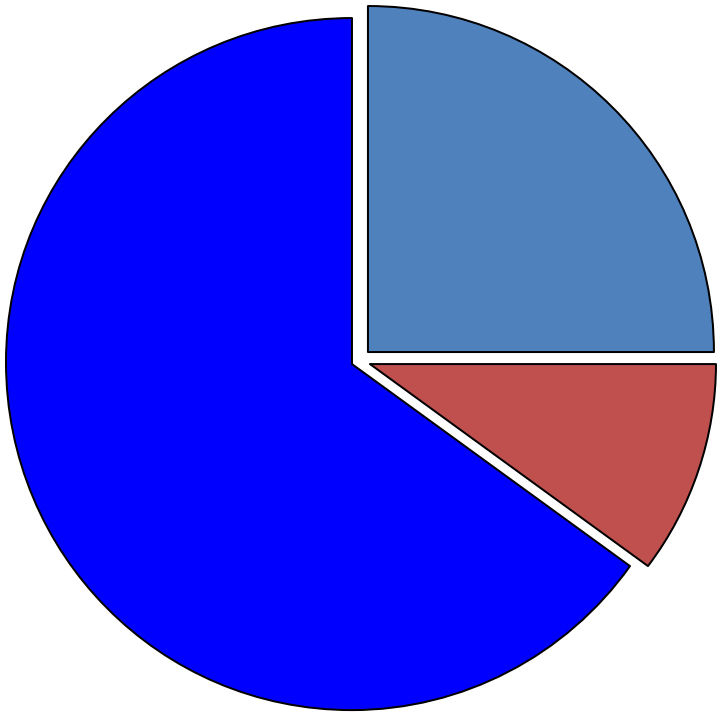
- Fuel quality improvement (BS-V, BS-VI quality fuel).
- Checking of fuel adulteration.
- Improved I/M system for in-use vehicles.
- Stringent mass emission standards for new vehicle (BS-IV, BS-VI norms).
- Improvement of mass transport system (Buses, Metro services etc.).
- Improvement of road conditions.
- Restrictions on personal vehicles during strong inversion condition / calm atmospheric condition.

# STEPS TAKEN TO CONTROL VEHICULAR POLLUTION

- BS(IV) norms for vehicles and fuels implemented.
- Pollution under control certificate (PUC) for in-use vehicles (not very effective)
- Comprehensive inspection and maintenance system (exists only in few places)
- Independent fuel testing laboratories for checking fuel adulteration
- Thrust on use of clean transportation fuel (CNG) in few cities
- New AAQS for ozone, PAH, Benzene etc. notified

# TYPICAL PARTICLE COMPOSITION
# A MEDIUM SPEED DIESEL ENGINE USING HEAVY FUEL OIL

≈65 wt -%
Ash
Metal
- Oxides
- sulphates



≈25 wt -%
Carbon Soot

≈10 wt -%
Hydro – Carbons
-fuel oil
- lubrication oil

Dry particulate matter

# ENVIRONMENTAL ISSUES IN DIESEL BASED POWER PLANTS

- Diesel Engine based power station are coming close to load centers (Major Cities)
- Already in Major Cities / towns air pollution level are quite significant
- NOx emission from Diesel Engine based power plant is very high

- NOx is responsible for secondary pollutant formation (O3, photochemical oxidant)
- SO2 emission is quite significant as these power plant are using high Sulphur liquid fuel
- V and Ni emission are significant
- Oily sludge disposal is problem, this has been identified as hazardous waste

# EMISSION STANDARDS AND OTHER REQUIREMENT FOR NEW DIESEL ENGINE BASED POWER PLANTS

**(Engine rating more than 0.8 MW)**
**(Plants commissioned before 1.06.2002)**

| Parameter | | Standards |
|---|---|---|
| NOx (as $NO_2$) (at 15% $O_2$, dry basis) | | 1100 ppmv |
| CO (at 15% $O_2$) | | 150 mg / $Nm^3$ |
| HC (at 15% $O_2$) | | 150 mg / $Nm^3$ |
| PM (at 15% $O_2$) | Fuel HFO, LSHS,HPS, etc. | 150 mg / $Nm^3$ |
| | Fuel HSD, LDO, etc. | 75 mg / $Nm^3$ |
| Sulphur content in fuel | | Sulphur content in fuel should not be more than 2%, in urban area |
| Stack height | | Stack height (H) shall be maximum of the following, in m<br>1. $14Q^{0.3}$, Q = Total $SO_2$ emission from the plant in kg / hr,<br>2. 30 m<br>3. H + (KVA) $^{½}$, h = height of the DG set building, in m. KVA = nominal power rating of the DG set |

Note: 1. These standards are applicable to power plants using any liquid fuel
2. Individual units with engine ratings less than or equal to 0.8 MW are covered by this notification.

# EMISSION STANDARDS AND OTHER REQUIREMENT FOR NEW DIESEL ENGINE BASED POWER PLANTS

(engine rating more than 0.8 MW)
(Plants commissioned on or after 1.06.2002)

<table>
<tr><th>Parameter</th><th colspan="6">Standards</th></tr>
<tr><td rowspan="4">NOx (as $NO_2$ at 15% $O_2$, dry basis</td><td colspan="3">Urban Area (within municipal limit)</td><td colspan="3">Other Area</td></tr>
<tr><td rowspan="2">Engine rating</td><td colspan="2">Plant commissioned</td><td rowspan="2">Engine rating</td><td colspan="2">Plant commissioned</td></tr>
<tr><td>Before 1.1.2005</td><td>On or after 1.1.2005</td><td>Before 1.1.2005</td><td>On or after 1.1.2005</td></tr>
<tr><td>> 0.8 – 75 MW</td><td>970 ppmv</td><td>710 ppmv</td><td>> 0.8 – 150 MW</td><td>970 ppmv</td><td>710 ppmv</td></tr>
<tr><td>> 75 MW</td><td>710 ppmv</td><td>360 ppmv</td><td>> 150 MW</td><td>710 ppmv</td><td>360 ppmv</td></tr>
<tr><td>CO (at 15% $O_2$)</td><td colspan="6">150 mg / $Nm^3$</td></tr>
<tr><td>HC (at 15% $O_2$)</td><td colspan="6">50 mg / $Nm^3$</td></tr>
<tr><td>PM (at 15% $O_2$)</td><td colspan="6">75 mg / $Nm^3$</td></tr>
<tr><td>Sulphur content in fuel</td><td colspan="6">Sulphur content in fuel should not be more than 2%, in urban area</td></tr>
<tr><td>Stack Height</td><td colspan="6">Stack height (H) shall be maximum of the following, in m<br>1. $14Q^{0.3}$, Q = Total $SO_2$ emission from the plant in kg / hr,<br>2. 30 m<br>3. H + $(KVA)^{½}$, h = height of the DG set building, in m. KVA = nominal power rating of the DG set</td></tr>
</table>

**Note:**

1. Stringent emission standards are proposed for plants with engine rating more than 75 MW (in urban area) and more than 150 MW (in other area) to minimise NOx emission.
2. Engine rating mentioned in the table is the total engine rating of all the units in the power plant (including that of existing units) and not the engine rating of individual unit.
3. Individual units with engine ratings less than or equal to 0.8 MW are not covered by this notification.
4. For expansion project, the new units shall be covered by standards in table – 2. Engine rating, for deciding NOx standards, shall include existing units as well as new units.
5. These standards are applicable to power plants using any liquid fuel.
6. For expansion project, stack height of new units shall be as per total SO2 emission

   (including existing as well as additional load).
7. Stack height should be provided, keeping in mind, the future expansion.
8. For multi engine plants, flues shall be grouped in cluster to get better plume rise and dispersion. Provision for any future expansion, should be made in planning stage itself.

# ISSUES ON INSPECTION AND MONITORING

- Sulphur content in liquid fuel used in DG set to be Regulated
- Emission monitoring shall be done as per CPCB protocol
- NOx monitoring shall be done as per USEPA guideline
- Sludge generated from diesel engines to be disposed as per Hazardous Waste Management Rules
- Stack height of DG Set shall be as prescribed under EP Act
- Storage of oil should follow the various provisions of hazardous chemical storage and management rules
- Acoustic enclosure of the engine should be as per CPCB guidelines to meet the noise limit

# RECOMMENDATION FOR ACHIEVING BETTER AIR QUALITY BY REGULATING EMISSION FROM OFF-ROAD VEHICLES

- All new DG sets installed at mobile towers in non-attainment cities should be either CNG based or they should have alternate source of power like solar power etc.
- All new DG sets installed at malls, hotels, commercial complexes located in non-attainment cities should be based on CNG.
- Sulphur content in diesel used in existing DG Sets should be regulated (preferably <0.5%) to reduce the formation of sulphate which is part of PM2.5.
- All DG set should comply mass emission standards notified under EP Act, 1986 by MoEF.
- Instead of large number of individual DG sets working in industrial area, common power generating and distribution system should be promoted.
- Emission standards for other off-road engine like tractor, engine of pump sets etc. to be formulated by CPCB / MoEF

# THANKS ALOT.

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