The battle against solid UFP-emissions from internal combustion engines without waiting for Euro VI

Vahid Hosseini, Ph.D.
Assistant professor of Mechanical Engineering at Sharif University of Technology
Head of Tehran air quality control co., a subsidiary of Tehran Municipality
Tehran, Iran

A presentation for
FOCUS-Event
Cleaner Air for Megacities

19th ETH Conference on Combustion Generated Nanoparticles
Zurich, June 28th – July 1st, 2015
Real-life experience!

- My sincere apologies to 19th ETH nanoparticle conference organizers for not being able to present my talk on Tehran particle pollution.
- During last two weeks, I have suffered from a mild heart attack, diagnosed with Coronary Artery Disease, two of my major coronary arteries were almost blocked, the leading cause has been identified as air pollution!!
- The very reason that we people are working hard to identify/measure/understand/calculate health risks/mitigate UFPs and in general air pollution has caused serious troubles for myself, and for many others like me.
- I am not alone in this city of 8.5 millions. Hundreds of people at young age rush to the emergency wards everyday in Tehran as we encounter high concentrations (mass and number) of particles.
Tehran Air Quality
Tehran Air Quality
Tehran Air Quality Data, obtained from monitoring stations
A comparison of the last two Iranian calendar years

1392 (21 March 2013 to 20 March 2014)

1393 (21 March 2014 to 20 March 2015)
Monthly concentrations of PM\textsubscript{10} & PM\textsubscript{2.5} during the year 1393
(21 March 2014 - 20 March 2015)
Daily Concentration of PM$_{10}$ & PM$_{2.5}$ in a sample air quality monitoring station in Tehran (March 2014 - February 2015)

An example of the occurrence of dust storm

An example of the occurrence of inversion

Daily Standard PM$_{10}$

PM$_{2.5}$ Daily Standard

Months

Farvardin
Ordibehesht
Khordad
Tir
Mordad
Shahrivar
Mehr
Aban
Azar
Dey
Bahman
Esfand
Hourly average concentration of PM$_{10}$ & PM$_{2.5}$ in a selected air quality monitoring station (March 14-18, 2015)

- **AQI=106**
- **AQI= 109**
- **AQI= 59**
- **AQI= 66**
- **AQI= 66**

- **Increase in Wind Speed**
- **Increasing the concentrations (last Wednesday of the year- bonfire)**
- **Decreasing the Concentrations with Increase wind speed and precipitation**
The impact of **temperature inversion** phenomenon occurrence on PM$_{10}$ & PM$_{2.5}$ Concentrations

Elevated particulate matter concentrations due to the occurrence of the temperature inversion

- Stable atmospheric conditions
- Temperature inversion
- Increase Air pollution

AQI = 110

AQI = 152

AQI = 146
The impact of temperature inversion phenomenon occurrence on PM\textsubscript{10} & PM\textsubscript{2.5} Concentrations

Elevated particulate matter concentrations due to the occurrence of the temperature inversion

Increasing levels of PM as a result of decreasing wind speed & increasing atmospheric stability conditions

AQI = 110

AQI = 152

AQI = 146
The impact of temperature inversion phenomenon occurrence on PM\textsubscript{10} & PM\textsubscript{2.5} Concentrations

Elevated particulate matter concentrations due to the occurrence of the temperature inversion

Decreased levels of PM concentration & a slight increase in wind speed
The impact of surface Temperature inversion & mixing depth on air quality

Vertical profile of temperature (Lapse rate)
- Dry adiabatic lapse rate

Maximum Mixing Depth (1663 m)
Maximum Mixing Depth (723 m)
Upper layer Temperature Inversion
Surface layer Temperature Inversion

AQI = 61
Healthy

AQI = 152
Unhealthy
The impact of rainfall & relative humidity on PM$_{10}$ & PM$_{2.5}$ Concentrations

A slight decrease in PM concentrations - limited amount of rainfall

Continuous rainfall

Reduction in PM concentration due to frequent rainfall

AQI = 137
AQI = 124
AQI = 112
Patrice counting
Device: Matter Aerosol DiscMini
impactor size < 700 nm
A Comparison of Diurnal Concentration of Nanoparticles Between Tehran, Zurich and Basel
Daily particle number count in two traffic and urban stations, Winter 2015
Averaged values of particle counts over all air quality monitoring stations, Winter 2015.
Source apportionment studies
Study description

• First source apportionment study in Tehran
• Sampling site: Sharif University of Technology, Tehran
• 24-hour PM$_{2.5}$ samples collected on 47mm quartz and Teflon filters every 6$^{th}$ day using BGI PQ200 sampler
• Analysis by Prof. Shauer and his team at University of Wisconsin-Madison
• Chemical measurements:
  • Elemental and organic carbon (ECOC)
  • Water-soluble organic carbon (WSOC)
  • Primary and secondary inorganic ions
  • Organic molecular marker compounds
  • Trace elements using ICP-MS
• Results:
  • Bulk composition of PM$_{2.5}$ in Tehran
  • Source apportionment using chemical mass balance (CMB) model
Comparison with other cities

- **OC**
  - Mobile sources and VOCs
  - Athens - Amsterdam - Barcelona - Pittsburgh - Los Angeles - Mexico City - Shanghai

- **EC**
  - HDVs and heavy fuels
  - Athens - Amsterdam - Barcelona - Pittsburgh - Los Angeles - Mexico City - Shanghai
Tehran Emission inventory
Major traffic sources: gasoline carburetor vehicles

- Total number of gasoline LDVs: 3,379,741

- 10% of LDV fleet emit 45% of total pollution!
Contribution of mobile vs. stationary sources of PM

- Mobile sources: 62%
- Stationary sources: 38% (mainly power plants and...)

PM: 9,550 Tonnes/Year
Mobile source contributions

- Public buses: 18%
- Other buses: 26%
- Diesel: 32%
- Minibuses: 6%
- Trucks: 2%
- Motorcycles: 15%
- Pickups: 1%

Total: 6000 Tonnes/year
Tehran annual PM emission sources

PM emission from different sources (2013)

- Total: 7.9 thousand tons/year
- Mobile: 3.2 thousand tons/year
- Industries: 0.8 thousand tons/year
- Household, Commercial, Energy conversion: 1.2 thousand tons/year
- Terminals: 0.9 thousand tons/year

- Mobile: 50.7%
- Industries: 23.0%
- Household, Commercial, Energy conversion: 22.9%
- Terminals: 0.9%
Concluding remarks
• Tehran air particulate matter concentration has reached a very dangerous level and immediate actions are needed.
• Contribution of mobile sources to the particles is quite obvious.
• Black carbon (soot) fraction of particles are considerable.
• Mega cities like Tehran cannot wait for Euro VI vehicles to come, by then, thousands will be affected by UFPs.
• Retrofit and new-fit with BATs are immediate solutions, this mush be done with the current available fuel in the market.
Thanks for your attention

vhosseini@sharif.edu