Health impacts of new generation pollutant: Ozone

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The Problem of Ozone Air Pollution

- In India, monitoring of ozone in the ambient air is not done on a regular basis as it is done for particulates, sulphur dioxide and oxides of nitrogen
- Our present concerns about the adverse effects of air pollution have been related to the particulates
- Ozone air pollution is a major health concern in developed countries
- Limited data available on levels of ozone in the ambient air in Delhi shows that the concentrations often exceed standards

Good Ozone & Bad Ozone

Ozone is a natural constituent of the atmosphere

Good Ozone

- In the stratosphere10 - 30 miles above the earth, it provides protection from potentially harmful UV radiation

Bad Ozone

- Closer to earth in the troposphere, ozone is an air pollutant that can be harmful. It is created and hangs around in the layer of air near the ground

Ground level ozone as a global pollutant

- Generated by sunlight driven chemical reactions between NOX and volatile organic compounds (VOC) including methane (CH_4) and other more complex organic compounds
- Ozone precursors may be:
  - of natural origin (vegetation, soil, forest fires or lightning)
  - a consequence of human activities, especially those that involve combustion of fossil fuels (power plants or internal combustion engines) and biomass
- With the ever-increasing number of vehicles, ozone air pollution already constitutes a major problem in India as well and is going to increase future

Ground level ozone as a global pollutant

- The average lifetime of ozone in the troposphere is approximately three weeks
- Varies with altitude, and is determined by the processes which remove ozone from the atmosphere
- Long tropospheric life-time means that ozone can be transported large distances
- Ozone may be produced from precursors long after they have been emitted
- Thus, ozone is not local but a global pollutant

Mechanisms of Toxicity

- Ozone is water-insoluble and a strong oxidant
- It is adsorbed in proximal and peripheral areas of the respiratory system and causes oxidative damage to the epithelium
- Powerful respiratory irritant: causes spasm
- Oxidizes molecules in body tissues: oxidation products are pro-inflammatory
- Increases response to allergens in asthmatics
- Ozone has a significant impact on human health
- Is one of the most dangerous air pollutants
- Can lead to a significant economic burden

Health Impacts

- Strongest evidence relates to acute effects
- Documented clinical effects:
  - Shortness of breath, chest pain, discomfort
  - Impairment of lung function
  - Inflammation of the lung lining, wheezing and coughing
  - Increased risk of asthma attacks (common trigger)
  - Need for medical treatment and for hospitalization for people with lung diseases, such as asthma or chronic obstructive pulmonary disease
  - Premature death (all cause, respiratory, cardiovascular)

Vulnerable population

- Vulnerable populations includes
  - elderly, infants
  - children
  - persons with existing respiratory issues such as diabetes mellitus, asthma or allergies, asthmatics, chronic respiratory patients (COPD)
  - pregnant women
  - smokers
  - persons with lung cancer
  - existing cardiovascular disease
  - those with immune system deficiency
  - can even harm the unborn child
  - outdoor workers

Harmful effects in Healthy Subjects

Irritates the Respiratory System

- Coughing
- Throat irritation
- Uncomfortable sensation in the chest

These symptoms can last for a few hours after exposure to ozone and may even become painful

Harmful effects

Healthy Airways

Airways exposed to Ozone

Harmful effects in Healthy Subjects

- Reduces “Lung Function”
  - volume of air that we draw in when we take a full breath and
  - speed at which we are able to blow it out

- Difficulty to breathe deeply and vigorously as we normally would
  - Uncomfortable breathing
  - More rapid and shallow breaths than normal during an exercise

Impact on All-cause Mortality

- Italian study: 4% increase / 25-ppb increase in the levels of ambient ozone (Parodi et al Public Health. 2005 ; 119:844–50)

- US/European Data: For each 10-ppb increase in 1-hour average of ozone, increase in mortality between 0.39 and 0.87 % (Bell et al JAMA 2004; 292: 2372–8; Gryparis et al Am J Respir Crit Care Med. 2004; 170: 28-28; Ito et al Epidemiology. 2005; 16: 446–57)

- The association with increased mortality persists even at levels of ambient ozone of 15 ppb, which is well below the current EPA standard (Bell et al Environ Health Perspect 2006; 114: 532–6)

Chronic Health Impacts

- Damage to the respiratory tract may occur without symptoms or with symptoms too subtle to be noticed
- Growing evidence that ozone may also cause chronic effects by causing permanent damage to the lung
  - Impaired growth of lungs in children, reducing the eventual lung capacity
  - ? Increased prevalence of asthma
  - Lung cancer

Health Effect of Ozone in children

- Children are at special risk because they breathe more rapidly than adults and inhale more pollutant per weight
- Airways are smaller, hence more likely to become blocked when irritated (spasm, inflammation)
- Children are at risk when they are outside playing and exercising
- Children who grow up in areas of high ozone pollution may never develop their full lung capacity as adults
- Thus, they have greater risk of lung disease throughout their lives
- Poorer physical performance
- Lower lung function is a surrogate of poorer health status, all-cause and cardiovascular mortality

Health Effects of Ozone in Patients with Asthma

- Injury, inflammation, and increased airway reactivity induced by ozone exposure may result in a worsening of a person's underlying asthma status
- Increased response to inhaled allergen
- Ambient ozone exposure results in a higher probability of experiencing an asthma attack and other manifestations of worsening asthma
- Definite effects demonstrable at 0.08, 0.1 or 0.12 ppm

Effect of Ozone exposure on development of asthma in experimental model

Chhabra et al Indian J Med Res. 2010;132:87-93

Objectives

- To study the effects of exposure to ambient concentrations of ozone on response to allergens in guinea pigs
- To study the oxidant-antioxidant balance in allergen-induced asthma and the effect of exposure to ozone on it
- To evaluate the protective effect of dietary supplementation with antioxidant vitamins - alpha-tocopherol and ascorbic acid on the Ozone-Allergen interaction

Effect of ozone on Allergic Asthma

- Current levels of ambient ozone are likely to aggravate the response of allergic bronchial asthma patients to allergen inhalation
- Likely mechanism is a potentiation of oxidative stress
- Dietary supplementation with vitamin E and C may have a protective role against the allergen-ozone interaction

Ambient Air Standards

- The lowest concentration at which effects are observed depends upon
  - the level of activity
  - the duration of exposure
  - the sensitivity of each individual to ozone

- Effects can occur at 40, 80 or 120 ppb

- In 1997, the EPA reduced the ozone standards from 120 to 80 ppb

- The American Lung Association recommends 60 ppb

India: National Ambient Air Quality Standards 2009:
8 hrs, 100 ug/m^3 (50 ppb)
1 hr, 180 ug/m^3 (90 ppb)

(1 ppb O_3 corresponds to about 2 µg/$m^{3)}$

CENTRAL POLLUTION CONTROL BOARD

CONTINUOUS AMBIENT AIR QUALITY

Date : Monday, November 07, 2011
Time : 2:40:57 PM

Air Quality Monitoring Station: Delhi College of Engineering
Type of Area: Residential
Current Air Pollution Levels

Parameters	Date	Time	Concentration	Concentration (previous 24 Hours)/ Prescribed Standard	Remarks
Sulfur Dioxide	27/10/2011	11:45:00	NA	-36.0 µg/m3 Prescribed Standard : 80.0 µg/m3	
Nitric Oxide	27/10/2011	11:45:00	2.0 µg/m3	5.0 µg/m3	
Nitrogen Dioxide	27/10/2011	11:45:00	NA	-6.0 µg/m3 Prescribed Standard : 80.0 µg/m3	
Oxides of Nitrogen	27/10/2011	11:45:00	NA	0.0 ppb	
Carbon Monoxide	27/10/2011	11:45:00	664.0 µg/m3	643.0 µg/m3 * Prescribed Standard : 4,000.0 µg/m3	
Ozone	27/10/2011	11:45:00	472.0 µg/m3	286.0 µg/m3	

* Prescribed Standard for CO is one hourly Average

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CENTRAL POLLUTION CONTROL BOARD

CONTINUOUS AMBIENT AIR QUALITY

Date : Monday, November 07, 2011
Time : 2:39:23 PM

Air Quality Monitoring Station: ITO
Type of Area: Kerbside
Current Air Pollution Levels

Parameters	Date	Time	Concentration	Concentration (previous 24 Hours)/ Prescribed Standard	Remarks
Sulfur Dioxide	27/10/2011	11:45:00	8.0 µg/m3	**6.0** µg/m3 Prescribed Standard : 80.0 µg/m3	
Nitric Oxide	27/10/2011	11:45:00	9.0 µg/m3	**4.0** µg/m3	
Nitrogen Dioxide	27/10/2011	11:45:00	63.0 µg/m3	**78.0** µg/m3 Prescribed Standard : 80.0 µg/m3	
Oxides of Nitrogen	27/10/2011	11:45:00	41.0 ppb	**45.0** ppb	
Carbon Monoxide	27/10/2011	11:45:00	943.0 µg/m3	**767.0** µg/m3 * Prescribed Standard : 4,000.0 µg/m3	
Ozone	27/10/2011	11:45:00	200.0 µg/m3	**105.0** µg/m3	

* Prescribed Standard for CO is one hourly Average

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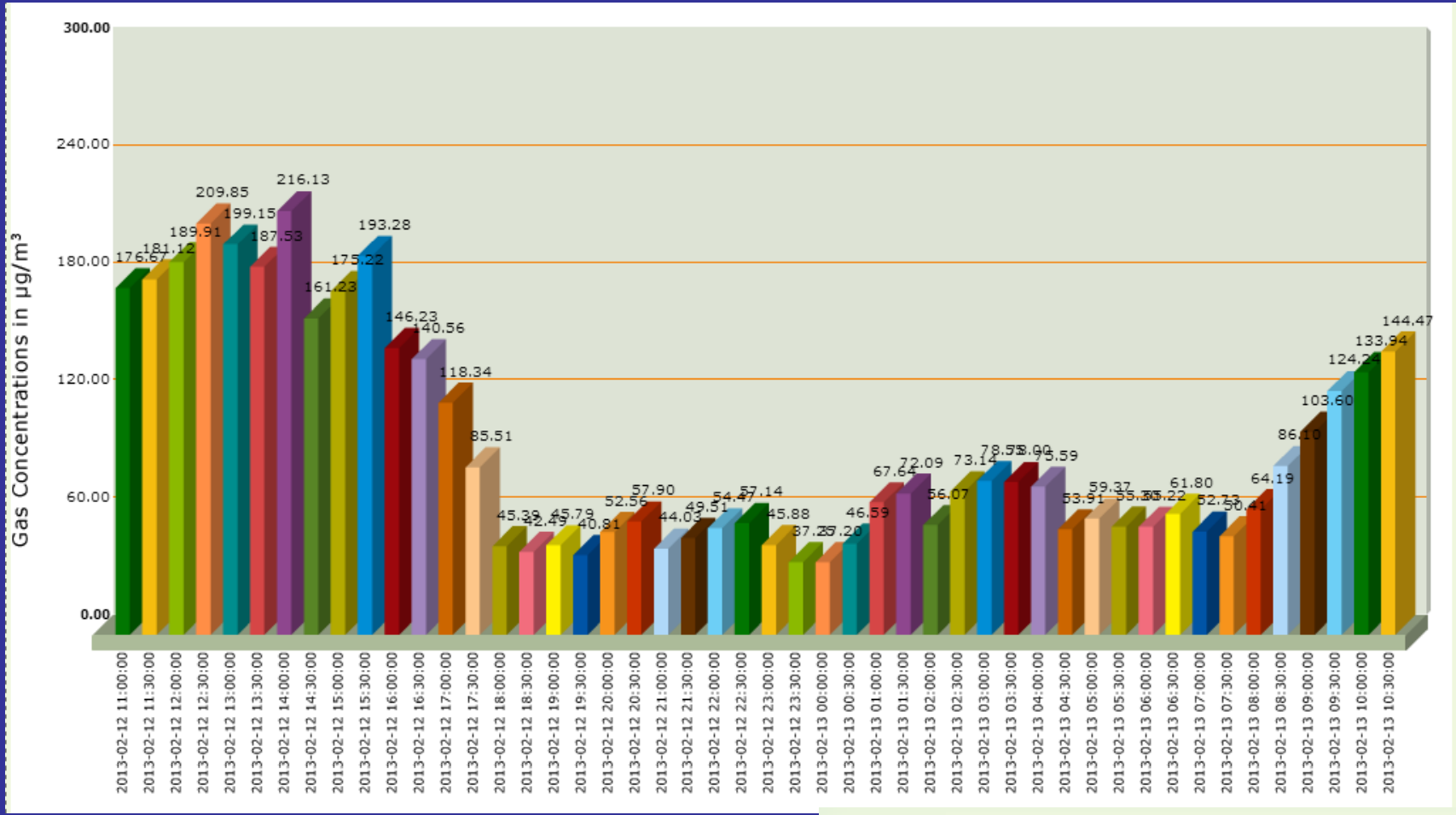
Ozone Real Time Data 12-13 Feb, 2013



NAAQS 2009: 8 hrs, 100 ug/m^3, 1 hr, 180 ug/m^3

DELHI POLLUTION CONTROL COMMITTEE
(Government of N.C.T. of Delhi)
4th Floor, I.S.B.T. Building, Kashmere Gate, Delhi - 110006
Website : http://www.dpcc.delhigovt.nic.in

Economic Benefits of Control

- Strict adherence to the established 8-hour ozone standard would result in reductions in the
  - 800 premature deaths
  - 4,500 hospital admissions
  - 900,000 school absences
  - More than 1 million restricted activity days with an estimated $5 billion annual economic burden
    [Hubbell et al Environ Health Perspect. 2005; 113: 73–82]

Summary

- Ground level (tropospheric) ozone, an air pollutant and key ingredient of urban smog, has a negative impact on human health
- Short-term exposures to ozone irritate the respiratory system and damage lung tissue, reducing lung function, increased airway inflammation and making the lungs more sensitive to other irritants
- Documented increases in emergency-room visits, hospital admissions, and mortality for patients with these conditions, associated with days of increased ozone

Summary

- Affects people with existing breathing problems, but also can affect healthy children and adults
- Long-term exposure to ozone may be associated with lung cancer
- Poorer lung growth with long term implication (physical performance, health status, all-cause mortality)

Summary

- Practically no awareness among media, health professionals and the publics
- Limited monitoring
- No “ozone-alerts”
- Need to carry out studies in India on health impacts
- Need to evaluate the appropriateness of standards
- Ozone pollution is not a “future” problem – it is already here