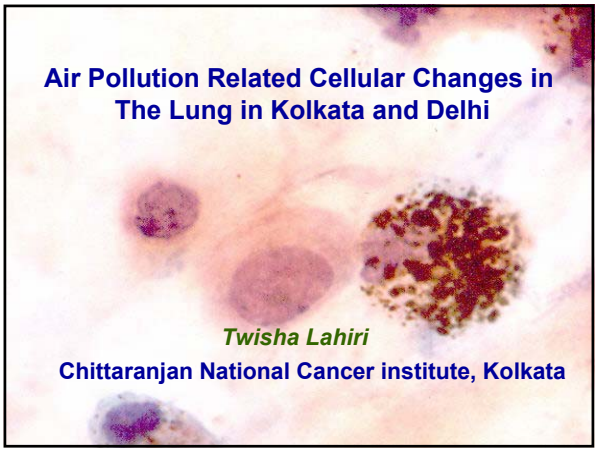
## Air Pollution Related Cellular Changes in The Lung in Kolkata and Delhi



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## Urban Air Pollution in India is a matter of grave concern

- 285 million urban Indians are exposed to alarmingly high level of pollutants
- Health risks of air pollution exposure are well recognized
- Dimension of the problem in India is relatively unknown

## In all major cities of India the pollutant levels over the last 10 years were far above NAAQS

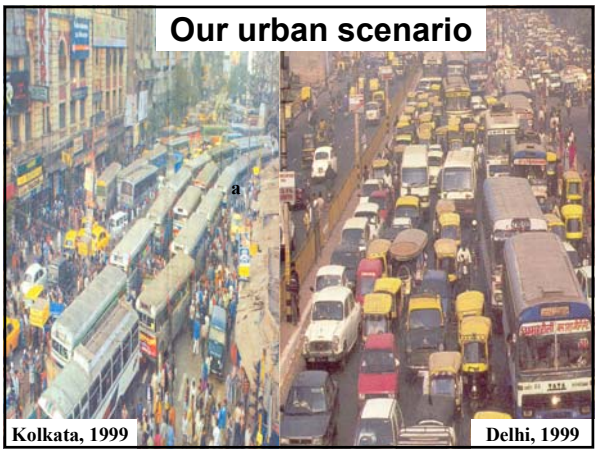
Mean annual conc. of $PM_{10}$ in Indian cities >150μg/m$^3$, 2.5-times over the standard

Vehicular emission contribute 50-70% of urban pollution load - aggravated by

- sharp rise in no. of vehicles
- old & ill-maintained vehicles
- low traffic speed & traffic jams
- poor fuel quality
- adulterated fuel

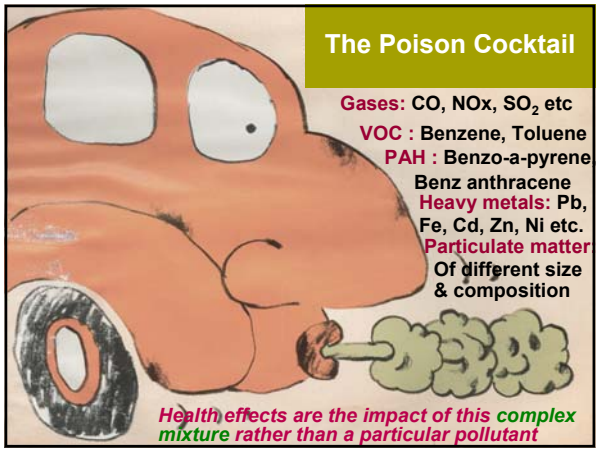
*If the pollutant levels in Indian cities are brought down to the standards, more than 40,000 premature deaths per year could be avoided (World Bank, 1998).*

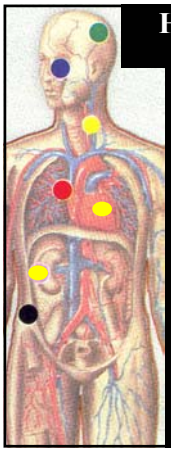
## Our urban scenario



Kolkata, 1999

Delhi, 1999



## Health Impacts of Air Pollution

- **Increase in mortality**

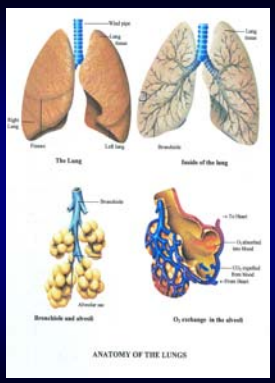
  500,000 deaths annually worldwide due to urban air pollution
- **Induction or revival of diseases**
  - Respiratory illness / disorders
  - Genotoxicity leading to cancer
  - Systemic & Immune alterations
  - Cardiovascular problems
  - Brain damage
  - Retardation of fetal growth

## Response Pattern

Air pollutants are likely to have similar adverse effects on diverse human population but responses may differ due to

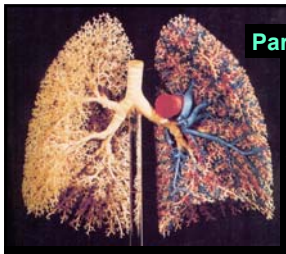
- extent of exposure
- co-exposure of different pollutant mixtures
- population structure
- socio-economic status
- nutritional status
- susceptibility factors

*Real dimension of the problem has not been evaluated in India till date*




Route of Invasion

- Lung - the main entry point of air pollutants
- Target organ is the alveolus (300 million alveoli in human lungs)
- 10,000 – 15,000 lit of air enters the adult lung every day
- Increase in concentration of pollutants cause parallel increase in toxic insult to the lungs. *At 160 $\mu g/m^3$ $PM_{10}$ level, 404 $\mu g$ particles deposit in lung/day*
- From alveolus, pollutants travel via lymph or blood to different organs



The Branching Airways

## Particulate Matter (PM)

**- the single best indicator of potential harm**

It is a complex mixture of variable size (0.01-100μm), composition (Metals, nitrates , sulfate, PAH, VOC etc.), & concentration

**Particle deposition depends on** Breathing patterns, Particle size and Airway geometry

**Determinants of particle toxicity**

| Less toxic | | More toxic |
|---|---|---|
| Increasing size | -------- | Decreasing size |
| Soluble | -------- | Insoluble |
| Less free radicals | -------- | More free radicals |
| Less transitional metals | -------- | More transitional metals |

Chittaranjan National Cancer Institute, Kolkata

## Health effects of chronic air pollution exposure are being assessed in a 10-year study using pollution-sensitive biomarkers

**Objectives**

- To prepare a database on air pollution related respiratory and systemic changes in
  - children of urban and rural areas
  - adult residents of Kolkata & Delhi of different age, sex, occupation & socio-economic status
- To explore the underlying mechanism of health effects for development of intervention strategies

## Children - the 'soft' target

Both in rural & urban areas, children are the most vulnerable group due to

- *Lower breathing zone*
- *Greater oxygen consumption*
- *More susceptible target organs*
- *Immunity not fully operational*

*Air pollution related respiratory symptoms have been assessed through specially designed questionnaires & lung function tests*

*12,000 - rural & suburban areas of West Bengal*

*3,200 - Kolkata; 3,500 - Delhi*

*Age groups - 8-16 years*

## Study approach

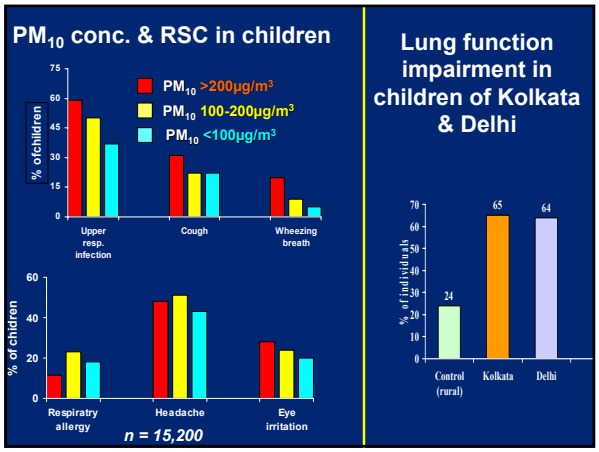
***Air quality data*** **- obtained from WBPCB & CPCB**

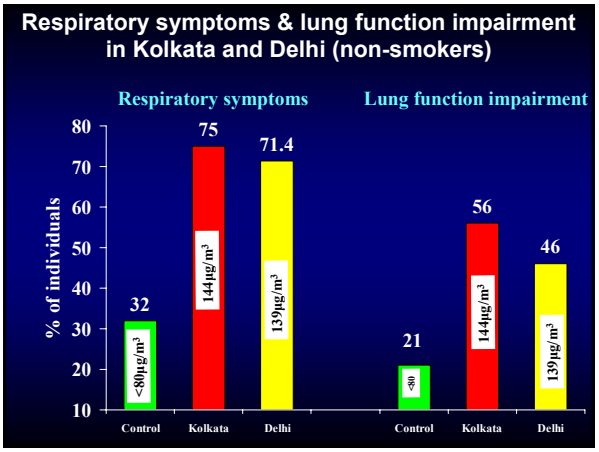
***Health data*** **from apparently healthy adults through**

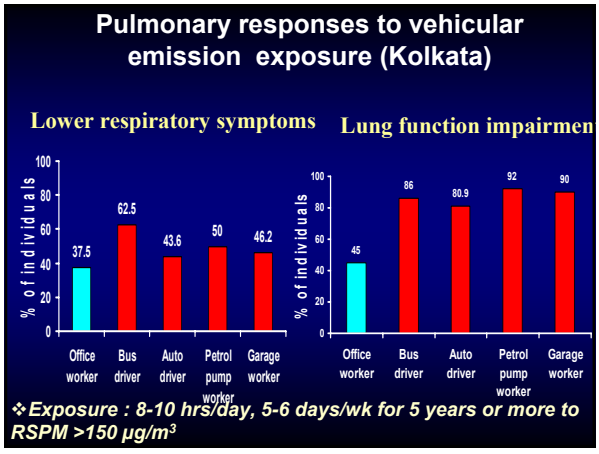
- **questionnaires for detailed personal history - age, sex, occupation, exposure, & respiratory symptoms**
- **clinical examination & lung function by spirometry**
- **sampling and detailed analysis of sputum & blood by appropriate techniques**

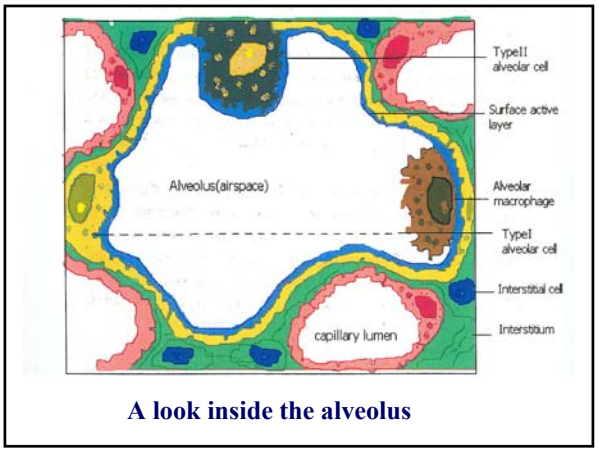
***Statistical analysis*** **- data analyzed in the Dept. of Medical Statistics using the software SYSTAT 9.0 (SPSS INC Chicago, USA)**

**Statistical tests & mathematical models- bivariate correlation, logistic regression, multiple regression have been used as per requirements**

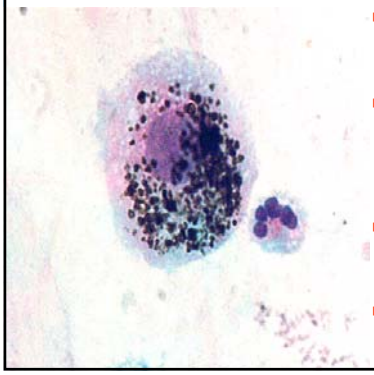

PM10 conc. & RSC in children
PM10 >200µg/m3
PM10 100-200µg/m3
PM10 <100µg/m3
% ofchildren
Upper resp. infection
Cough
Wheezing breath
% of chidren
Respiratry allergy
Headache
Eye irritation
n = 15,200
Lung function impairment in children of Kolkata & Delhi
% of individuals
24
65
64
Control (rural)
Kolkata
Delhi


Respiratory symptoms & lung function impairment in Kolkata and Delhi (non-smokers)
Respiratory symptoms
Lung function impairment
% of individuals
32
75
71.4
21
56
46
<80µg/m3
144µg/m3
139µg/m3
Control
Kolkata
Delhi


Pulmonary responses to vehicular emission exposure (Kolkata)
Lower respiratory symptoms
Lung function impairmen
% of individuals
37.5
62.5
43.6
50
46.2
45
86
80.9
92
90
Office worker
Bus driver
Auto driver
Petrol pump worker
Garage worker
❖Exposure : 8-10 hrs/day, 5-6 days/wk for 5 years or more to RSPM >150 µg/m3

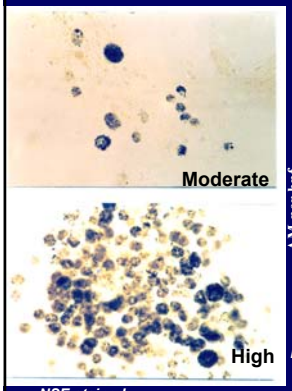

TypeII alveolar cell
Surface active layer
Alveolus(airspace)
Alveolar macrophage
TypeI alveolar cell
Interstitial cell
capillary lumen
Interstitium
A look inside the alveolus

## Alveolar macrophage - the biomarker of air pollution exposure

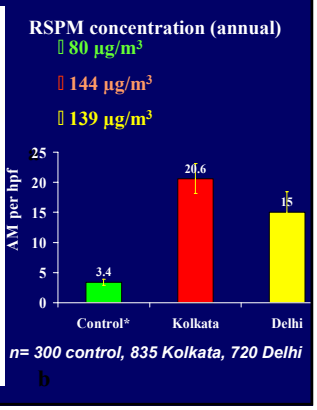


- AM interact directly with toxic particles and gases.
- Phagocytosis, migration and secretion of AM is pivotal in pathogenesis of lung diseases.
- AM count varies with the level of air pollution.
- Easily accessible by noninvasive procedure.

## Alveolar macrophage distribution in sputum

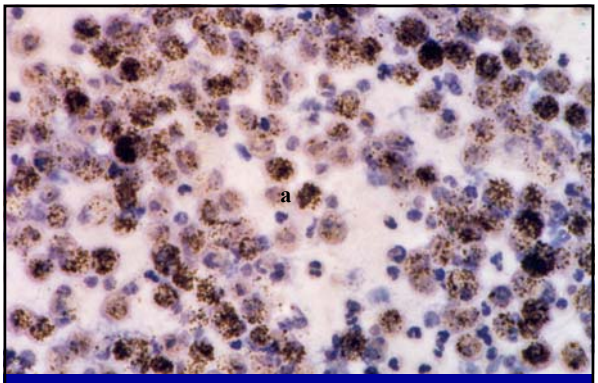



NSE stained

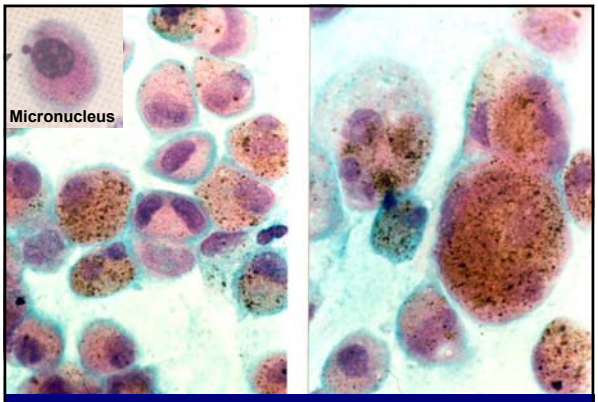



n= 300 control, 835 Kolkata, 720 Delhi

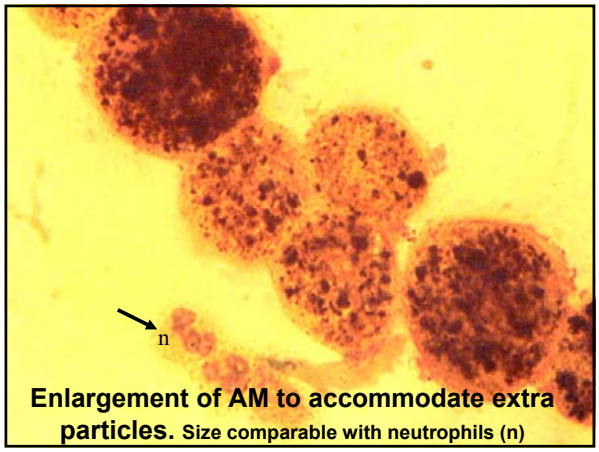
b



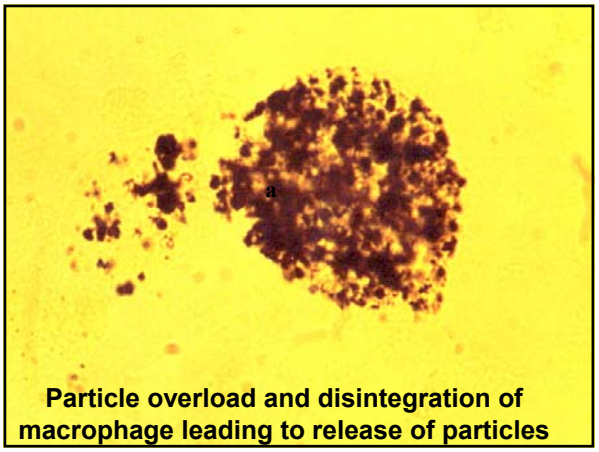

Sputum of taxi driver showing marked increase in particle laden macrophage (Pap stain)



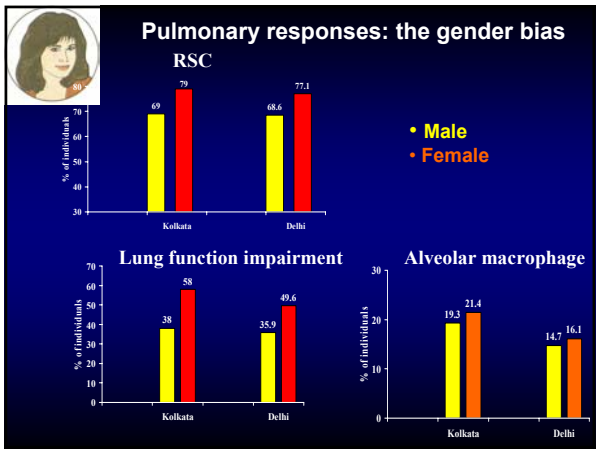

Sputum smear of a resident of Delhi showing marked hetorogenity in size, particle deposition & nuclear structure (PAP stain)

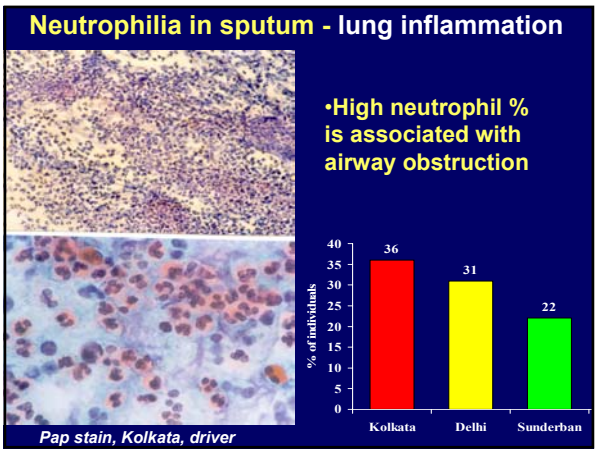



**Enlargement of AM to accommodate extra particles.** Size comparable with neutrophils (n)

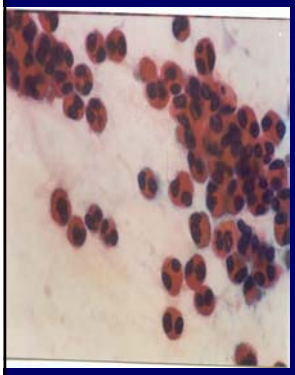


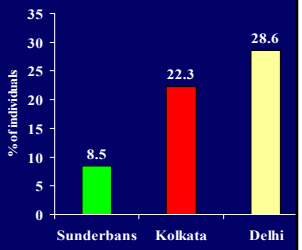

**Particle overload and disintegration of macrophage leading to release of particles**



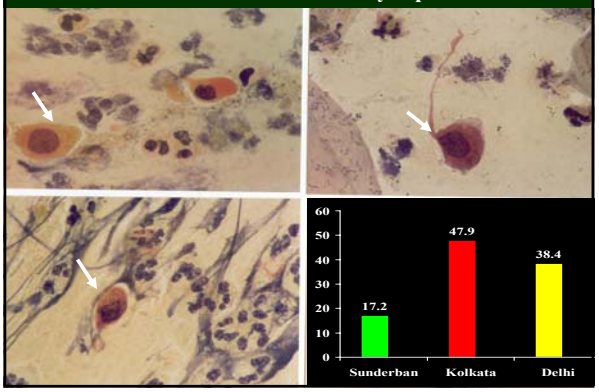
## Sputum eosinophilia - allergy, bronchitis, asthma

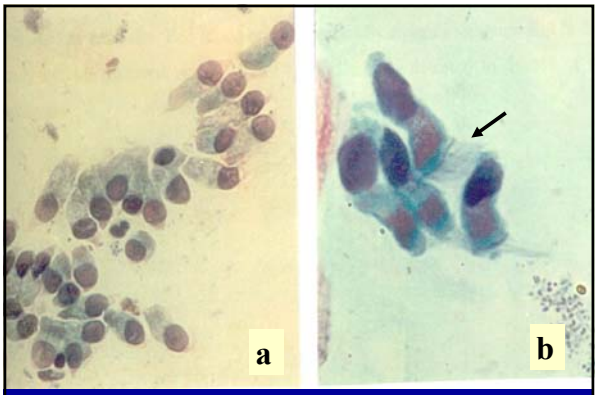




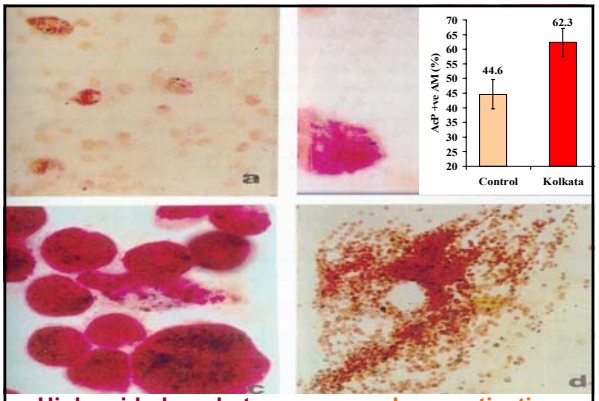

*Pap stain, office worker, Delhi*

## Sputum showing metaplastic epithelial cells – injury to the bronchial wall and faulty repair



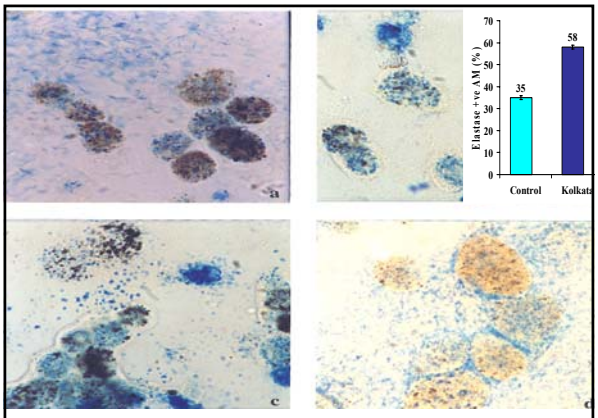




Sheets of columnar (a) & ciliated columnar epithelial cells (b) in sputum - damage to the bronchial wall

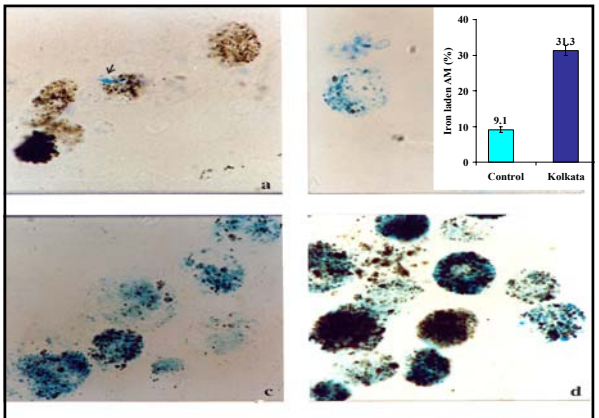



High acid phosphatase - macrophage activation

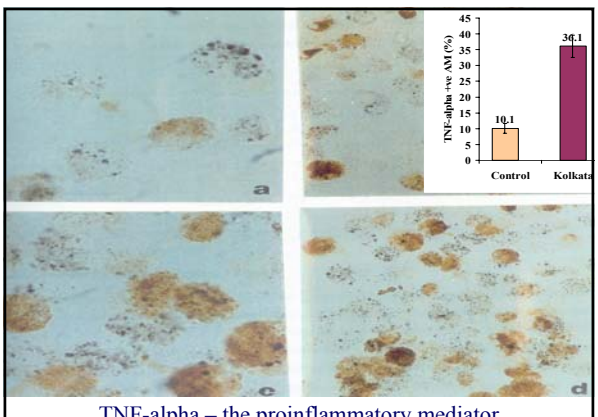
a. control b. c. d. emission exposed



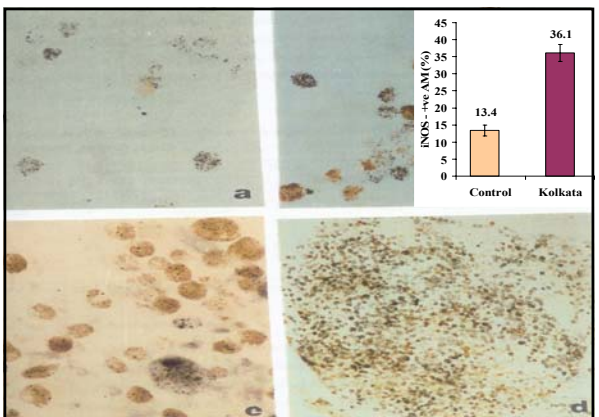

Release of elastase – the tissue degrader (vehicular emission exposed)



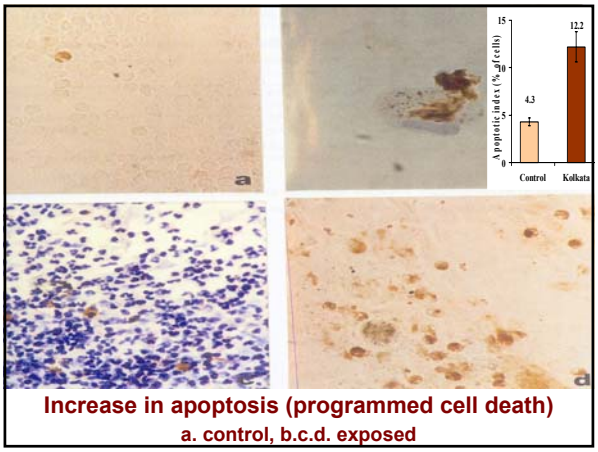

Iron in AM – Pulmonary hemorrhage ? A, Control; b, c & d, Exposed




TNF-alpha – the proinflammatory mediator
a, control; b, c & d, exposed

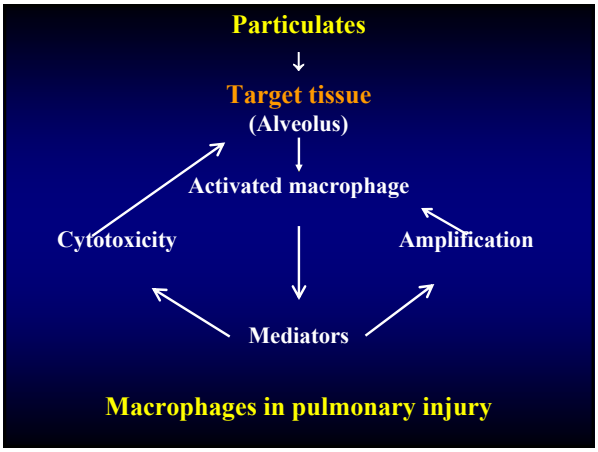



**Increase in iNOS – Oxidative stress** a, control; b, c & d, exposed




Increase in apoptosis (programmed cell death)

a. control, b.c.d. exposed




Macrophages in pulmonary injury

## Summary

*RSC in children correlate with $PM_{10}$ values*

*Exposure to vehicular emissions causes significant increase in :*

- Respiratory symptoms
- Lung function impairment
- Numerical, structural & functional alteration of AM
- Cellular indicators of lung inflammation & airway injury
- Genotoxicity & Systemic alterations

*Adverse effects are more pronounced in women, low socio-economic group and persons exposed to vehicular emissions*

**The study warrants immediate measures by all concerned to abate the alarmingly high vehicular pollution in Indian cities**

**Otherwise, we should be prepared for a disaster in not too distant future**


Let us ensure her
A Brighter Future....