Health Impacts of Air Pollution

The Indian Perspective

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The silent killer

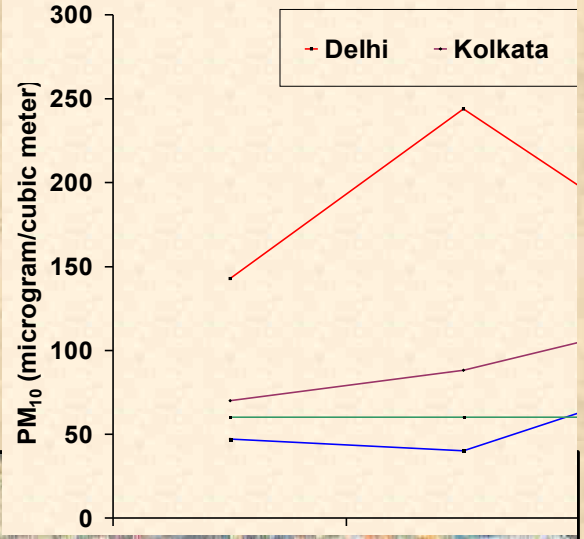
India faces the dual problem of air pollution at rural & urban fronts

- **Millions affected** - Urban & rural
- **Health risk** - Fairly Established
  High risk group
  Children
  Elderly (> 65 yr)
  Persons with RI & heart problems
  Diabetics
- **Prevention** - At an early stage
- **Dimension** - Practically unexplored

Although vehicular & industrial pollution are much emphasized, biomass emission affecting a greater populace has received very little attention

Our Urban Scenario

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



Mean annual conc. of PM_{10} in Indian cities >150µg/m³, 2.5-times NAAQS

Vehicular emission contribute

50-70% of urban pollution load

- *aggravated by*

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

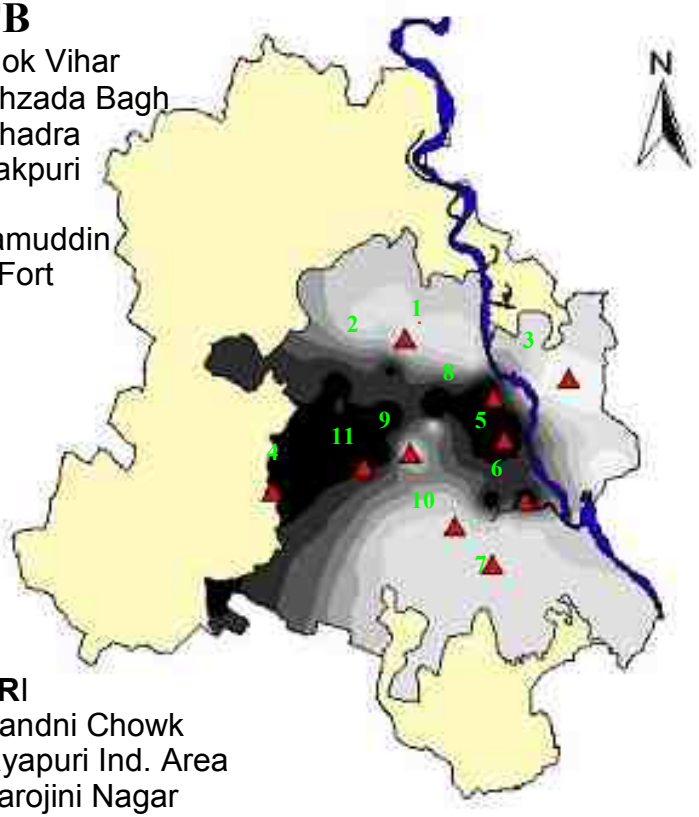
Kolkata

Annual average PM10 conc. during (2003-2005)

DELHI

CPCB

1.Ashok Vihar
2.Shahzada Bagh
3.Shahadra
4.Janakpuri
5.ITO
6.Nizamuddin
7.Siri Fort



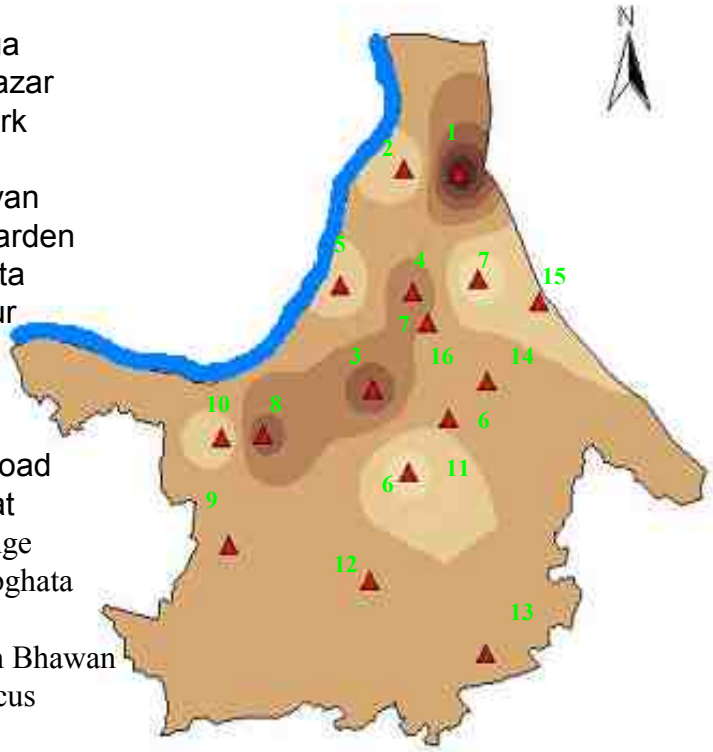
NEERI

8.Chandni Chowk
9.Mayapuri Ind. Area
10.Sarojini Nagar
11.Moti Bagh

KOLKATA

WBPCB

1. Ultadanga
2. Shyambazar
3. Minto Park
4. Moulali
5. Raj Bhavan
6. Picnic Garden
7. Beliaghata
8. Mominpur
9. Behala



10. Hyde Road
11. Gariahat
12. Tollygunge
13. Baishnabghata
14. Topsia
15. Parivesh Bhawan
16. Park Circus

PM 10

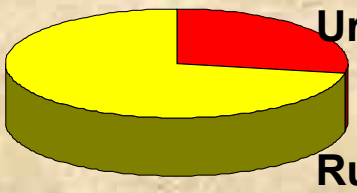
130 - 137	158 - 165
137 - 144	165 - 172
144 - 151	172 - 179
151 - 158	179 - 186

MONITORING SITES

10 0 10 20 Kilometers

PM 10

80 - 90	120 - 130
90 - 100	130 - 140
100 - 110	140 - 150
110 - 120	150 - 160



The Rural Front

Biomass fuel used by 578 million (78%) people – 23% of total & 80% domestic energy consumption




Wood (302 m ton/yr) **Crop residues** (115 m ton/yr) **Dung** (121 m ton/yr)

estimated use: 1.2-2.1 kg/capita/day

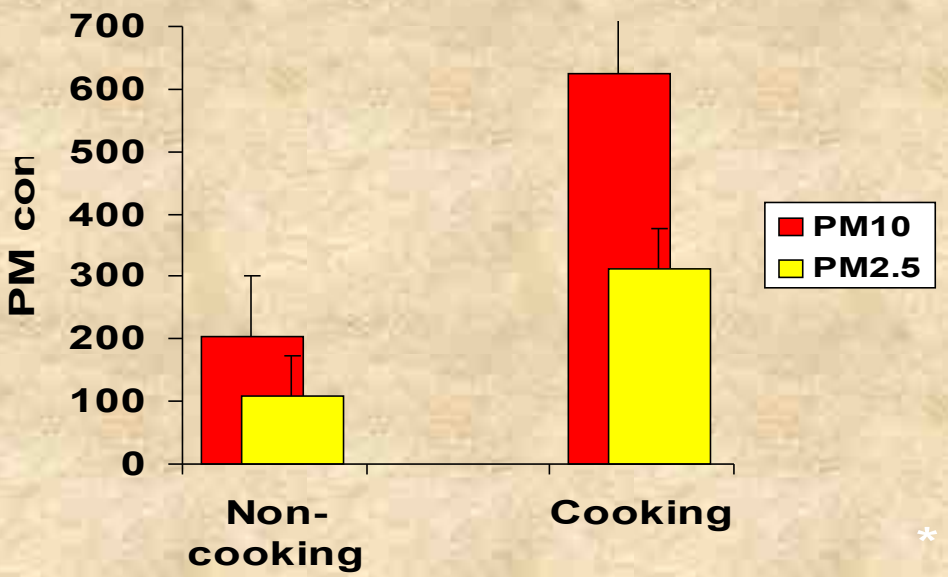
Energy efficiency & capital cost: wood > crop residue > dung

Scarcity of wood causes switch to inferior fuel

Behind the smoke

Emission conc. 10-100 times NAAQS; localized

Exposure- Very high for short duration (2-3h/dy)



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Vulnerable group - Over 400 million women & children in poor household

The Health Association

Urban

1 lakh excess deaths/yr
2 million lost life yrs. ***(WHO, 2002)***

- RSC
- Reduced PFT, COPD
- Heart disease
- Altered immunity
- Retardation of fetal growth
- Brain damage
- Cancer

Rural

6 lakh premature deaths/yr
12–20 million lost life yr &
5-7% of NBD ***(Smith, 2002)***

- Reduced lung function
- Pneumonia
- Tuberculosis
- COPD
- Blindness / cataract
- Heart disease
- Stillbirth, low birth wt.
- Cancer (oropharyngeal, cervical ?)

Air pollution is associated with similar pattern of disease in the rural and urban population but the impact is more in the biomass users due to higher exposure & greater number of people affected

Overall similar pollutant mixtures in rural & urban emission

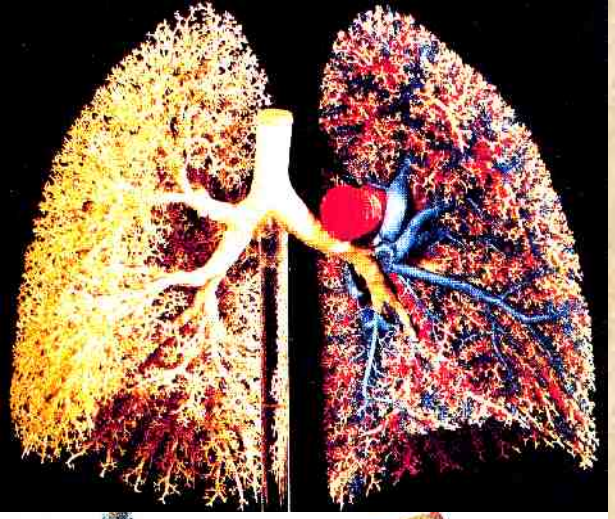
Gases, VOCs, PAH, Metals, Particulates & Secondary pollutants

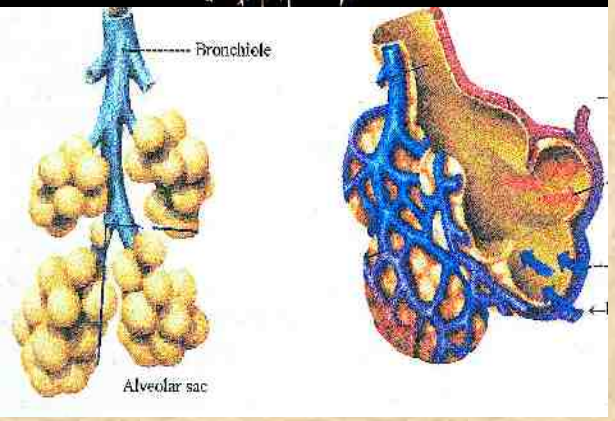
Particulate Matter- the single best indicator of potential harm

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

Particle toxicity ~ Decreasing size, solubility, presence of transition metals & free radicals

Health effects are the impact of this complex mixture rather than a particular pollutant





Road map of particles

Entry Lung → alveolus (300 million) → lymph / blood → different organs

Deposition ~

Breathing patterns, particle size & airway geometry

Daily loading*

Assuming Annual PM_{10} mean = 162 µg/m³

404 µg of particles are deposited in the lung each day {(Conc. x Vol. inhaled per hr. x time) x deposition efficiency}

Particle clearance

- Depends on its size & solubility
- Half time of clearance by cells – 300 days - yrs
- Particle retention time- determinant of adverse health effects

**(Calculated by the LUDEP computer programme of IRCP66 lung model)*



Response to air pollution across population differs due to

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

Our Research Goals

Research has been directed to pin down the impact to target interventions effectively.

- To prepare a **database** on air pollution related respiratory & systemic alterations
- To Understand the **mechanism** of air pollutant induced health effects
- To develop **simple, cost effective biomarkers** for biomonitoring air pollution effects
- To establish the

Study Approach

- **Target Population:**
  - *Urban residents of Kolkata & Delhi of different age, sex, occupation & socio-economic status (n= 8,200)*
  - *Rural women exposed to biomass fuel emission (n=850)*
  - *Children urban & rural (n=42,600)*
- **Questionnaires**
- **Clinical examination**
- **Lung function test**
- **Sampling & lab investigation:**
  - *Sputum - cytology*
  - *Buccal mucosa - genotoxicity*
  - *Blood – hematology, immunology biochemistry,enzymology*
  - *Urine – t,t-MA*
- **Statistical Analysis:**
  - *Epi Info6, SYSTAT 9.0 Software system*

Children - the 'soft' target

Children are most vulnerable group

- *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

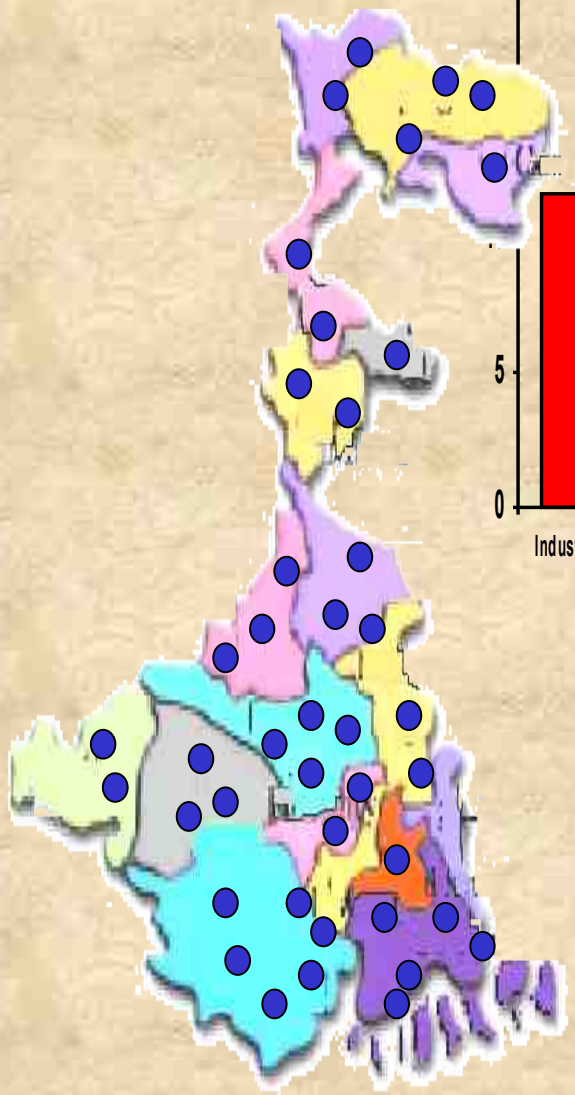
Rural & suburban areas of West Bengal – 31,000

Kolkata -3,800

Delhi – 11,628 ***Age groups - 8-16 years***

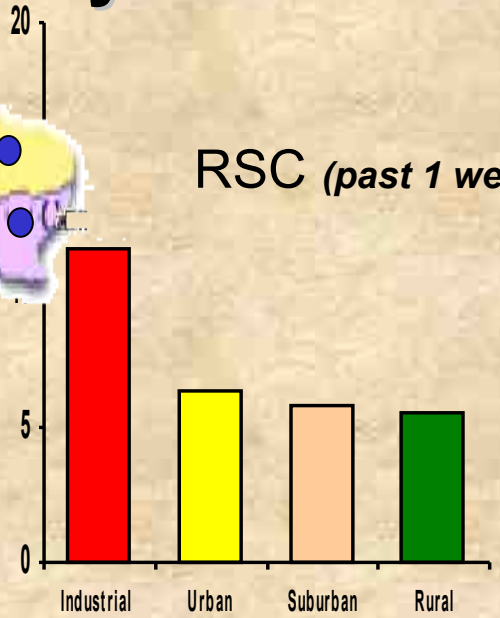
Study period – 2000 - 2006

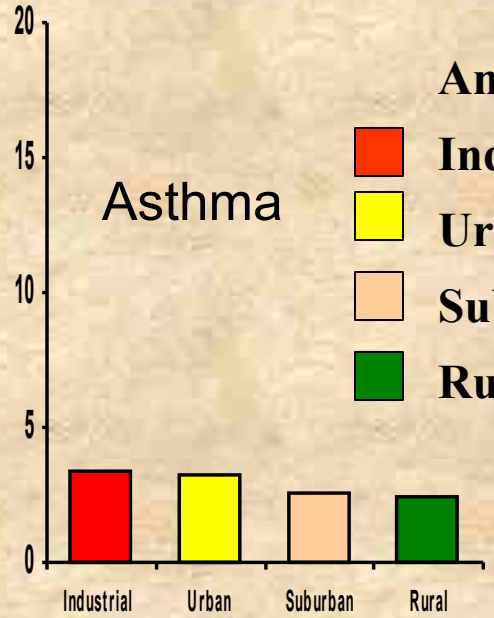
Respiratory health in children of West Bengal

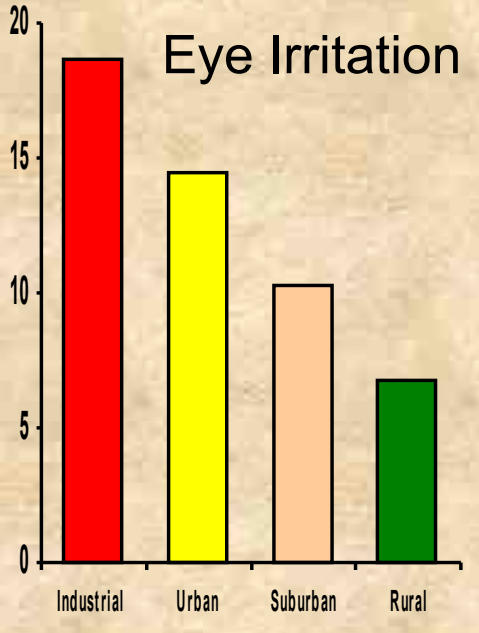


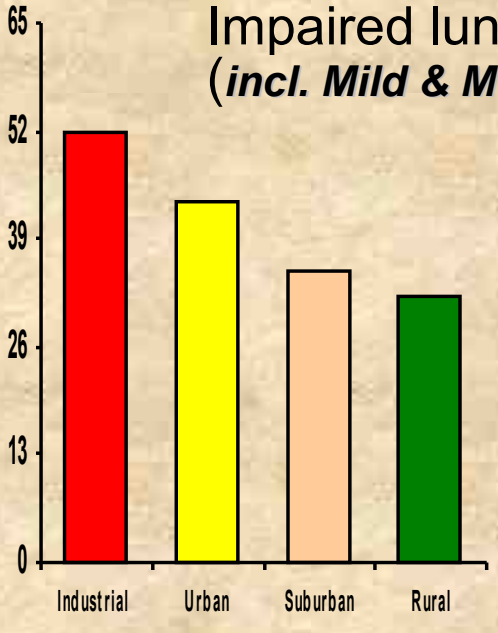
Sampling Sites

(n=31,000; Age 6-17 yrs)









PM10 concentration and respiratory symptoms in children of Delhi

CPCB

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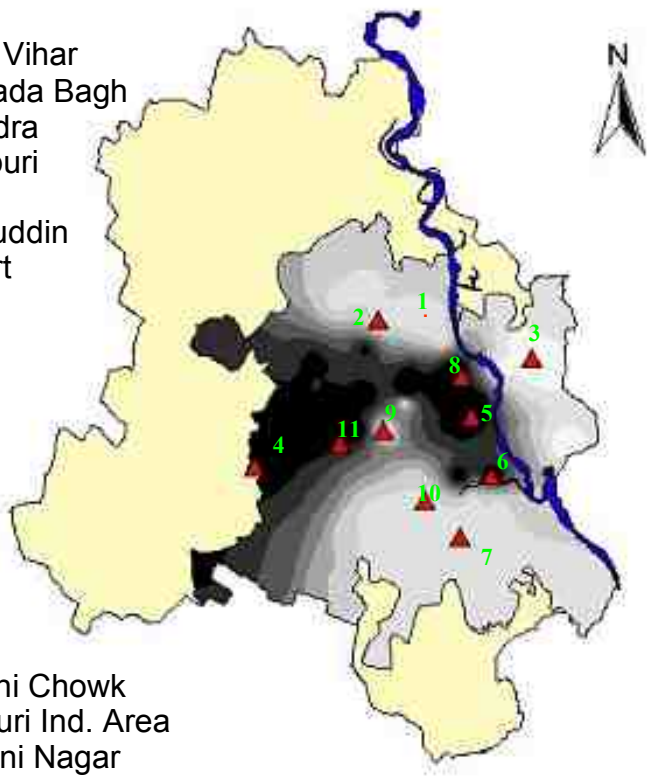

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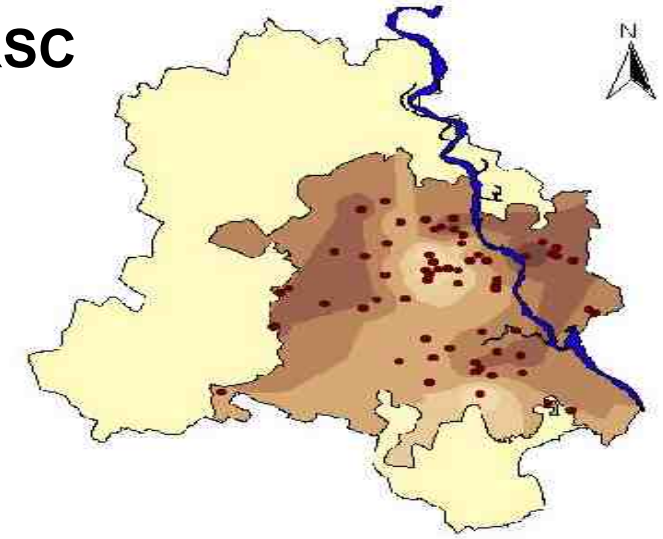
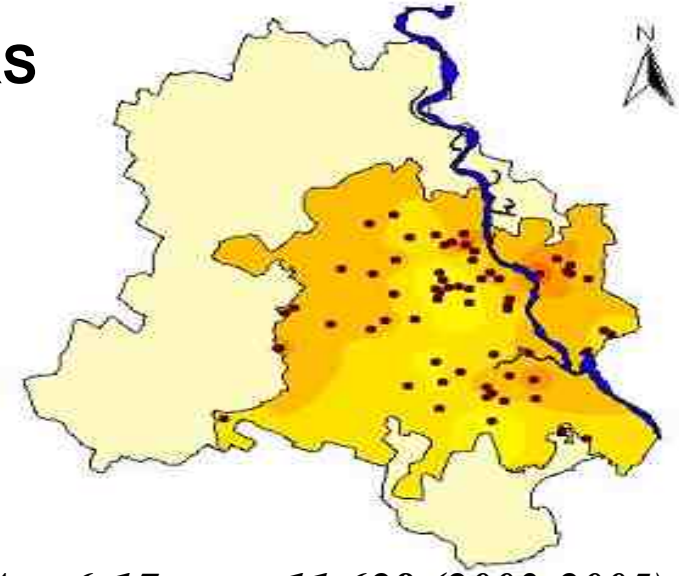
RSC



LRS



PM 10

130 - 137	158 - 165
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MONITORING SITES
CAMP SITES

RSC % *(Past 1week)*

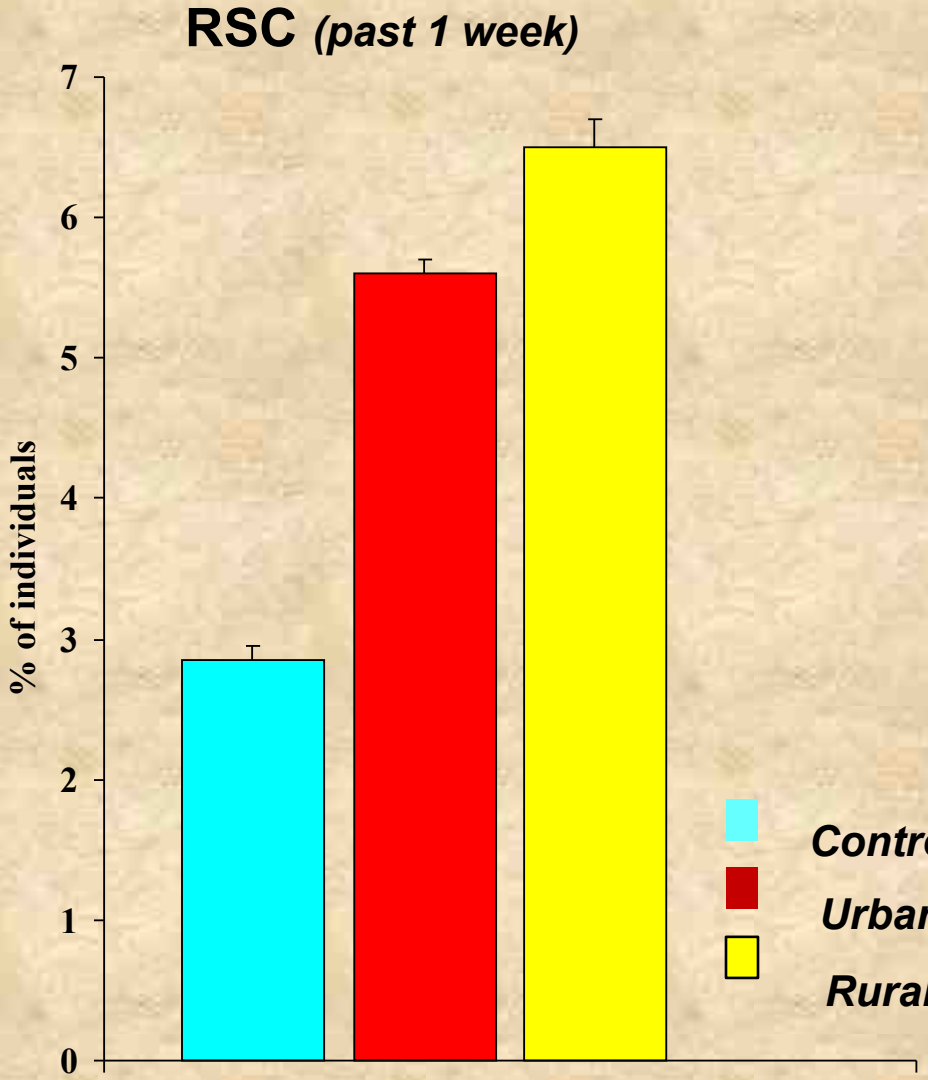
1-2	5-6
2-3	6-7
3-4	7-8
4-5	8-9

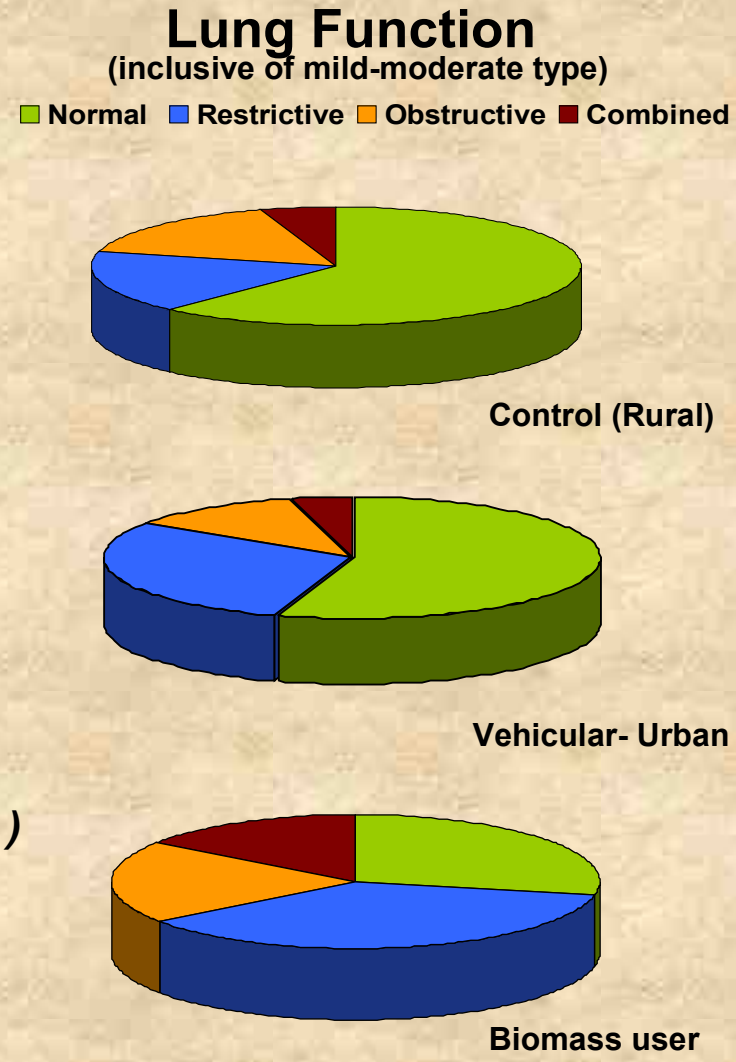
LRS % *(Past 1week)*

1-2	5-6
2-3	6-7
3-4	7-8
4-5	8-9

Age 6-17 yrs n-11,628 (2003-2005)

Pulmonary responses to vehicular and biomass emission





Urban (Kolkata & Delhi) – Vehicular emission exposed (Traffic police, hawker, driver)

Rural (West Bengal) – Biomass emission exposed women

PM10 concentration and pulmonary responses in adults of Delhi

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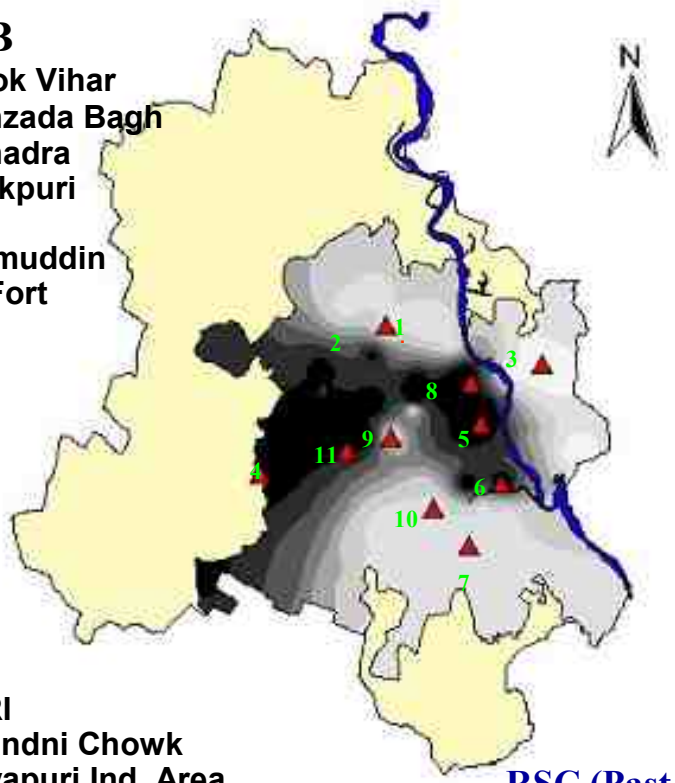

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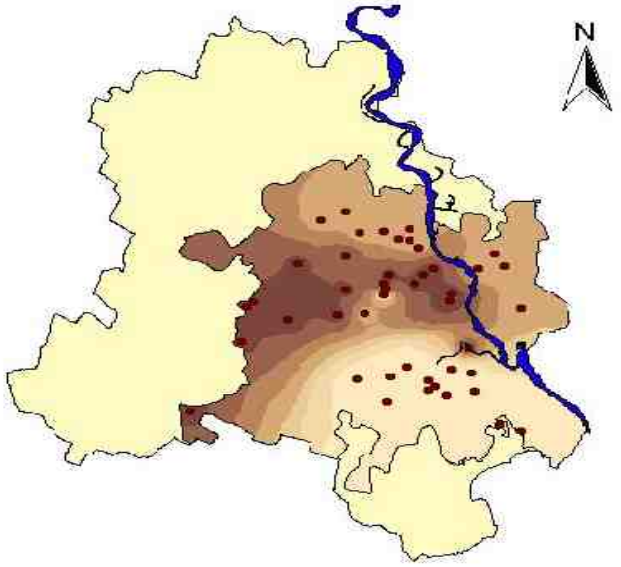
▲ MONITORING SITES
● CAMP SITES

n-6005 (2003-2005)

RSC



RSC (Past 1 week)

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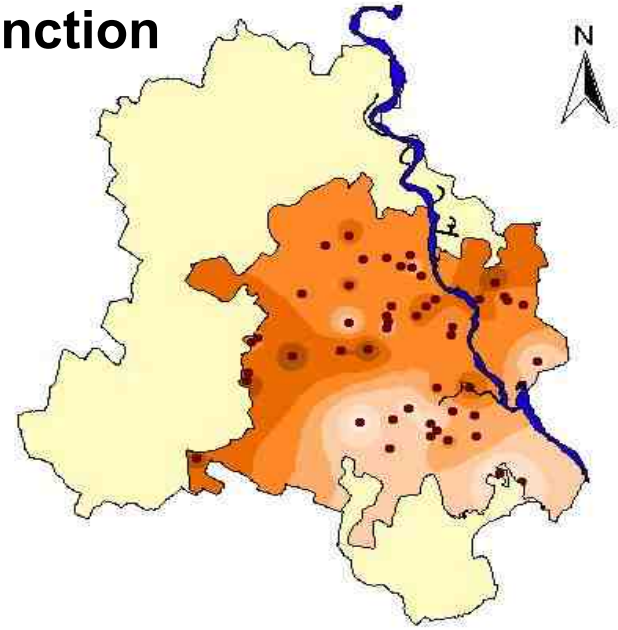
4-5	8-9

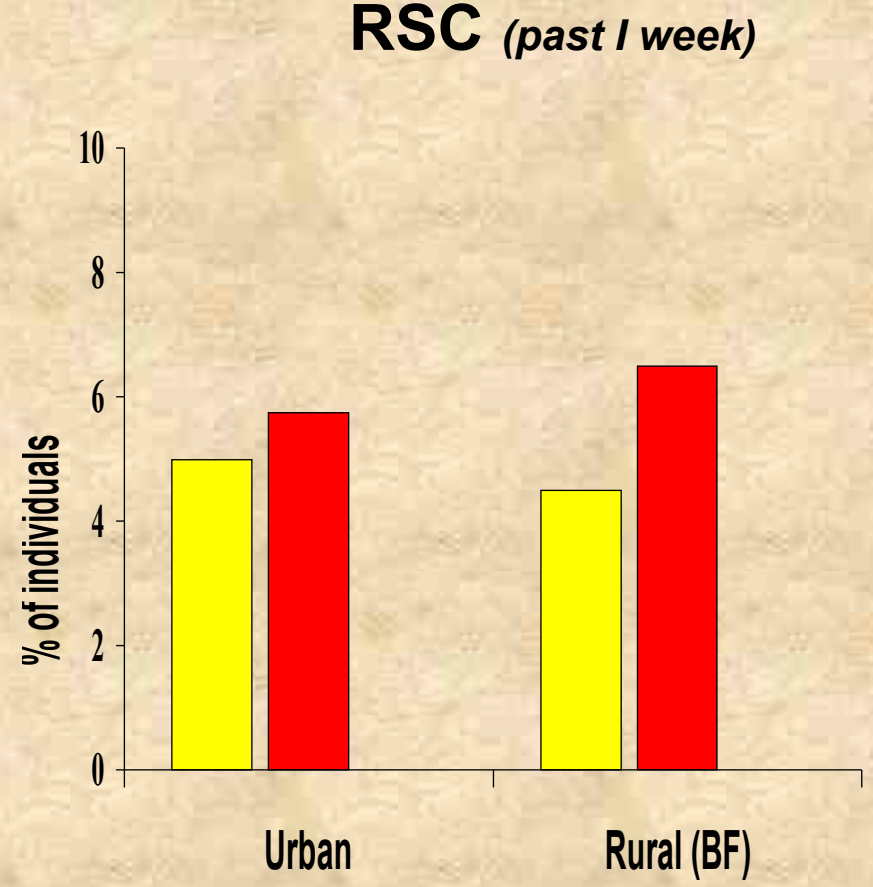
Lung Function



Lung Function Impairment (incl. Mild – Moderate type)

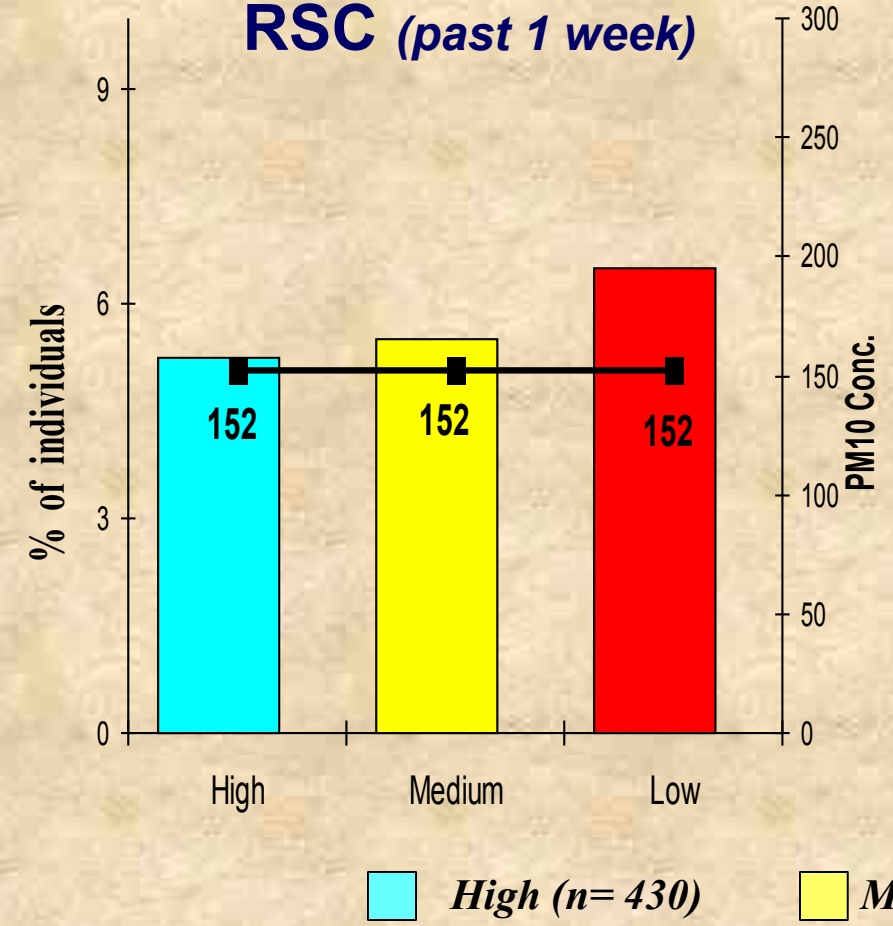
20 – 26	44 – 50
26 – 32	50 – 56
32 – 38	56 – 62
38 - 44	62 - 66

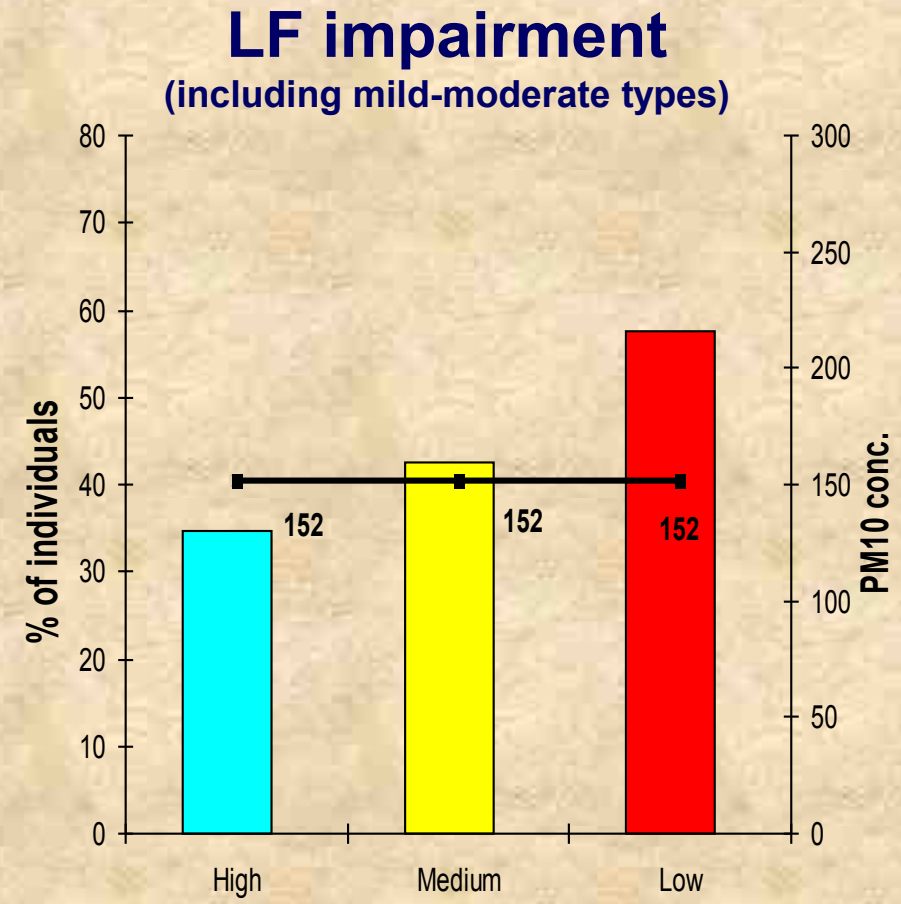
Lung responses - the gender bias



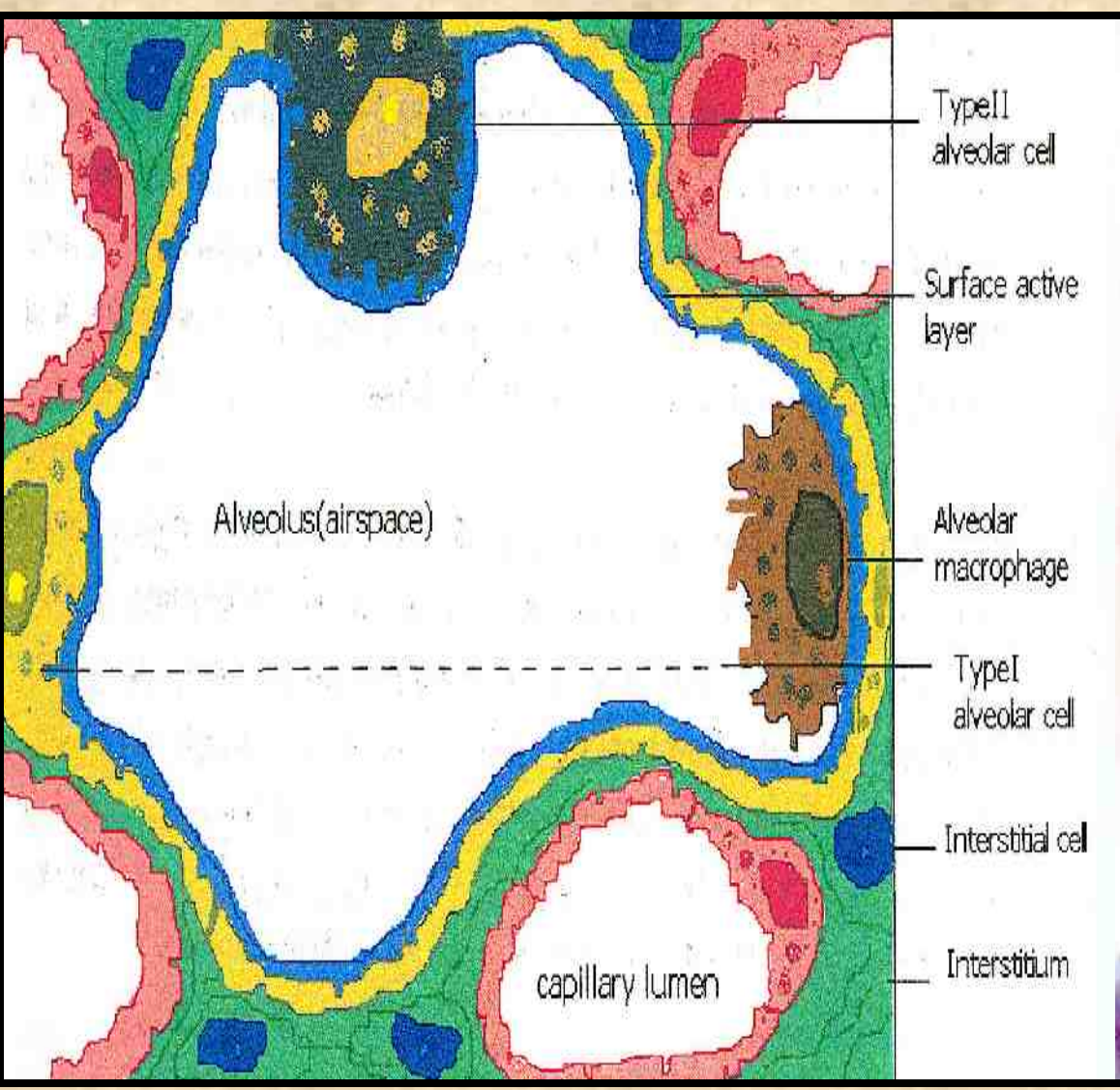
Urban male (n = 2900), female (n =3006) Rural male (n = 220) female (n = 450)

Lung responses
socio-economic status (Urban)





High (n= 430) *Medium (n=445)* *Low (n= 495)*



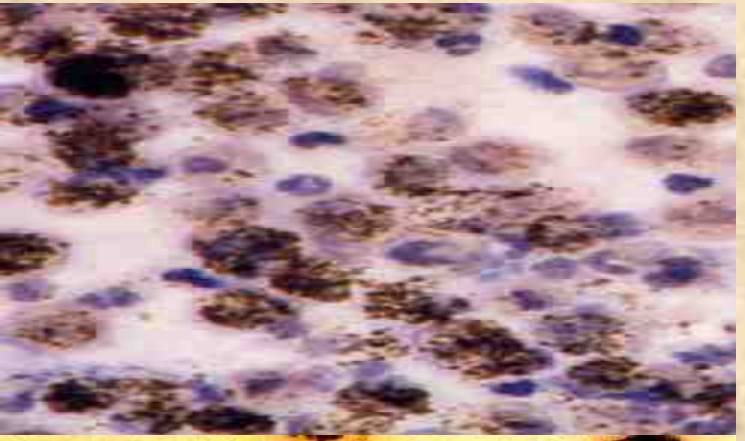
Inside the alveolus **Reflection in sputum**

Alveolar macrophage - the big eater

- a biomarker of pollution exposure

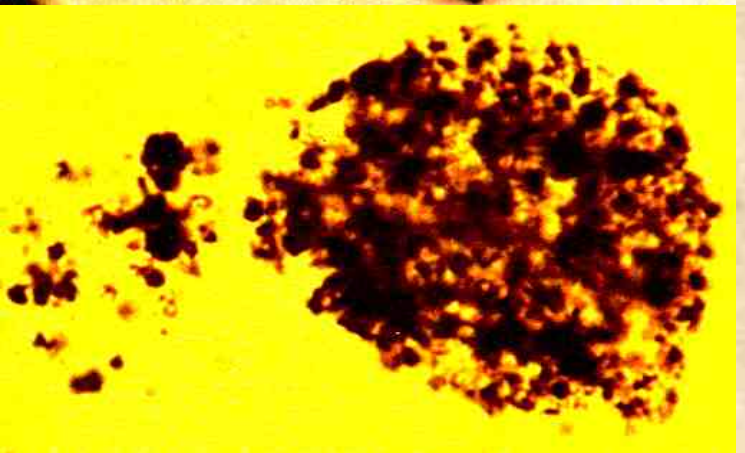
- AM is the first line of defense in the lung & interact directly with toxic particles and gases.
- Phagocytosis, migration & secretion of AM is pivotal in pathogenesis of lung diseases.
- AM response varies with the level of pollutants *(Lahiri et al., 2000)*
- Easily accessible by noninvasive procedure.

Alveolar Macrophage (AM) Response

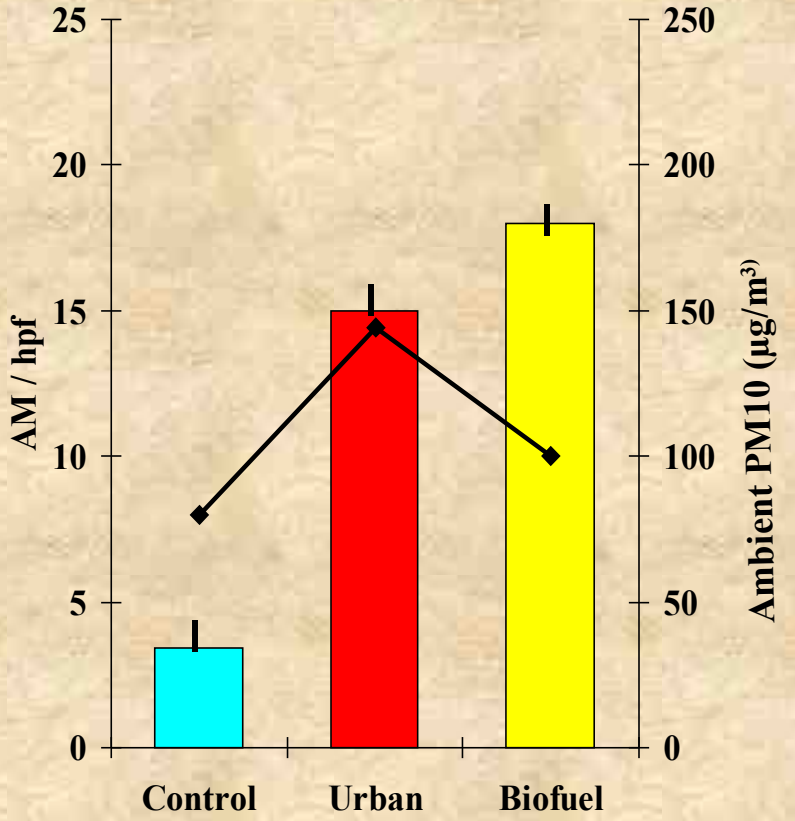


Increase in number & enlargement

Particle overload

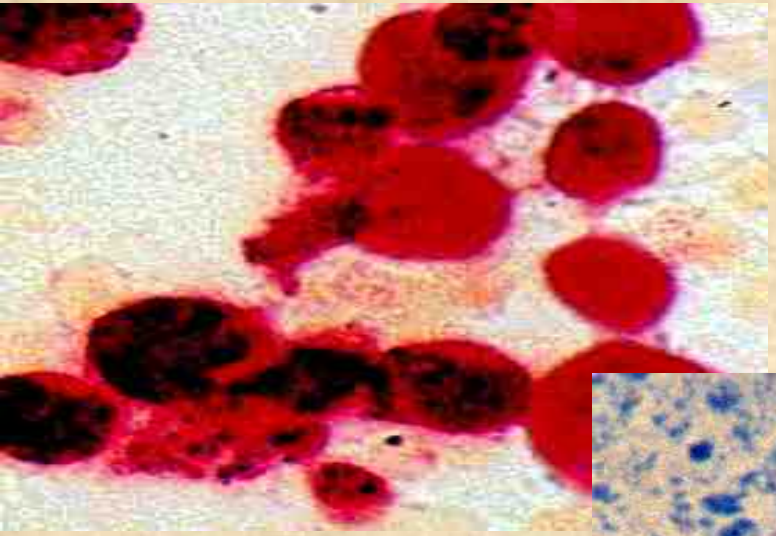


Disintegration & release of particles *initiation of lung injury*

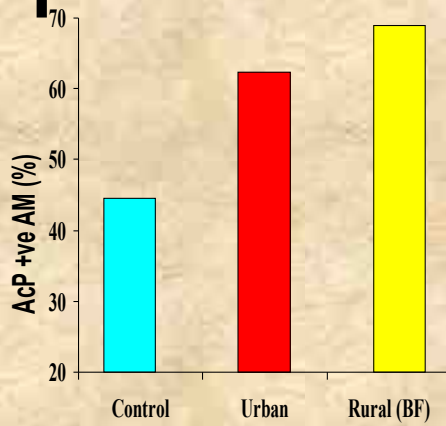


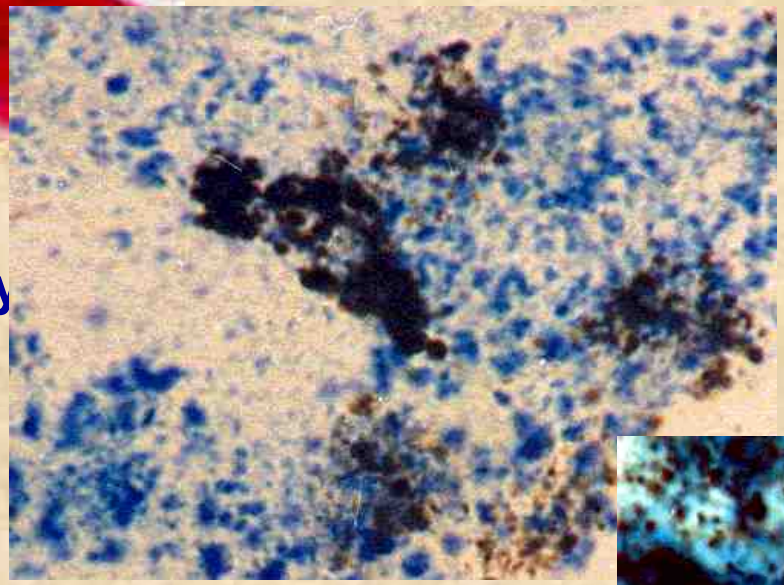
n= Control 300,
Urban (Kolkata & Delhi) 1714,
Rural (BF) 850

Functional Alteration of AM - 1

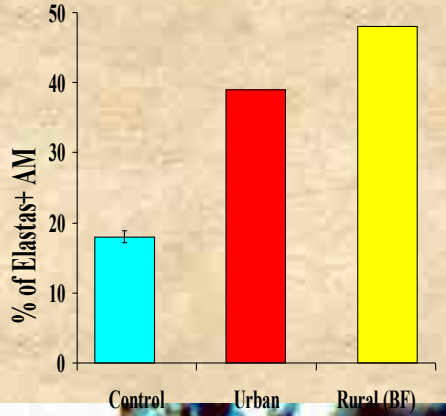


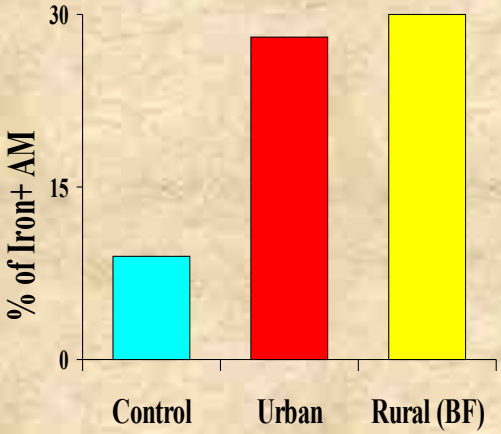
High acid phosphatase activity – ***activation of AM***



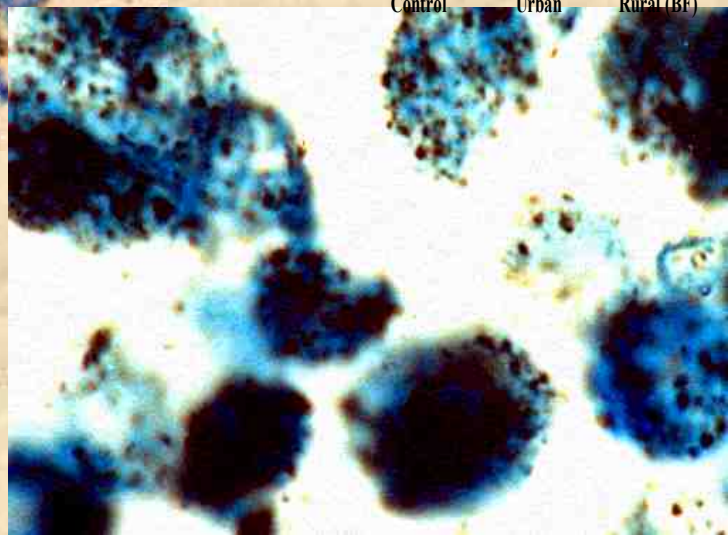


Release of elastase by AM– ***degradation of elastin -emphysema***



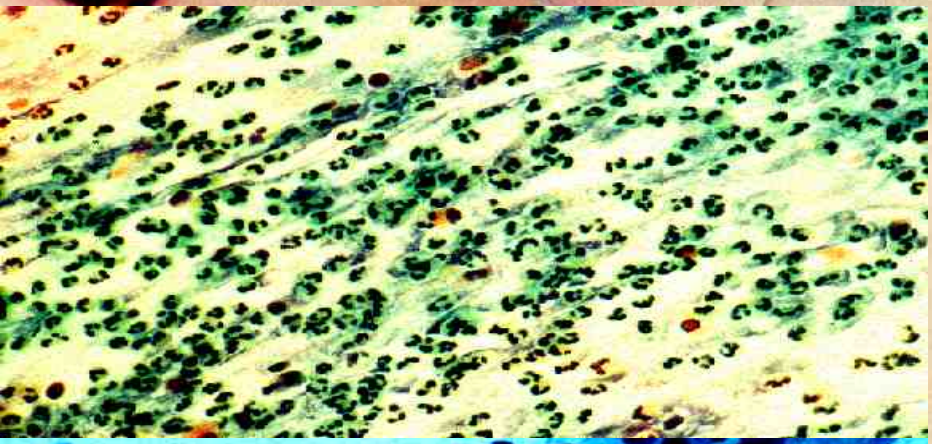


Heavy Iron deposition in AM – ***covert pulmonary hemorrhage?***

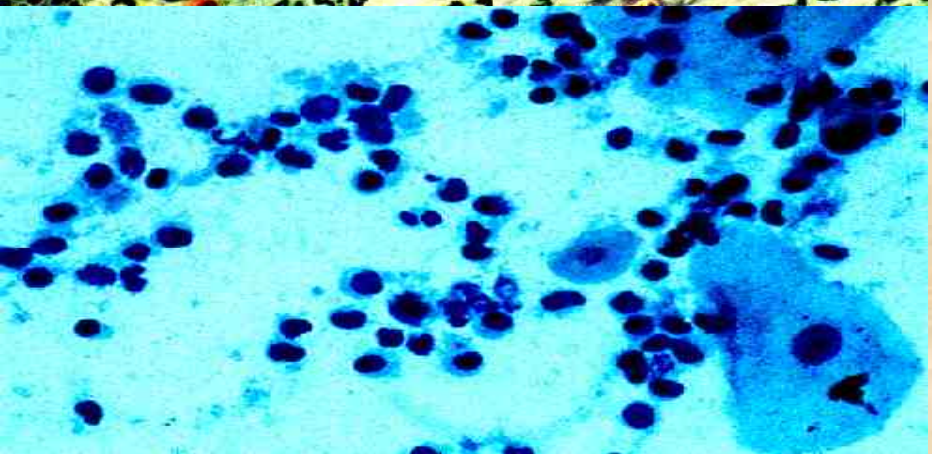


Sputum Cytology Alterations

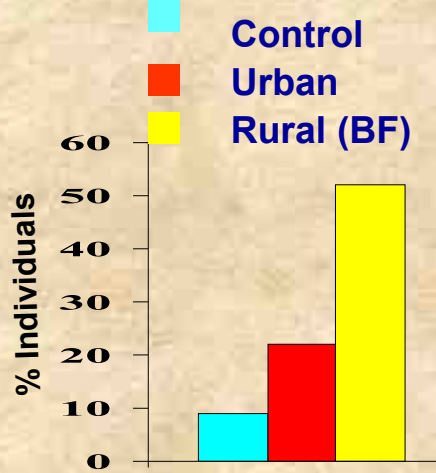
Eosinophilia
allergy
bronchitis
asthma

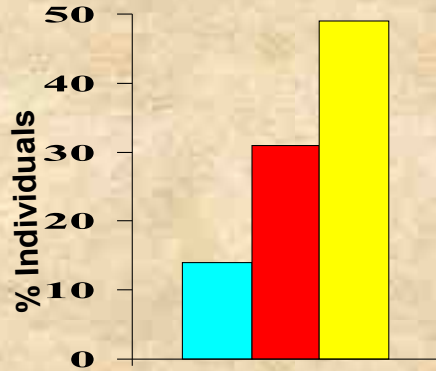


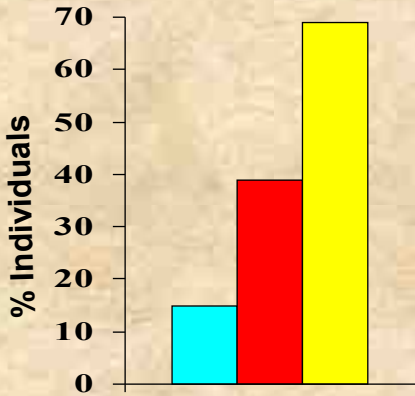
Neutrophilia
airway
obstruction &
Inflammation



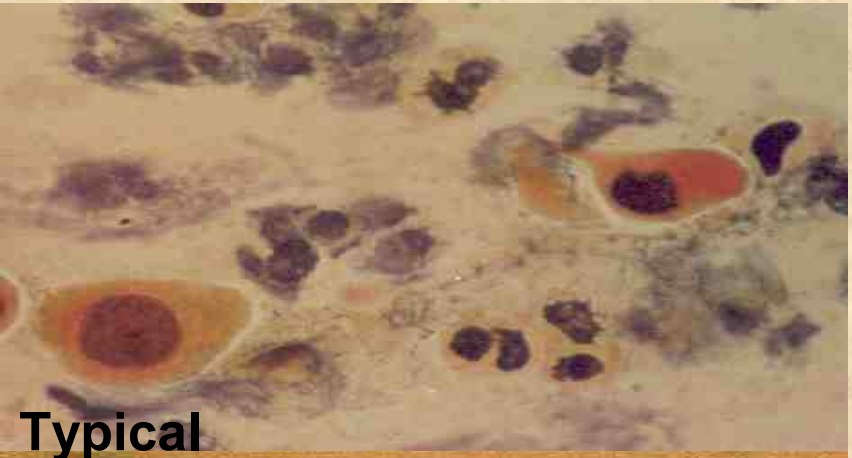
Lymphocytosis
viral infection







The Carcinogenic Assault



Typical

Atypical

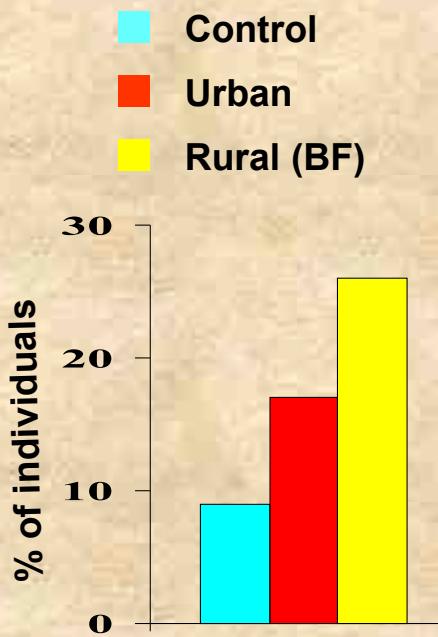
Koilocyte

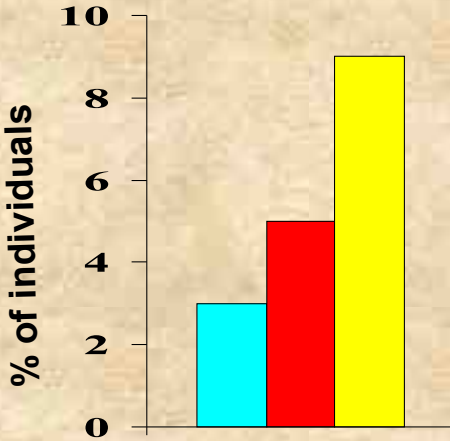
Metaplasia with atypia

carcinogen

Insult & faulty repair-

risk for COPD & lung cancer



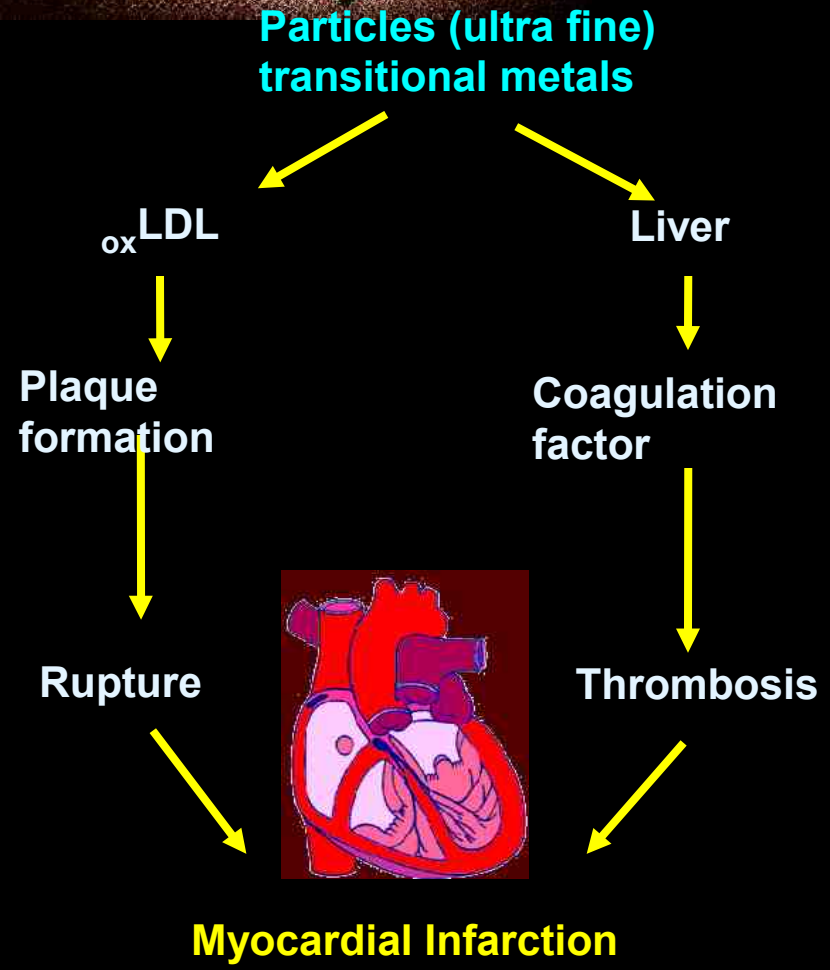


Koilocyte (with

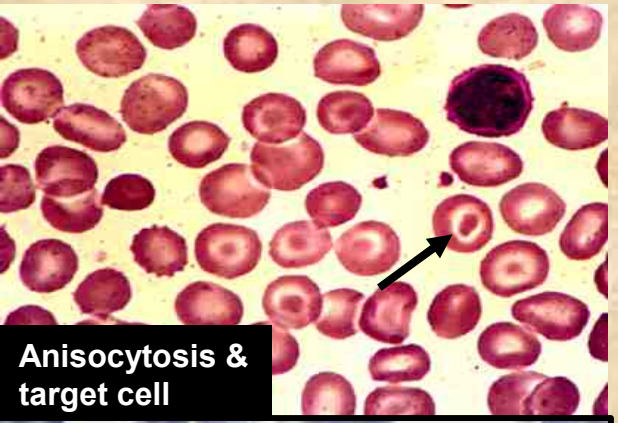
Systemic effects

Fine particulates can reach deep into blood stream & cause

- hematological alterations
- Inflammatory reactions
- immune alteration
- metabolic disorders
- Cardio vascular effects



The common blood response



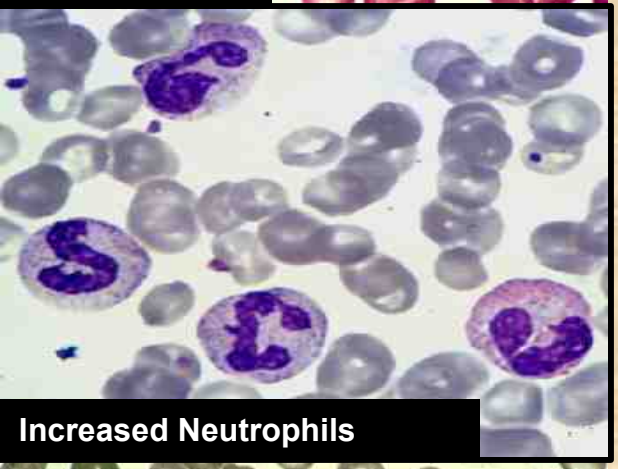
Anisocytosis & target cell

Suppressive effect on Hb & RBC values

Elevated no. of target cells

Anemia

Altered liver function



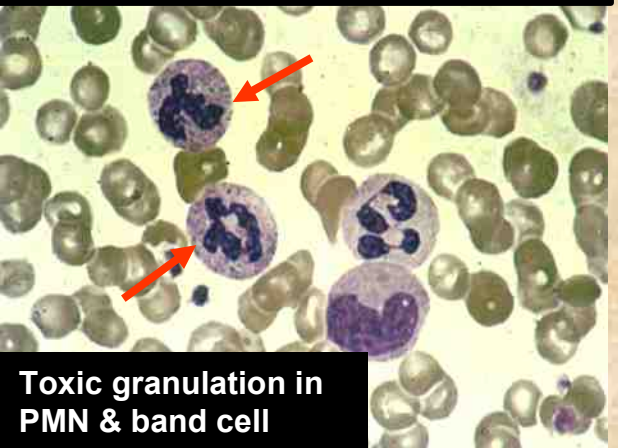
Increased Neutrophils

Increase in WBC(N & E)

Increased no. of immature neutrophils

Toxic granulation

Inflammatory response

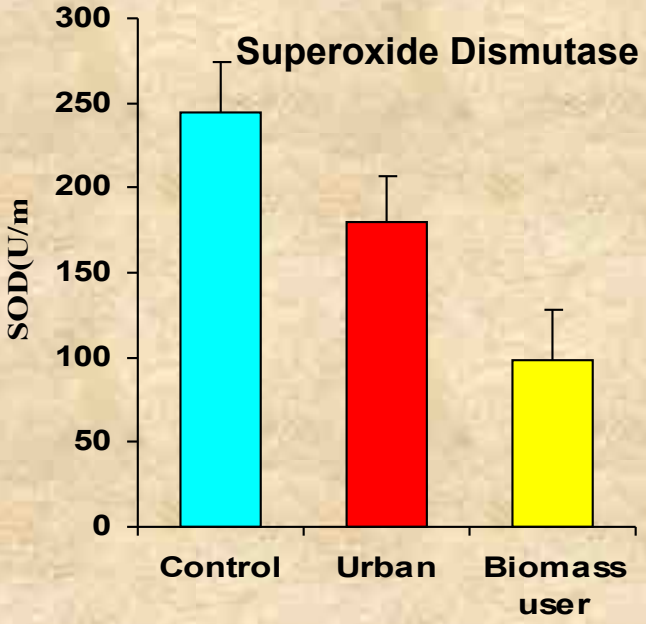


Toxic granulation in PMN & band cell

Increase in platelet count & p–selectin expression

Coagulation defect

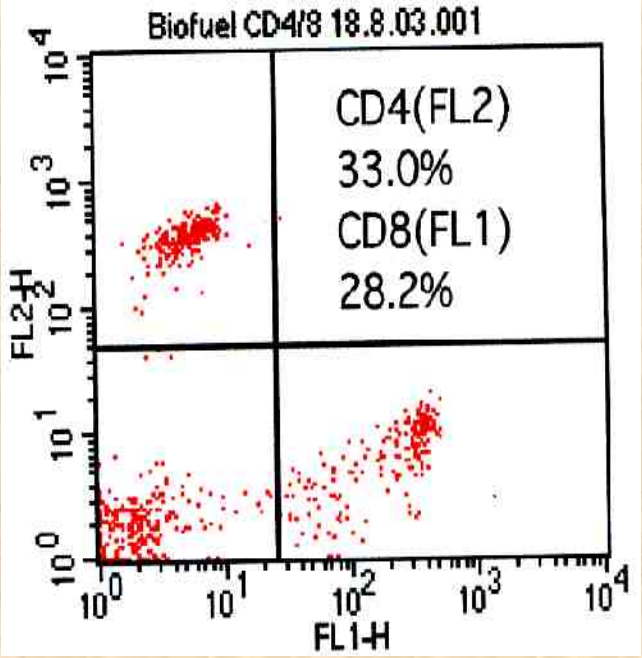
Increased oxidative stress through free radicals-oxidant–antioxidant imbalance



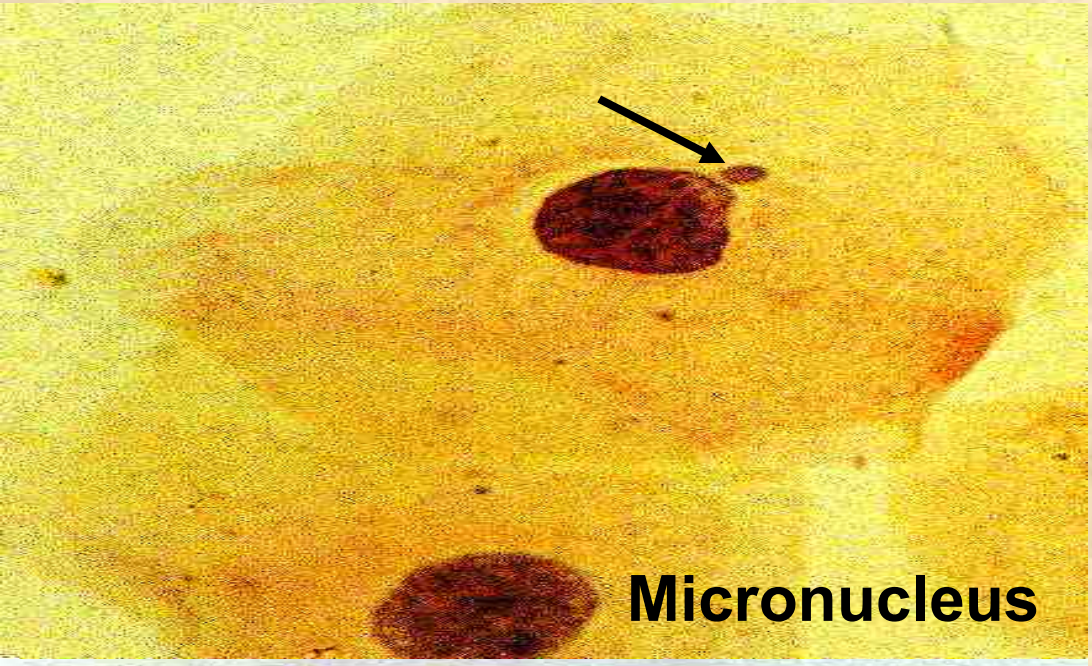
Alteration in immune status- increased susceptibility to disease

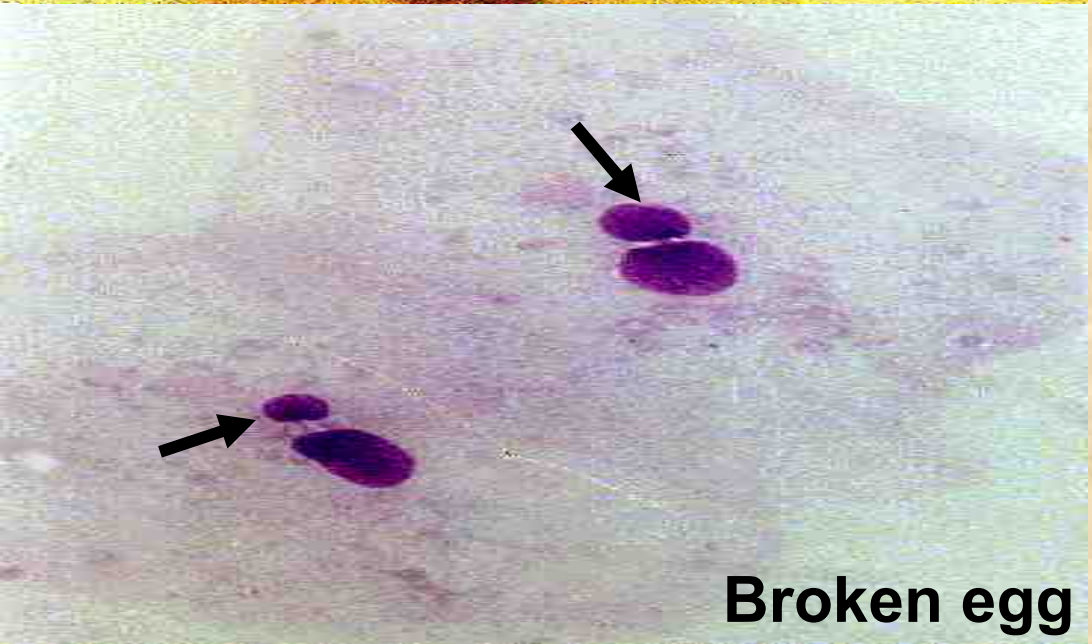
- ↓ suppression of CD4+ Th cells
- ↑ increase in CD 8+ Tc

  CD4:CD8 ratio 2:1 → 1:1
- ↓ decrease in CD19+ B cells
- ↑ increase in CD16+56+ NK cells

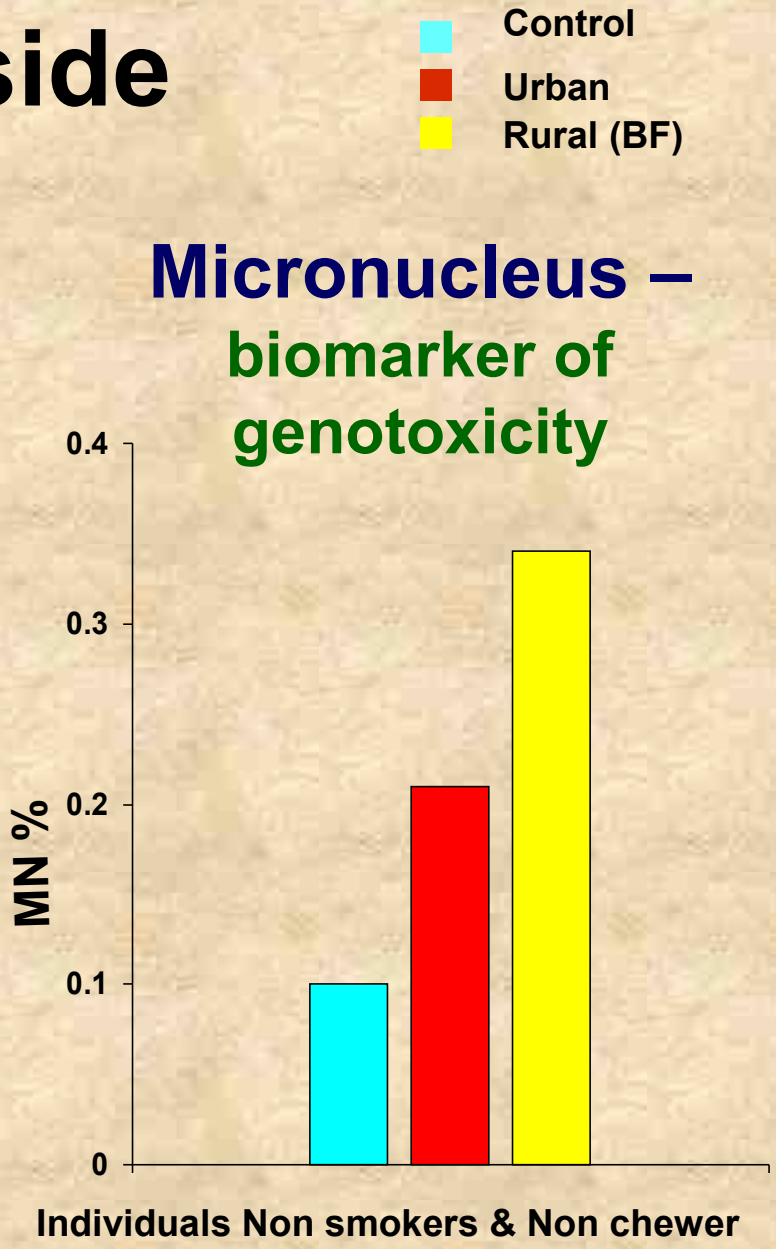


The hit inside





Micronucleus – biomarker of genotoxicity



n= Control 300, Urban (Kolkata & Delhi) 1714, Rural (BF) 850

Findings Summarised

Both vehicular & biomass emission cause marked increase in

- **Respiratory Symptoms**
- **Lung Function Impairment**
- **Numerical, Structural & Functional alteration of AM**
- **Systemic alterations**
  - **Genotoxicity**
  - **Hematological & Metabolic alterations**
  - **Immune alterations (vulnerable to infections)**

Effects more marked in biomass exposure

Some of these alterations are reversible & proper intervention measures can prevent the development of irreversible diseases like COPD & cancer

Research needs

- Epidemiological studies on the link between air pollution and cancer, cardiovascular disease, tuberculosis, adverse pregnancy outcomes & mental health problems
- Identification of susceptible groups through biomarkers
- Medical intervention strategies
- Emphasis on research for less polluting technologies to reduce outdoor & indoor air pollution

We advocate…

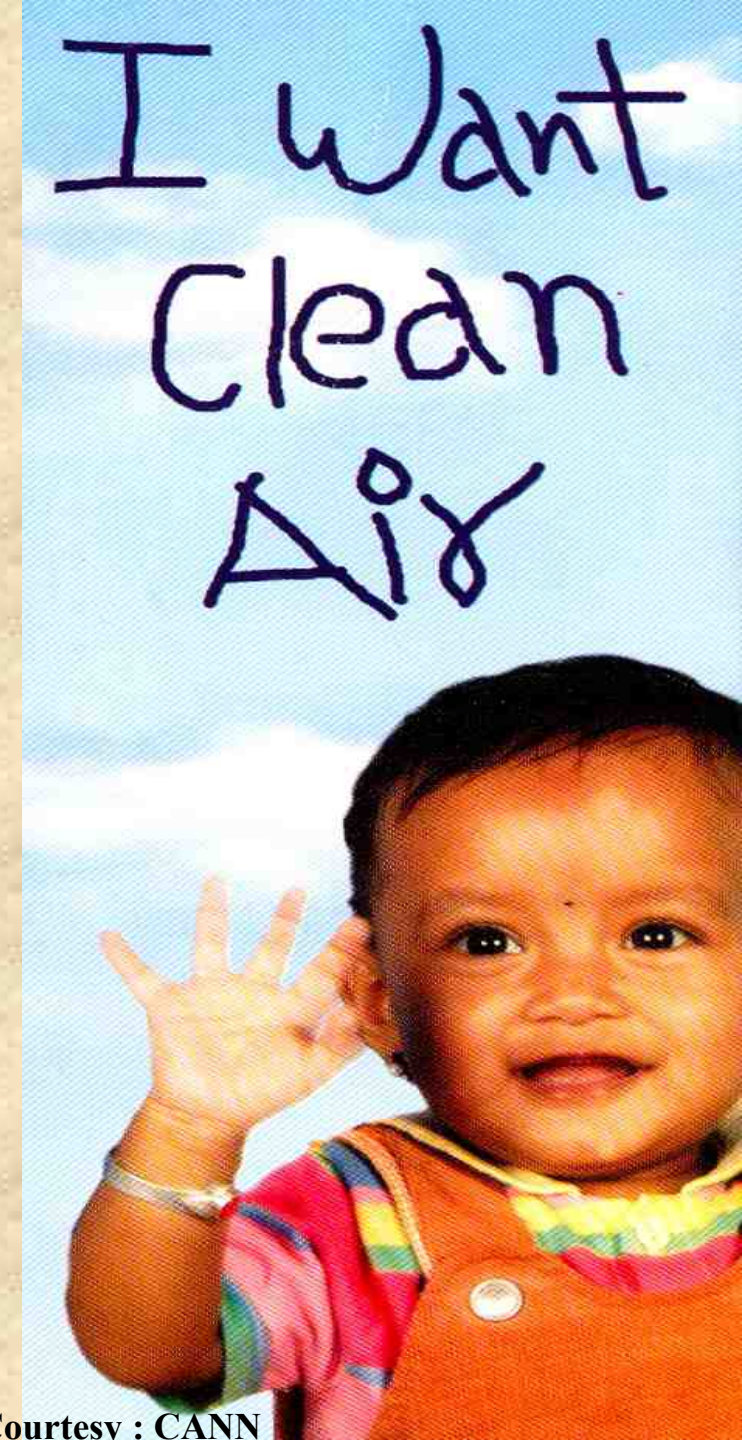
Drastic reduction of vehicular pollution by

- lowering emissions
- changing fuel composition
- cleaner energy options &
- alternative fuels (CNG)

Immediate interventions for reducing indoor air pollution exposure by

- improved cooking devices
- improved housing & ventilation / chimneys
- cleaner energy options *e.g., biogas*
- awareness campaigns on health & behavioral changes

Appropriate & immediate measures need to be taken by all concerned to abate the alarmingly high pollution exposure in urban & rural India to protect our future generation



Courtesy : CANN