
AIR
POLLUTION
CHIRAG BHIMANI

WHAT IS AIR POLLUTION??

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- **Air pollution** is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or cause damage to the natural environment or built environment, into the atmosphere.

WHAT IS AIR POLLUTANT??

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"**air pollutant**" means any solid, liquid or gaseous substance (including noise) present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment;

(As defined in Air Act, 1981 Sec. 2 (a))

TYPES OF AIR POLLUTION

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- There are several classifications of air pollution
- One is Indoor Air Pollution and Out Door Air Pollution. These include smog, acid rain etc.
- Another is the release of particles into the air and the release of gases
- Then there is classification due to source like natural or due to anthropogenic activities
- Primary air pollution or secondary air pollution

OUTDOOR AIR POLLUTION : SMOG

Smog is a type of large scale outdoor pollution. It is caused by chemical reactions between pollutants derived from different sources.

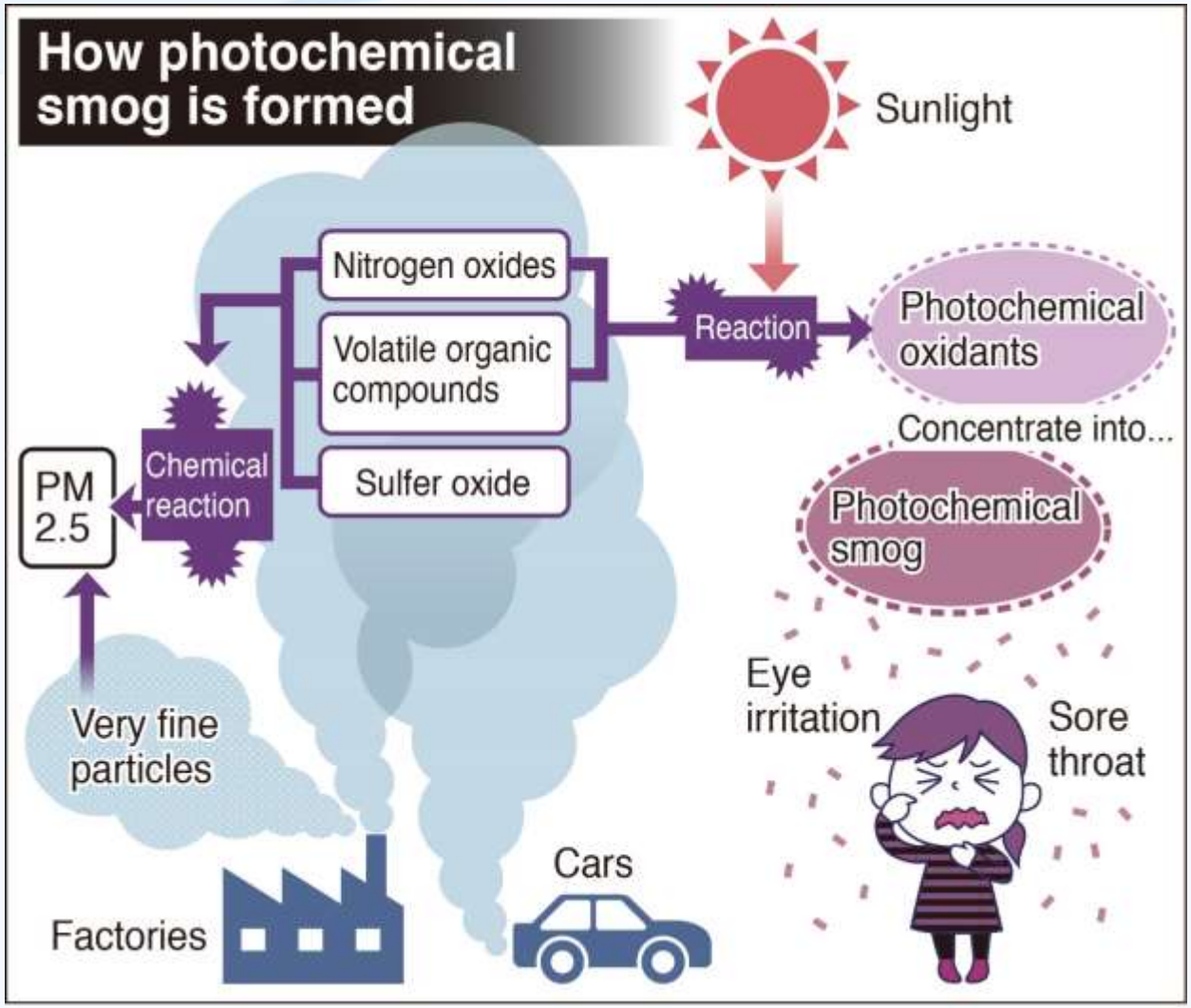
OUTDOOR AIR POLLUTION : SMOG

What is smog?

- Air pollution that hangs over urban areas and reduces visibility.
- Car exhaust reacts with air & sunlight to make ground level ozone.
- Ozone reacts with more car exhaust to make smog.
- Smog in Beijing, China (~2min)

CARBON DIOXIDE RECYCLE WITH ETHANOL FUEL

OUTDOOR AIR POLLUTION : SMOG

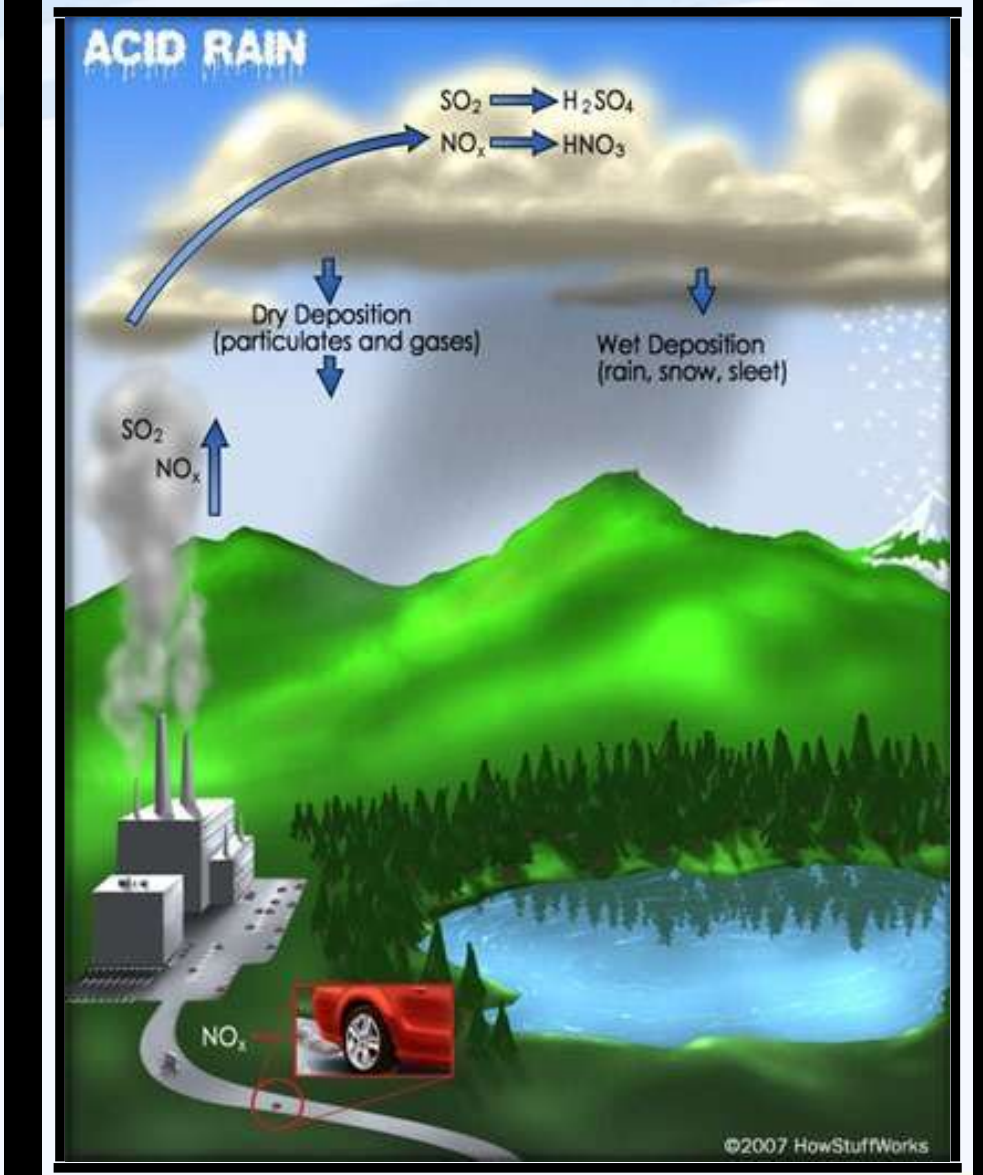


ACID RAIN

ACID RAIN

It is caused when a pollutant combines with droplets of water in the air.

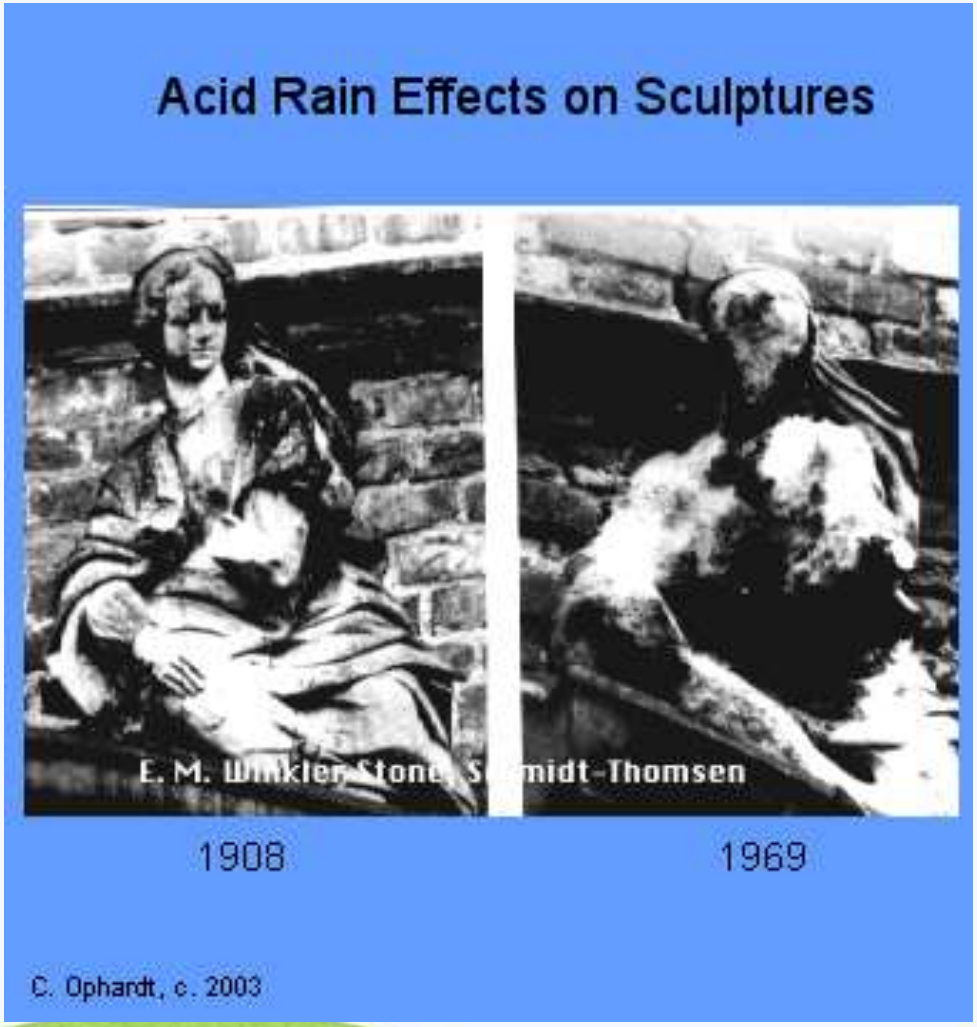
The effects of acid rain on the environment can be serious



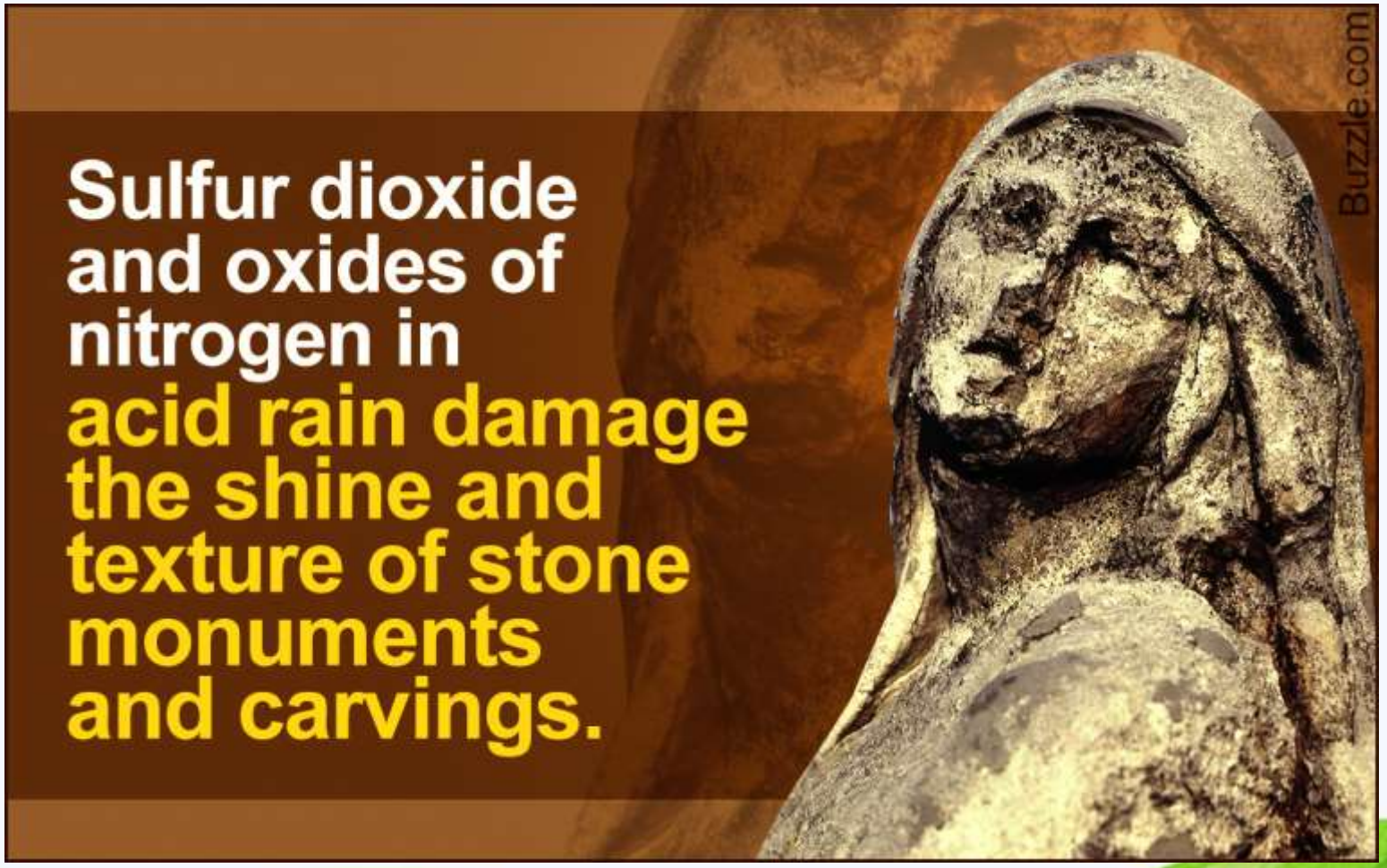
EFFECTS OF ACID RAIN

- Acid rain causes acidification of lakes and streams .
- It contributes to the damage of trees and many sensitive forest soils.
- It accelerates the decay of building materials and paints, including irreplaceable buildings, statues, and sculptures that are part of our nation's cultural heritage.

EFFECTS OF ACID RAIN



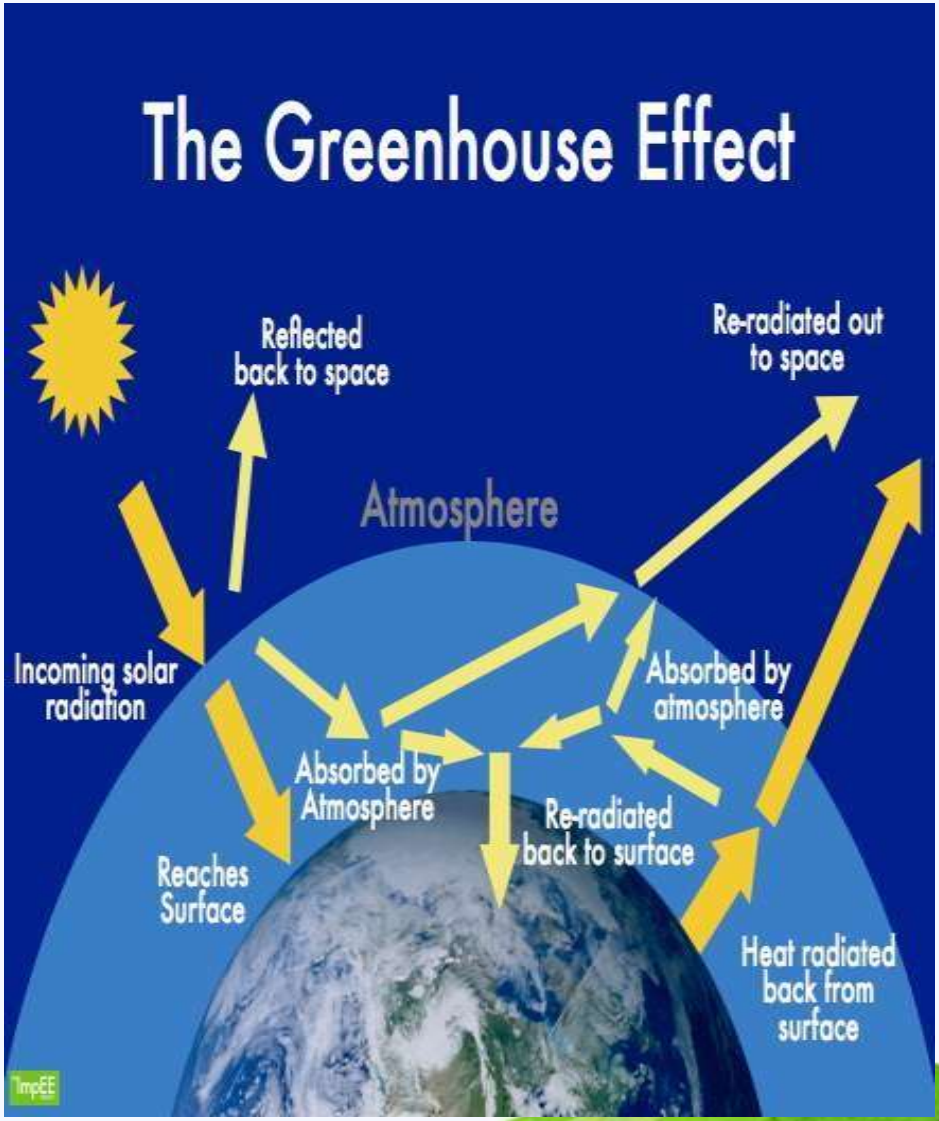
EFFECTS OF ACID RAIN



GREEN HOUSE EFFECT

GREEN HOUSE EFFECT

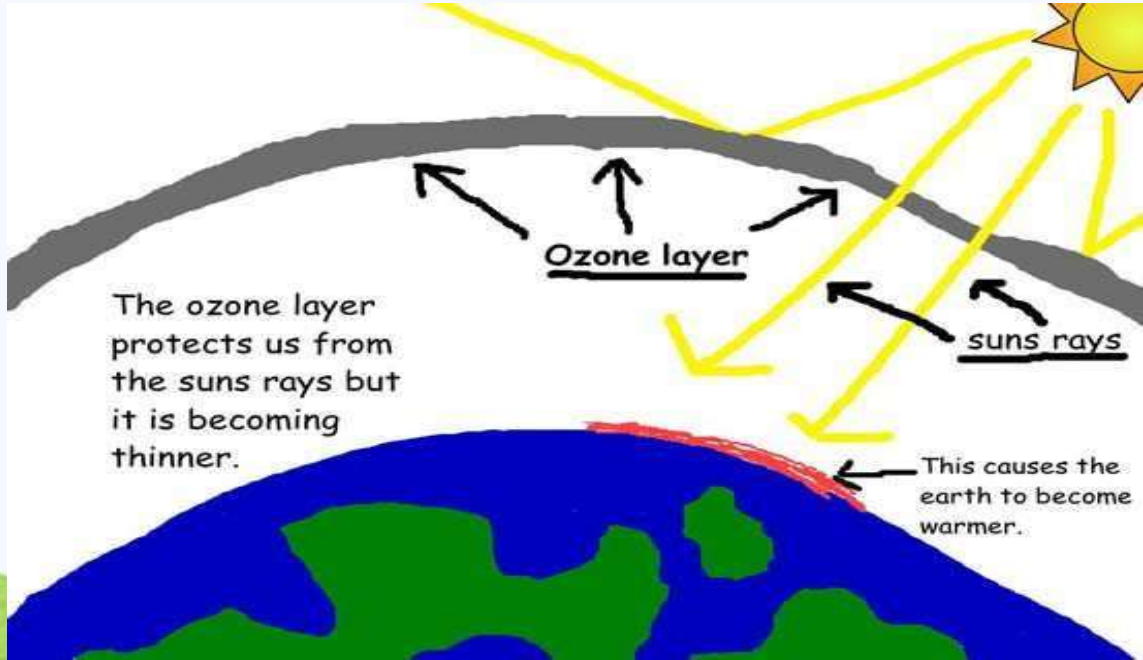
- It generally comes from the build up of carbon dioxide gas in the atmosphere.
- Carbon dioxide is produced when fuels are burnt.
- In this type of pollution sun rays go to the atmosphere and they are trapped by green houses gases. So the temperature on the earth rises.



HOLE IN THE OZONE LAYER

HOLE IN THE OZONE LAYER

- ✓ It is another result of air pollution.
- ✓ Chemicals released by our activities affect the stratosphere.
- ✓ Release of CFC from heating, aerosol cans, refrigerator equipments remove some of the ozone, causing “HOLES” .



INDOOR AIR POLLUTION

- It is more dangerous than the outdoor pollution, because we do everything in enclosed environments where air circulation may be restricted.

SOURCES OF INDOOR AIR POLLUTION

- Tobacco Smoke
- Cooking And Heating Appliances
- Vapors From Building Materials

CAUSES OF AIR POLLUTION

- *Dust raised on the ground during dust storms*
- *Stone dust raised by crushing of stones in quarries*
- *Smoke emitted by vehicles.*
- *Industrial activities*
- *Smoke from forest fires.*
- *Volcanic eruptions*



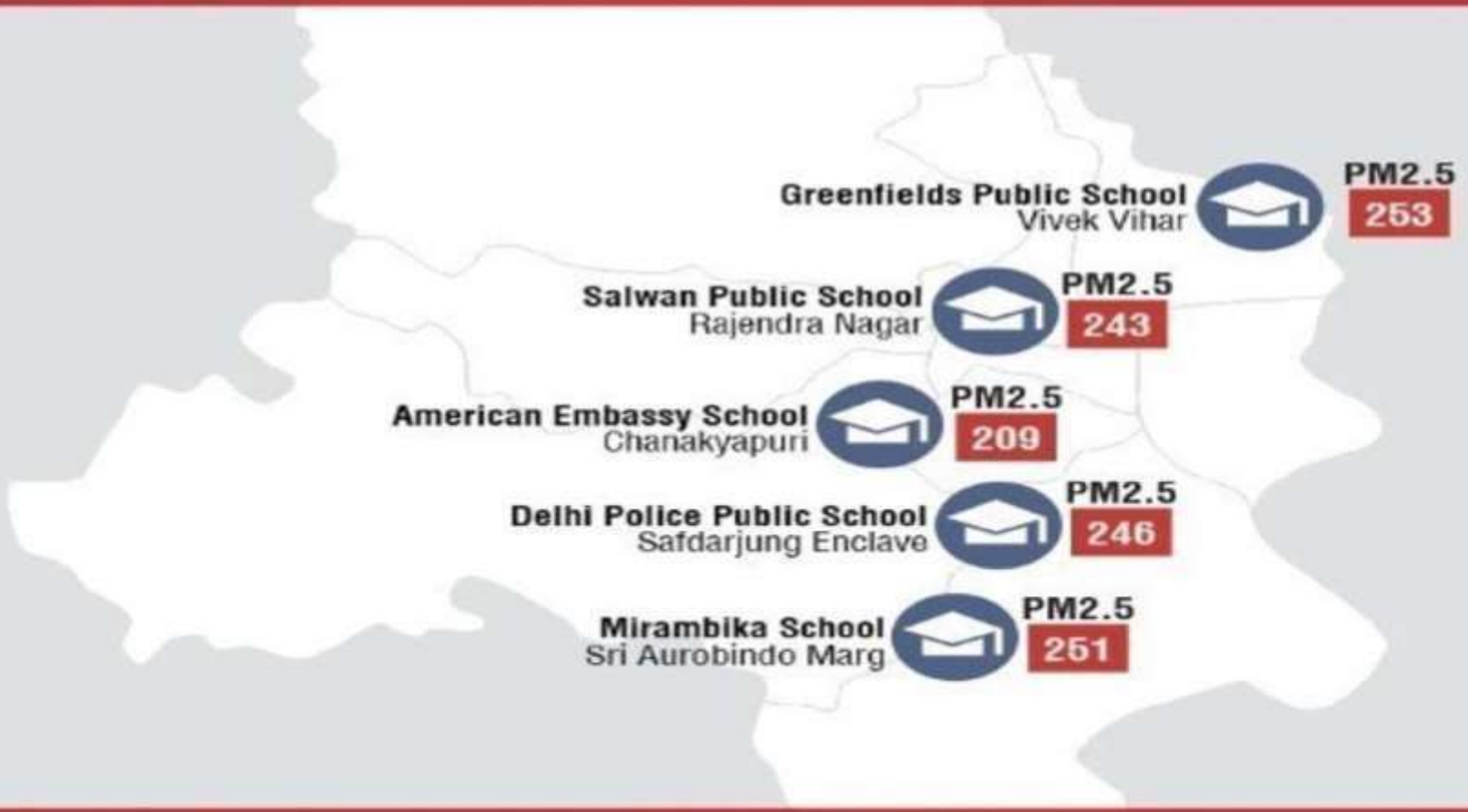

Air Pollutions & its effects on Crops, forests, monuments & buildings and aquatic life


In 2013, a report by Global Burden of Disease (GBD) said that outdoor air pollution was the 5th largest killer in India.


Nearly one lakh premature deaths happen
annually due to air pollution in India.


According to a World Health Organisation (WHO) study, Delhi has surpassed Beijing and is currently the most polluted city in the world. This puts its people at a dangerous risk of respiratory diseases
AP

DELHI AIR QUALITY INSIDE SCHOOLS VERY UNHEALTHY!



PM2.5 levels
Four times the safety limits!

TOXICITY
GREENPEACE

The air that school children in Delhi breathe is four times more toxic than the required safety limit.

Approximately 30 million people including children in India suffer from Asthma.

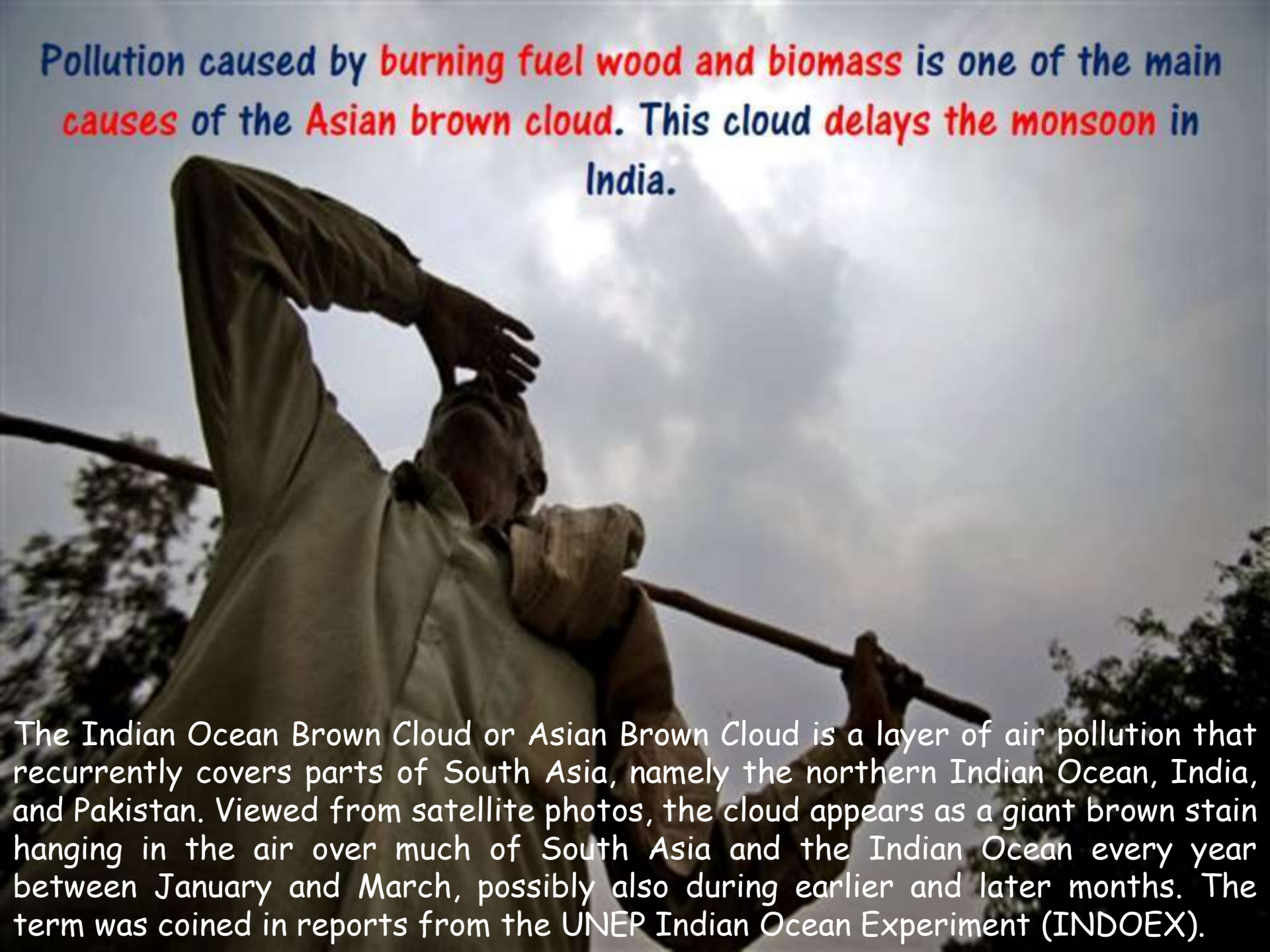

30% children in Bangalore suffer from Asthma due to air pollution.
The city is also regarded as the asthma capital of India.

The air pollution levels in Delhi put its residents at the highest of risk of lung cancer.


Many auto rickshaws and taxis in India use adulterated fuel.

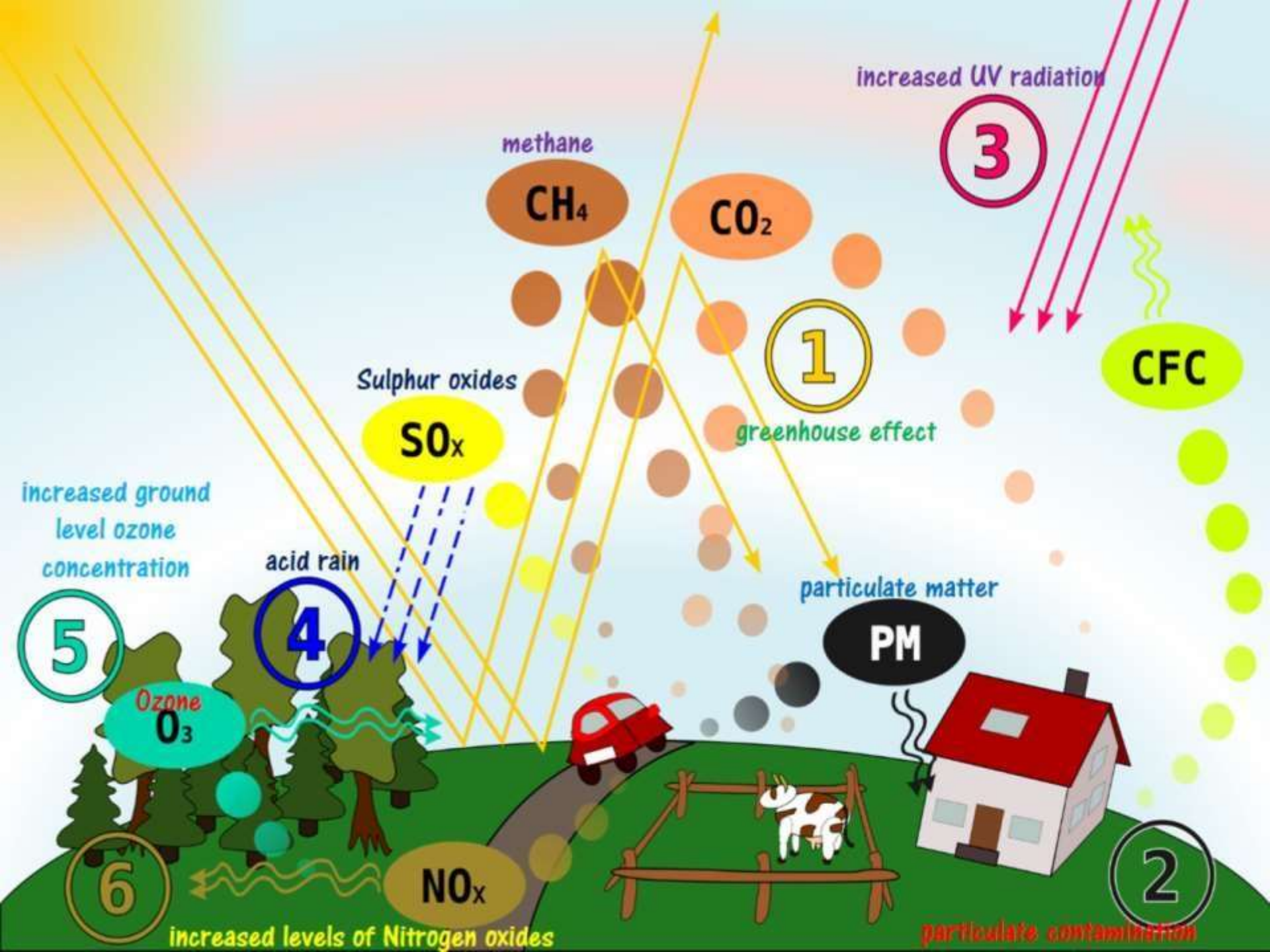

Most of the industries do not stick to the
environmental guidelines, regulations and laws.


Traffic at low speed especially during congestion burn fuel inefficiently and emit 4 to 8 times more air pollutants



The Indian Ocean Brown Cloud or Asian Brown Cloud is a layer of air pollution that recurrently covers parts of South Asia, namely the northern Indian Ocean, India, and Pakistan. Viewed from satellite photos, the cloud appears as a giant brown stain hanging in the air over much of South Asia and the Indian Ocean every year between January and March, possibly also during earlier and later months. The term was coined in reports from the UNEP Indian Ocean Experiment (INDOEX).

Effects of air pollution on crops & Forest


increased UV radiation
3
methane
CH_4
CO_2
1
greenhouse effect
CFC
Sulphur oxides
SO_x
increased ground level ozone concentration
acid rain
4
particulate matter
PM
5
Ozone
O_3
6
NO_x
increased levels of Nitrogen oxides
2
particulate contamination

New study based on a 'regression model' that predicts future events with information on past or present events says that

"Atmospheric pollutants may impact India's major crops like wheat and rice more than temperature rise"

Study by jennifer burney and V. Ramanathan, scientists at the university of California

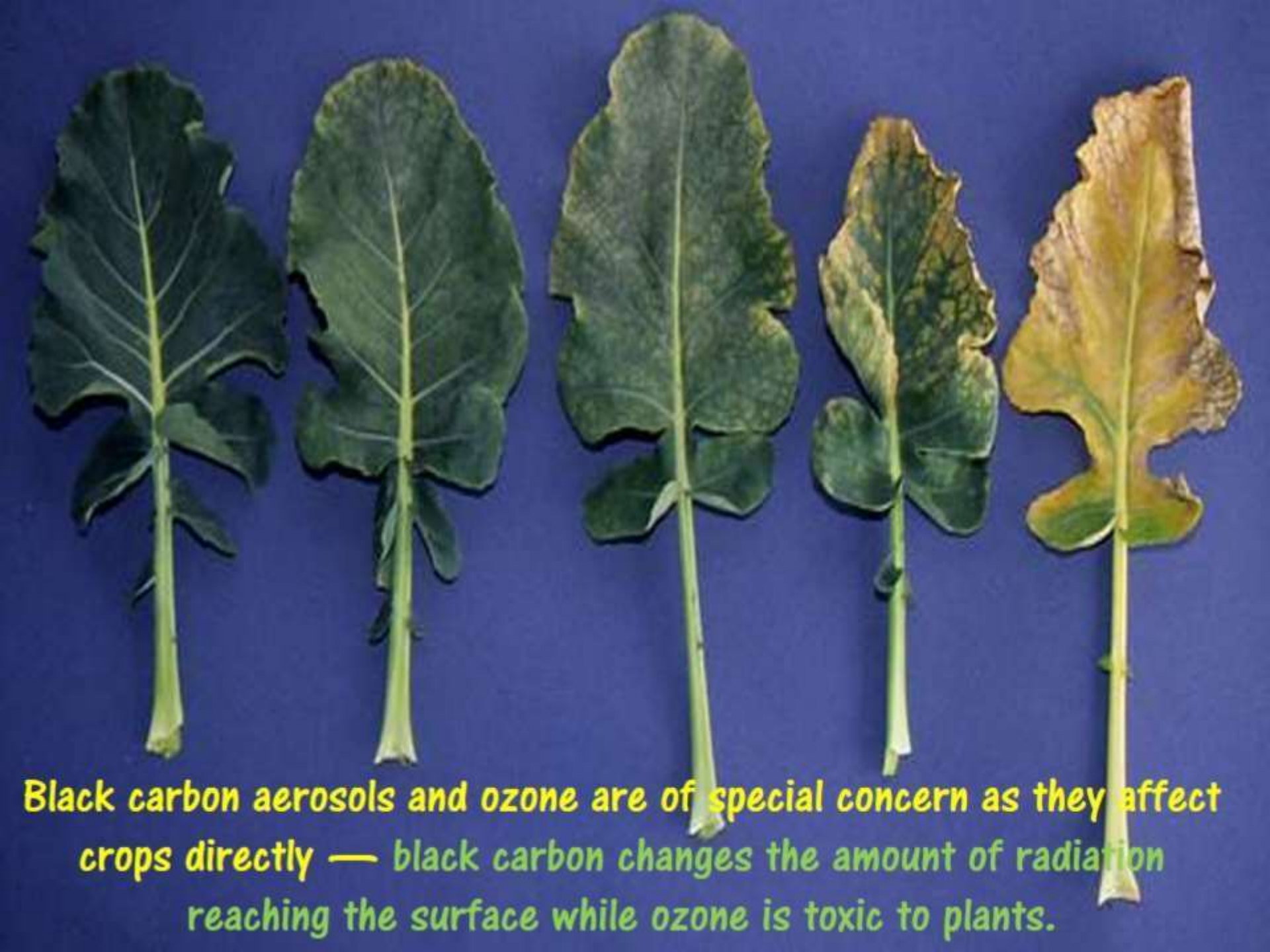
"One degree centigrade rise in temperature could lead to a crop decline of four per cent for wheat and five per cent for rice. But losses from pollution could be greater."

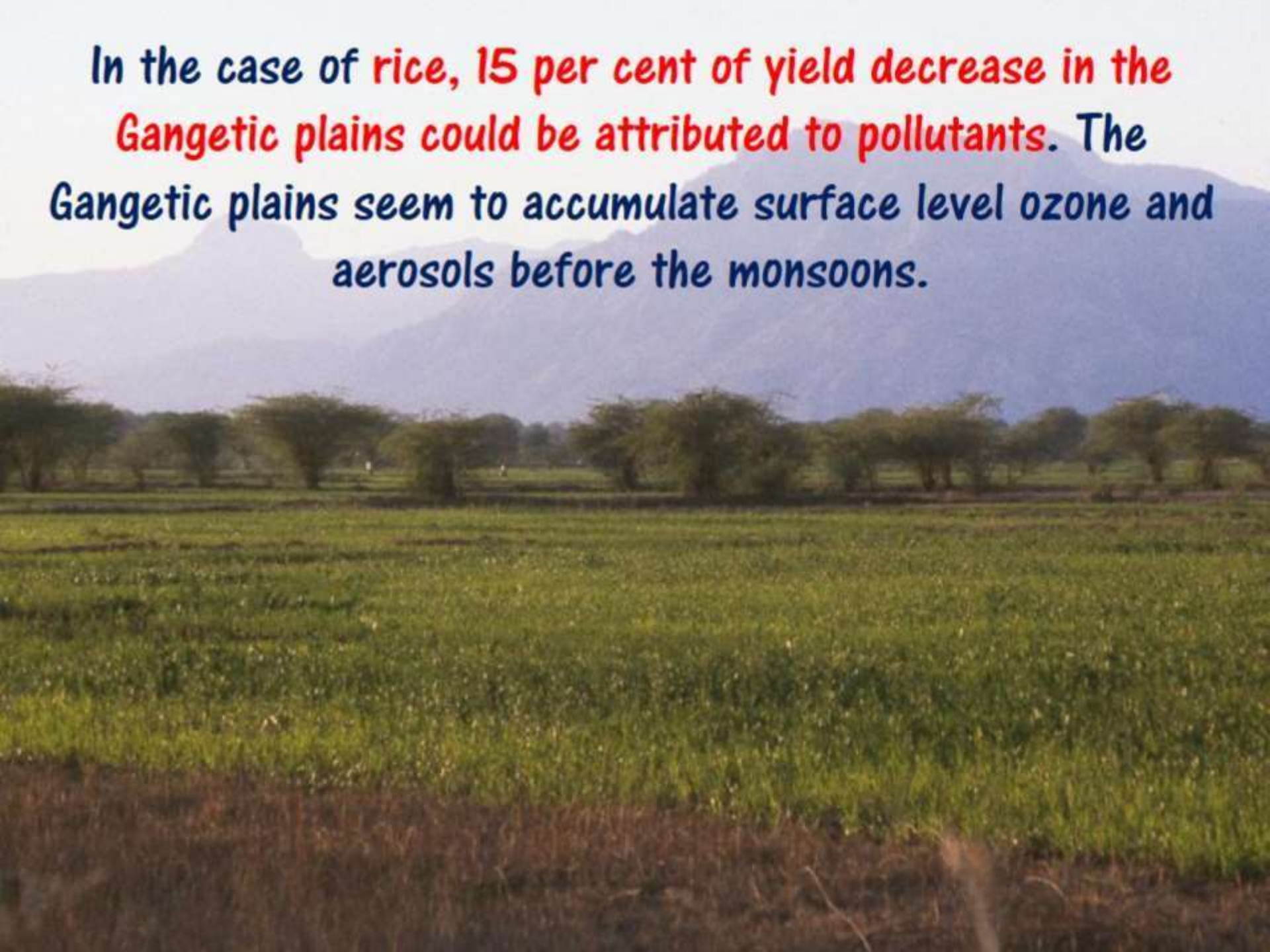
Yield loss for wheat attributable to pollutants alone in 2010 corresponds to over 24 million tons of wheat in India

In 2010, wheat yields were 36 per cent lower and the models show that 90 per cent of that change was due to the pollutants.

The impact was most drastic in the state of Uttaranchal and Uttar Pradesh.

Wheat yields in Uttar Pradesh were 50 per cent lower than they would have been without the current climate and pollutant trends with two-thirds of the decrease attributable to pollutant levels.


Black carbon aerosols and ozone are of special concern as they affect crops directly — black carbon changes the amount of radiation reaching the surface while ozone is toxic to plants.


In the case of rice, 15 per cent of yield decrease in the Gangetic plains could be attributed to pollutants. The Gangetic plains seem to accumulate surface level ozone and aerosols before the monsoons.

Burning of fossil fuel such as coal and diesel has reduced the growth of rice harvest in India. India is the third largest producer of coal in the world and at the top as far as CO2 emittance is considered.

THE HINDU


Much of the drop in yield came from air pollution caused by fine particles like soot as well as ozone generated by sunlight acting on emissions of precursor molecules.

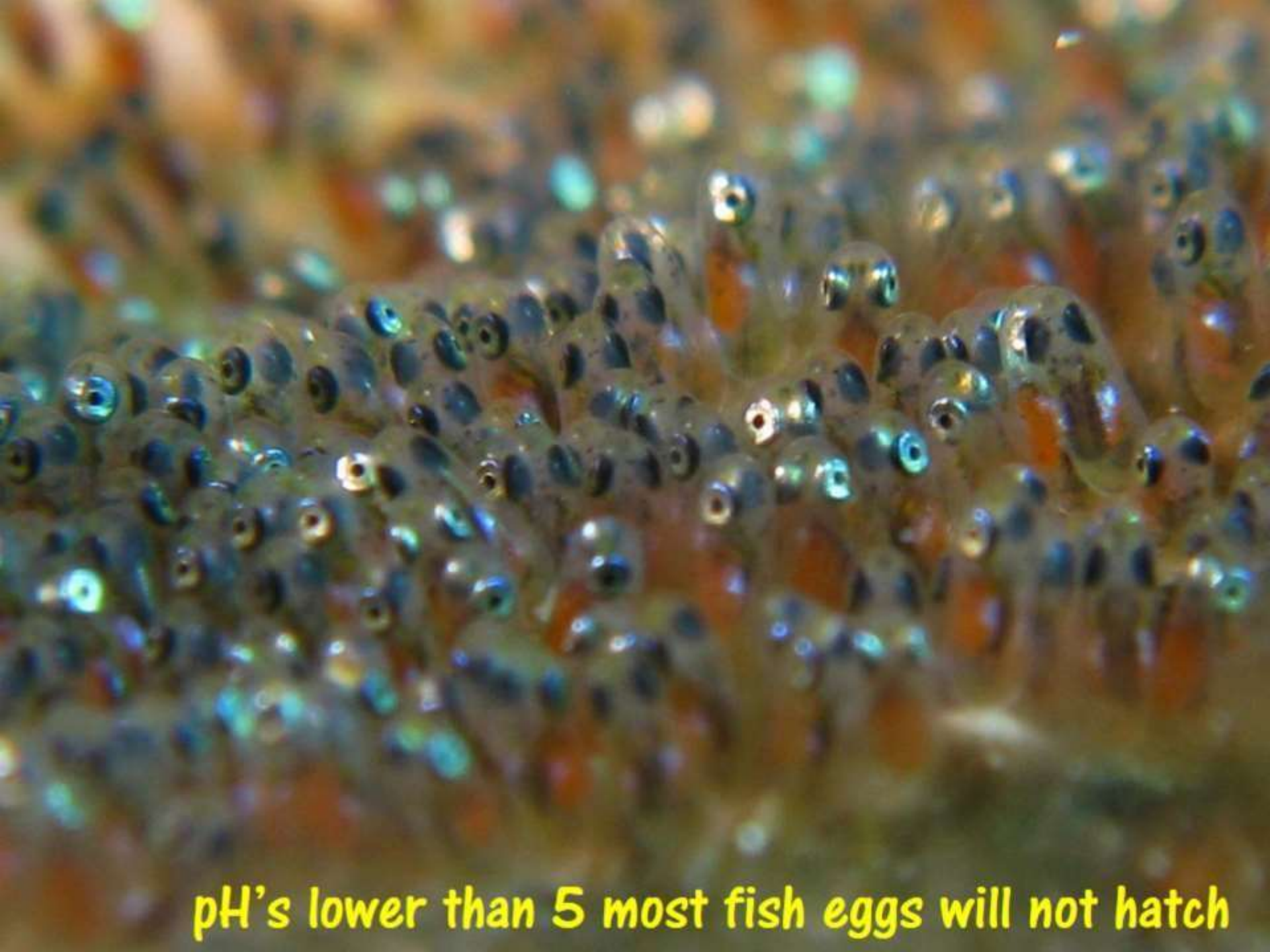
The ozone levels are high, especially in march-june, during which period winter crops are harvested and summer crops are sown.


Acid rain does not usually kill trees directly. Instead, it is more likely to weaken the trees by damaging their leaves, limiting the nutrients available to them, or poisoning them with toxic substances slowly released from the soil.

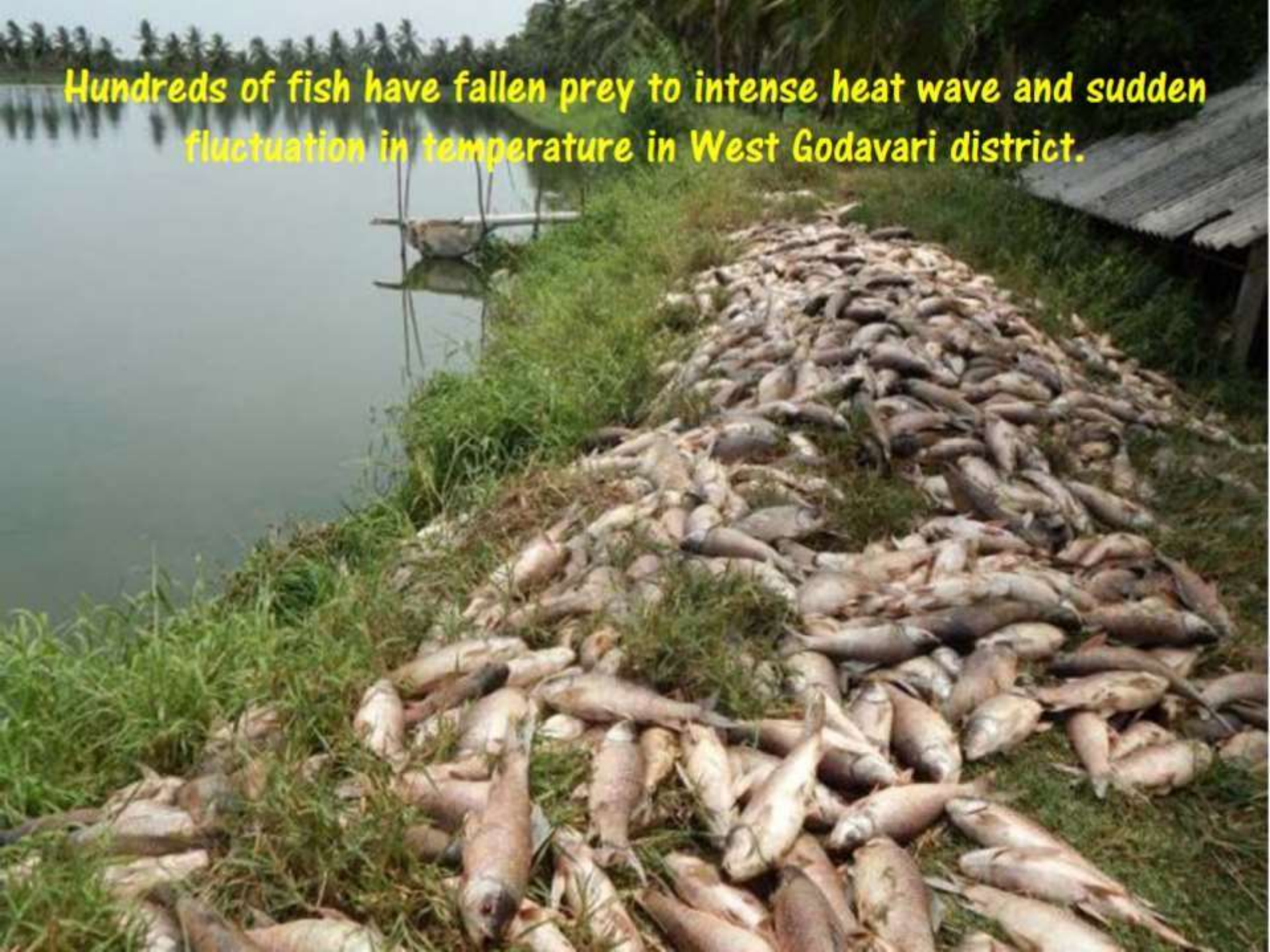
leaves are frequently bathed in this acid fog, their protective waxy coating can wear away. The loss of the coating damages the leaves and creates brown spots.

The air in this place contains serious levels of sulphur and nitrogen oxides. This is due to the large number of power plants and industries set up around this area. All these led to acid rain. Acid rain reacted with the marble (calcium carbonate) of Taj Mahal.

Both the lower pH and higher aluminium concentrations in surface water that occur as a result of acid rain can cause damage to fish and other aquatic animals.


pH's lower than 5 most fish eggs will not hatch


Lower ph's can kill adult fish.


Hundreds of fish have fallen prey to intense heat wave and sudden fluctuation in temperature in West Godavari district.

Acid rain has eliminated insect life and some fish species, including the brook trout in some lakes in Himalayan regions of India

What can be the steps to Curb Air Pollution and Conserve Environment???

Acts and Rules

1. THE AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, 1981 (as amended from time to time)

2. THE ENVIRONMENT (PROTECTION) ACT, 1986 (as amended from time to time)

3. THE ENVIRONMENT (PROTECTION) RULES, 1986 (as amended from time to time)

Important Provision of Air Act, 1981

Function of Central Board under section 16(2)

(a) Advice the central government on any matter concerning the improvement of the quality of air and the prevention, control or abatement of air pollution,
(b) Plan and cause to be executed a nation vide programme for the prevention, control or abatement of air pollution;
(c) Co-ordinate the activities of the State and resolve disputed among them;
(d) Provide technical assistance and guidance to the State Boards, carry out and sponsor investigations and research relating to problems of air pollution and prevention, control or abatement of air pollution;
(e) Plan and organise the training of persons engaged or to be engaged in programmes for the prevention, control or abatement of air pollution on such terms and conditions as the Central Board may specify;

(f) organise through mass media a comprehensive programme regarding the prevention, control or abatement of air pollution;

(g) collect, compile and publish technical and statistical data relating to air pollution and the measures devised for its effective prevention, control or abatement and prepare manuals, codes or guides relating to prevention, control or abatement of air pollution;

(h) lay down standards for the quality of air;

(i) collect and disseminate information in respect of matters relating to air pollution;

(j) perform such other functions as may be prescribed

Function of State Pollution Control Boards under section 17(1)

(a) To plan a comprehensive programme for the prevention control or abatement of air pollution and to secure the execution thereof;

(b) To advice the state government on any matter concerning the prevention control or abatement of air pollution;

(c) To collect and disseminate information relating to air pollution;

(d) To collaborate with central board in organising the training of persons engaged or to be engaged in programmes relating to prevention, control or abatement of air pollution and to organise mass education programme relating thereto;

(e) To inspect, at all reasonable times, any control equipment, industrial plant or manufacturing process and to give, by order, such direction to such person as it may consider necessary to take step for the prevention, control or abatement of air pollution;

(f) To inspect air pollution control areas at such intervals as it may think necessary, assess the quality therein and take steps for the prevention, control or abatement of air pollution in such areas

(g) To lay down in consultation with Central Board and having regard to the standards for the quality of air laid down by the Central Boards, standards for the emission of air pollution into the atmosphere from industrial plants and automobiles or for the discharge of any air pollutants into the atmosphere from any other source whatsoever not being a ship or an aircraft; provided the different standards for emission may be laid down under the clause for different industrial plants having regard to the quantity and composition of emission of air pollutants into the atmosphere from such industrial plants;

(h) To advice the state government with respect to the suitability of any premises or location for carrying on any industry which is likely to cause air pollution;

(i) To perform such other functions as may be prescribed by the central board or the state government;

Section 18 of Air Act
Power to give directions

1. In the performance of its function under this act

(a) The central board shall be bound by such directions in writing as the central government may give to it; and

(a) Every state board shall be bound by such direction in writing as the central board or the state government may give to it;

Section 19 of Air Act
Power to declare air pollution control areas

The State Government may, after consultation with the State Board, by notification in official gazette declared in such manner as may be prescribed, any area or areas within the State as air pollution control area or areas for the purposes of this act.

Section 31 (A) of Air Act
Power to give directions

1. Notwithstanding anything contained in any other law, but subject to the provisions of this Act, and to any directions that Central Government may give in this behalf, a Board may, in the exercise of its powers and performance of its functioning under this Act, issue any directions in writing to any person, officer or authority, and such person, officers or authority shall be bound to comply with such directions.

   Explanation : for the avoidance of doubts, it is hereby declared that the power to issue directions under this section, includes the power to direct –

(a) The closure, prohibition or regulation of any industry, operation or process ; or
(b) The stoppage or regulation of supply of electricity, water or any other service.

AMBIENT AIR QUALITY STANDARDS 2009

Sr. No.	Pollutant	Time Weighted Average	Concentration in Ambient Air		Methods of Measurement	Remarks
			Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (notified by Central Government)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	Sulphur Dioxide (SO_2), µg/m^3	Annual* 24 hours**	50 80	20 80	a) Improved West and Gaeke b) Ultraviolet fluorescence	Facilities available
2.	Nitrogen Dioxide (NO_2), µg/m^3	Annual* 24 hours**	40 80	30 80	a) Modified Jacob & Hocheiser (Na-Arsenite) b) Chemiluminescence	Facilities available

Contd..

3.	Particulate Matter (size less than 10 µm) or PM_{10} µg/m^3	Annual* 24 hours**	60 100	60 100	a) Gravimetric b) TOEM c) Beta attenuation	• Most of the NAMP Stations have Gravimetric measurement facility including CPCB • CAQMS is having BAM • TEOM has to be introduced gradually
4.	Particulate Matter (size less than 2.5 µm) or $PM_{2.5}$ µg/m^3	Annual* 24 hours**	40 60	40 60	a) Gravimetric b) TOEM c) Beta attenuation	• Gravimetric measurement facility may be developed countrywide • CAQMS is having BAM • TEOM is yet to be introduced gradually
5.	Ozone (O_3) µg/m^3	8 hours* 1 hour**	100 180	100 180	a) UV photometric b) Chemiluminescence c) Chemical Method	• CAQMS equipped with UV based or Chemiluminescence Online Analysers and may be used for 1 hourly data • Chemical method may be adopted nationwide but monitoring hours is not specified, however 09 hrs to 17 hrs may be introduced

Contd..

6.	Lead (Pb) µg/m^3	Annual* 24hours**	0.5 1.0	0.5 1.0	a) AAS/ICP method after sampling on EPM 2000 or equivalent filter paper b) ED-XRF using Teflon filter	• It appears that Pb is to be monitored in PM_{10}, this standard already exists but monitored in SPM only at few locations. • Once the sampling is done in Teflon the same may also be analyzed by other method ED-XRF
7.	Carbon Monoxide (CO) µg/m^3	8 hours* 1 hour**	02 04	02 04	Non Dispersive Infra Red (NDIR) spectroscopy	• Only option is to go with online analyzer
8.	Ammonia (NH_3) µg/m^3	Annual* 24hours**	100 400	100 400	a)Chemiluminescence b) Indophenol blue method	• Recently introduced at few locations in CAQMS • Chemical method may be adopted nationwide
9.	Benzene (C_6H_6) µg/m^3	Annual*	05	05	a)Gas chromatography based continuous analyzer b) Adsorption and Desorption followed by GC analysis	• BTX analysers are being used at CAQMS • Active 24 hourly sampling in diffusion tubes followed by desorption in CS_2 and finally GC Analysis may be adopted nationwide in NAMP

Contd..

10.	**Benzo(a) Pyrene (BaP) – particulate phase only, ng/m^3**	**Annual***	**01**	**01**	**Solvent extraction followed by HPLC/GC analysis**	• **Facilities available with CPCB but BIS method using GC-FID may not attain the desired lowest concentration level below 1ng/m^3 alternatively GC-MS or HPLC-UV Fluorescence may be provided**
11.	**Arsenic (As), ng/m^3**	**Annual***	**06**	**06**	**AAS/ICP method after sampling on EPM 2000 or equivalent filter paper**	• **It appears that 'As' is to be monitored in PM_{10}.** • **Micro-wave digester is required for digestion alternatively acid digestion at 70^0 C for 12 hours is required.**
12.	**Nickel (Ni), ng/m^3**	**Annual***	**20**	**20**	**AAS/ICP method after sampling on EPM 2000 or equivalent filter paper**	• **It appears that 'Ni' is to be monitored in PM_{10}.** • **Micro-wave digester is required for digestion alternatively acid digestion at 70^0 C for 12 hours is required.**

National Ambient Air Quality Monitoring

Four air pollutants *viz* ., Sulphur Dioxide (SO_2), Oxides of Nitrogen as NO_2, and Respirable Suspended Particulate Matter (RSPM / PM10) are regularly monitored at all the locations along with meteorological parameters such as wind speed and wind direction, relative humidity (RH) and temperature were also integrated with the monitoring of air quality.

Monitoring is carried out for 24 hours (4-hourly sampling for gaseous pollutants and 8-hourly sampling for particulate matter) with a frequency of twice a week, to have one hundred and four (104) observations in a year.

Emission norms for passenger cars		
	CO (g/km)	HC+Nox(g/km)
BS-II	2.2	0.5
BS-III	2.3	0.35 (combined)
BS-IV	1.0	0.18 (combined)
Emission norms for 2/3 wheelers		
2000 norms	2	2
BS-II	1.6	1.5
BS-III	1.0	1.0

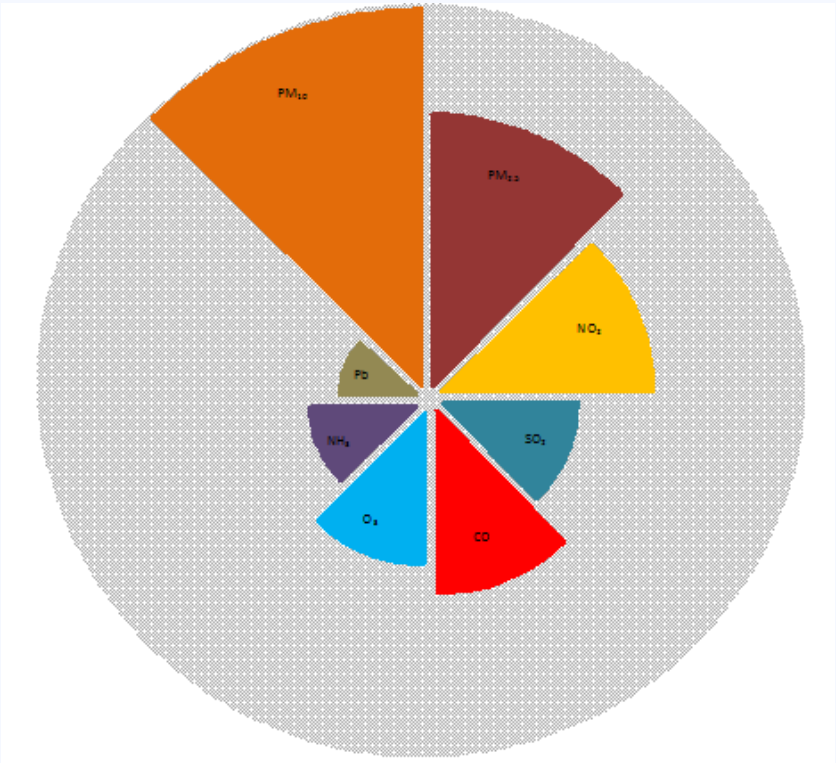
Emission norms for Heavy Diesel Vehicles				
	CO (g/kmhr)	HC(g/kmhr)	Nox (g/kmhr)	PM (g/kwhr)
BS-II	4.0	1.1	7.0	0.15
BS-III	2.1	1.6	5.0	0.1
BS-IV	1.5	0.96	3.5	0.02

Auto Fuel Quality

Gasoline specifications	
	2010
Rvp at 38^0C Kpa	
Benzene % by vol, max	1.0
Lead G/m3, max	0.005
Sulphur % by mass, max	0.015
Aromatics % v/v, Max	42
Oxygen % by volume, Max	2.7
Diesel Specifications	
Cetane No, min	51
Sulphur % w/w, Max	0.035
Distillation T95	360
Polyaromatic	11

National Air Quality Index

(How healthy is the air we breathe?)



Are we affected by poor AQ?

The very young are at risk

Lungs are not fully developed

Faster breathing rate: more air volume/body weight

The very old are at risk

Undiagnosed lung or heart diseases

Pollution can exacerbate these conditions

Persons with chronic illnesses: Respiratory, circulatory, or cardiac diseases

✓**Yes, EVERYONE!**

Even healthy persons can be affected when they exercise outdoors, or if the concentration of pollutants is very high

How do we know if Air Quality is poor?

AQI is an overall scheme that transforms individual air pollutant (e.g. SO_2, CO, PM_{10}) levels into a single number, which is a simple and lucid description of air quality for the citizens.

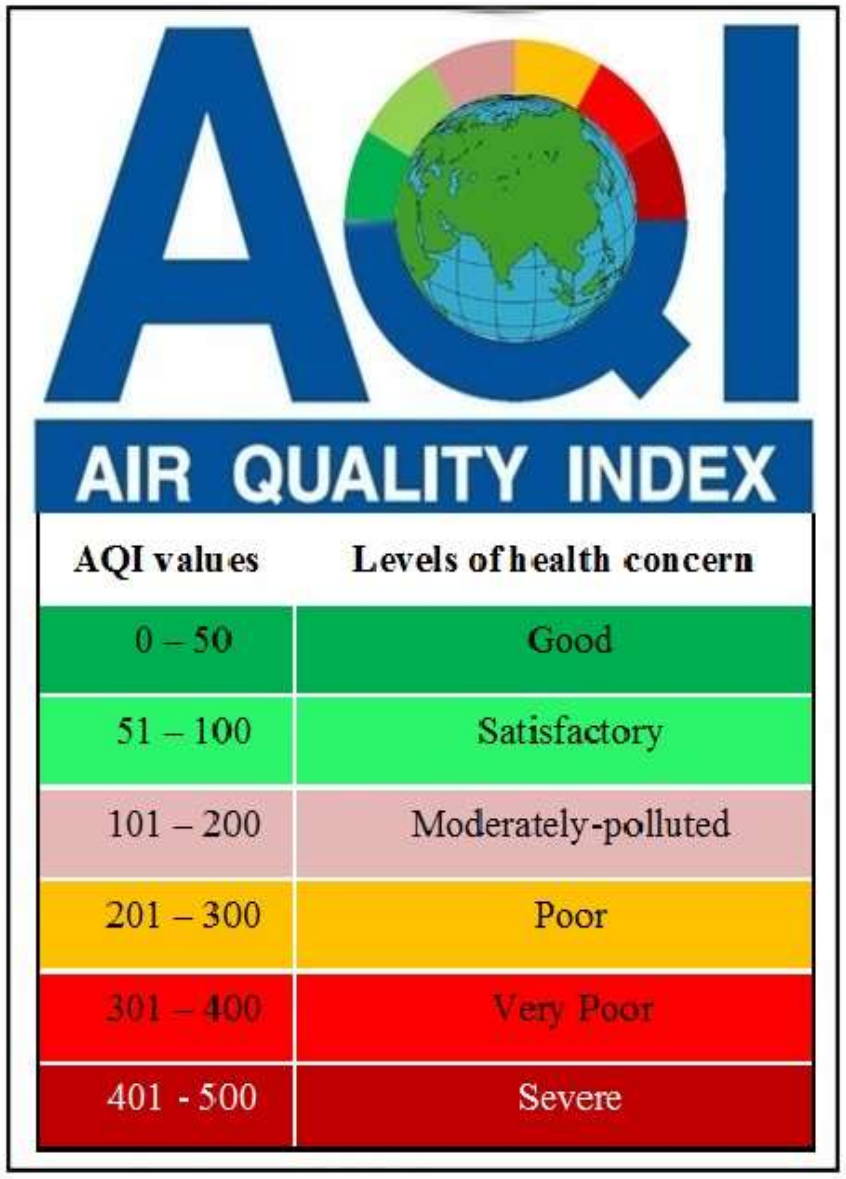
AQI relates to health impacts and citizens can avoid the unnecessary exposure to air pollutants;

AQI indicates compliance with National Air Quality Standards;

AQI prompts local authorities to take quick actions to improve air quality;

AQI guides policy makers to take broad decisions; and

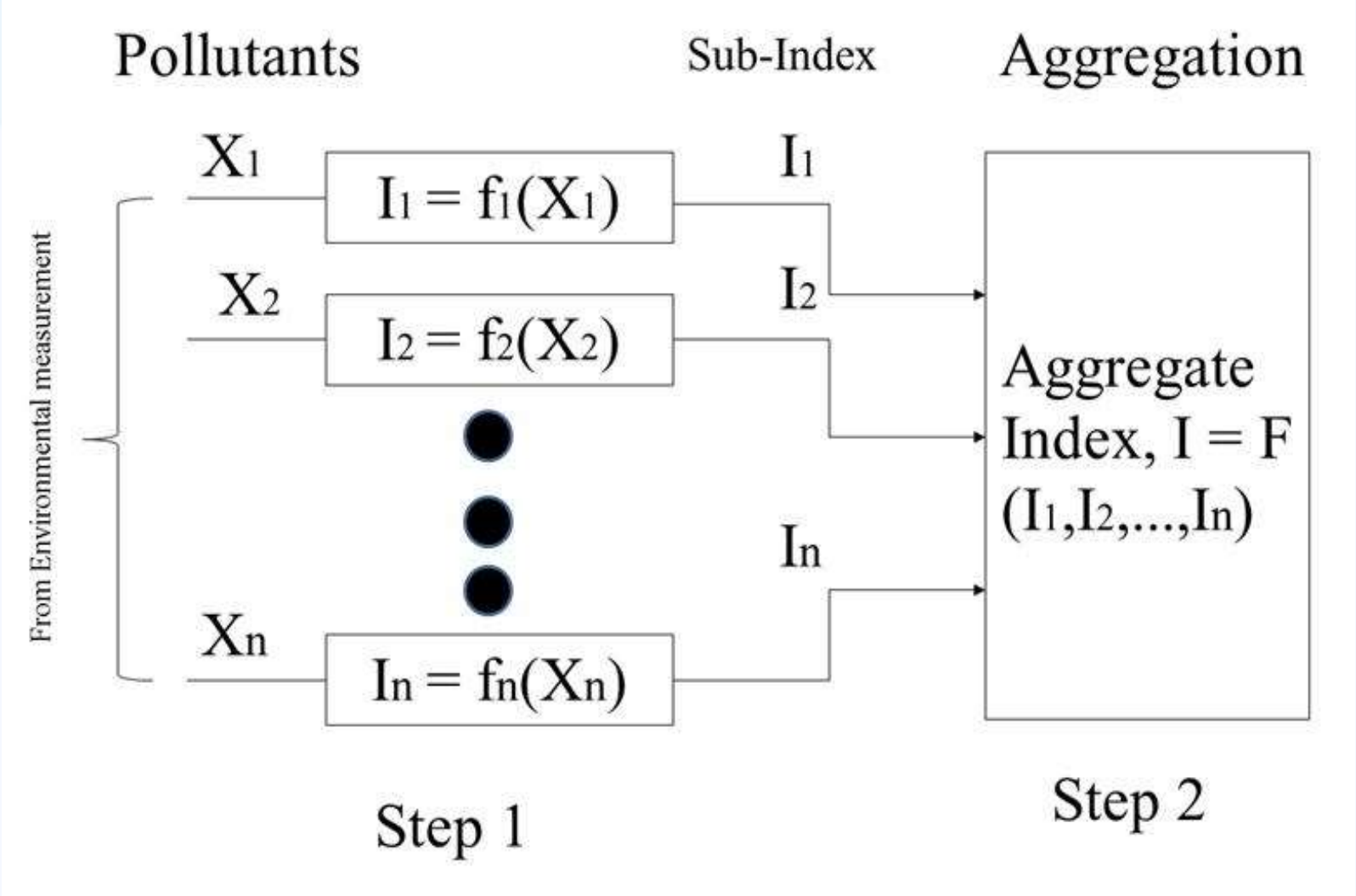
AQI encourages citizens to participate in air quality management.



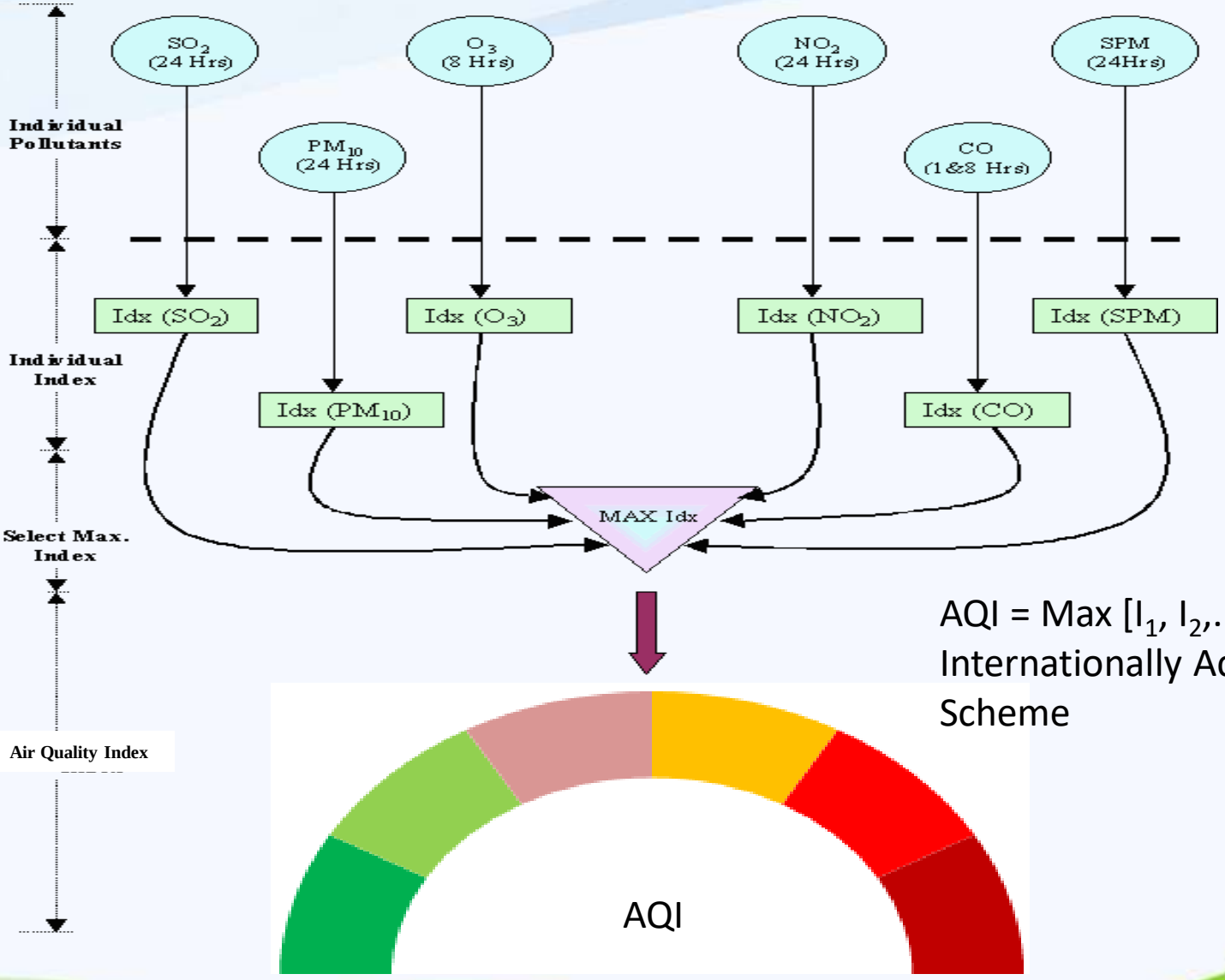
Pollutants Considered for AQI and Air Quality Standards

Pollutant	SO_2	NO_2	$PM_{2.5}$	PM_{10}	O_3		CO (mg/m^3)		Pb	NH_3
Averaging time (hr)	24	24	24	24	1	8	1	8	24	24
Indian Standard ($\mu g/m^3$)	80	80	60	100	180	100	4	2	1	400

Development of Aggregate AQI

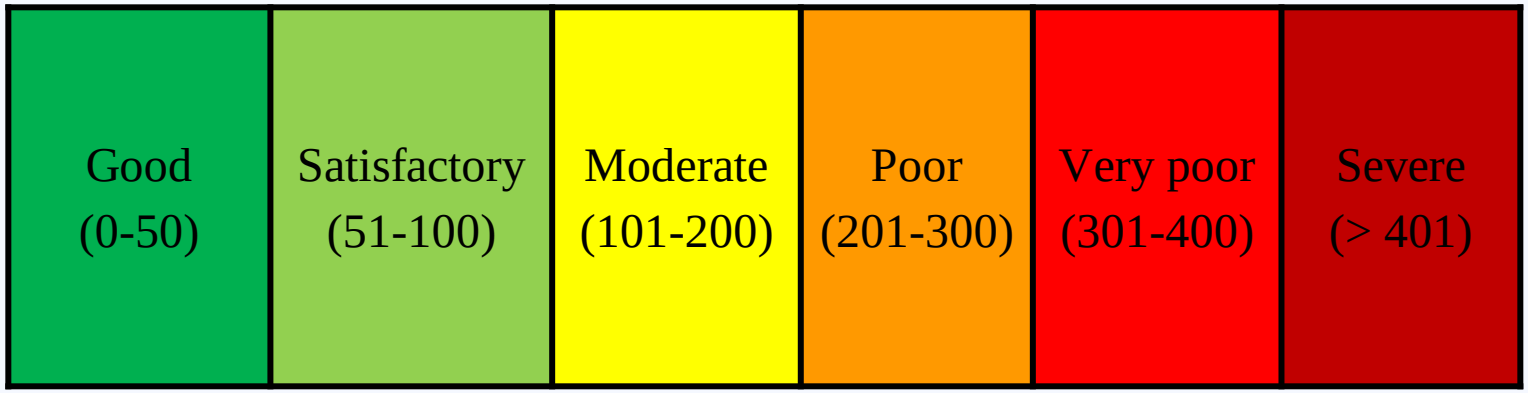


Sub-indices to AQI



AQI = Max [I_1, I_2,..,I_n]
Internationally Accepted Scheme

AQI Categories and Range



[Colour, Category, AQI Number]

AQI categories and breakpoint concentrations with averaging times
(units: µg/m^3 unless mentioned otherwise)

AQI Category (Range)	PM_{10} 24-hr	$PM_{2.5}$ 24-hr	NO_2 24-hr	O_3 8-hr	CO 8-hr (mg/m^3)	SO_2 24-hr	NH_3 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.6 –1.0
Moderate (101-200)	101-250	61-90	81-180	101-168	2.1- 10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10.1-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748*	17.1-34	801-1600	1201-1800	3.1-3.5
Severe (401-500)	430 +	250+	400+	748+*	34+	1600+	1800+	3.5+

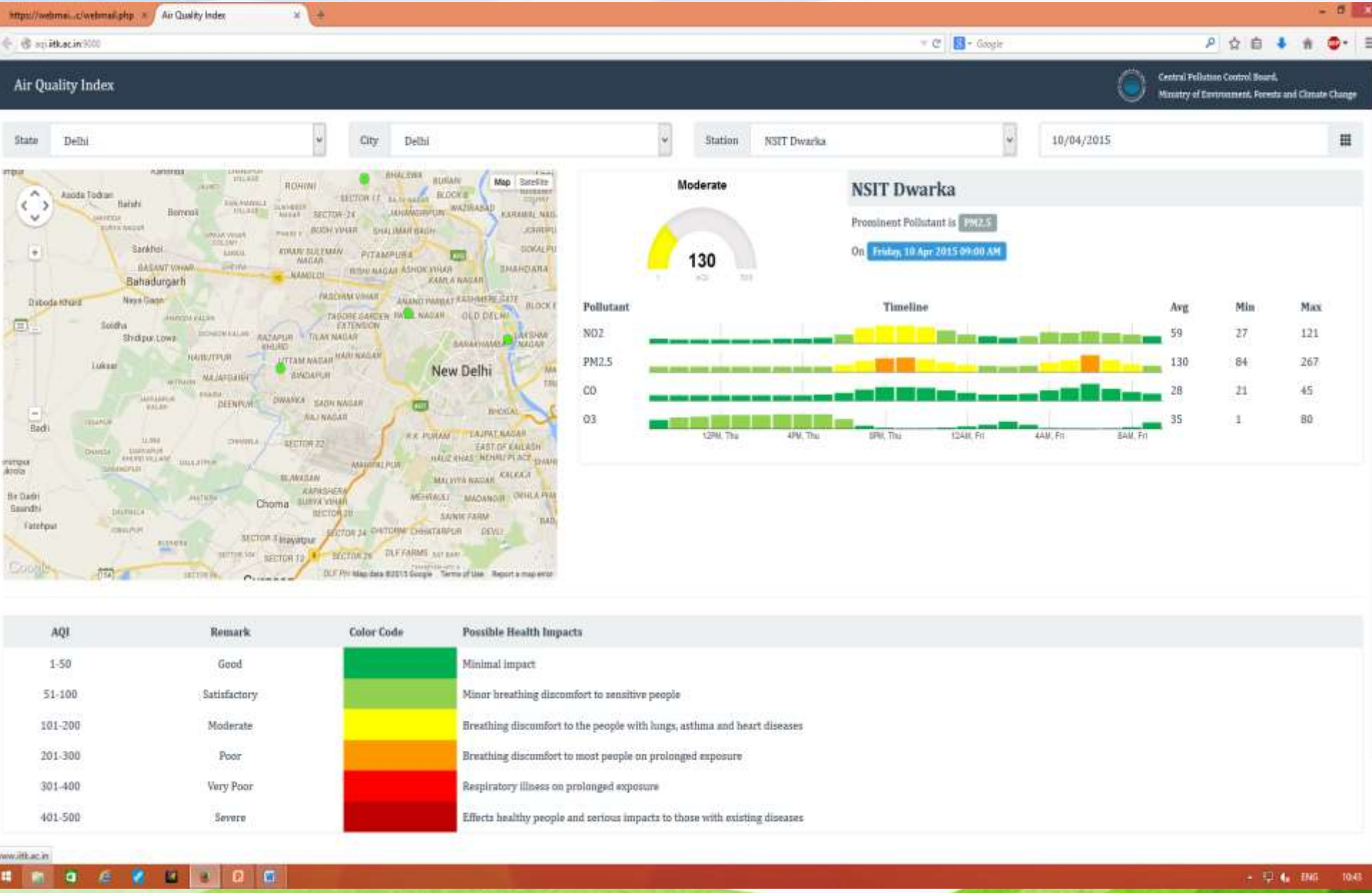
**One hourly monitoring (for mathematical calculation only)*

AQI: Health Impacts

AQI	Possible Health Impacts
Good	minimal impact
Satisfactory	minor breathing discomfort to sensitive people
Moderate	breathing discomfort to the people with lung disease such as asthma and discomfort to people with heart disease, children and older adults
Poor	breathing discomfort to people on prolonged exposure and discomfort to people with heart disease with short exposure
Very Poor	respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases
Severe	respiratory effects even on healthy people and serious health impacts on people with lung/heart diseases

The higher the AQI, greater the air pollution and health concerns

Web-based AQI dissemination



AQI	Remark	Color Code	Possible Health Impacts
1-50	Good		Minimal impact
51-100	Satisfactory		Minor breathing discomfort to sensitive people
101-200	Moderate		Breathing discomfort to the people with lungs, asthma and heart diseases
201-300	Poor		Breathing discomfort to most people on prolonged exposure
301-400	Very Poor		Respiratory illness on prolonged exposure
401-500	Severe		Effects healthy people and serious impacts to those with existing diseases

Summary

- AQI: Based on Indian Air Quality Standards
- Important tool for public information and participation; real-time and transparent
- Public health protection
- Trigger actions by regulatory agencies
- Time-bound action plan and implementation
- Continuous monitoring of Air Quality status

Graded Response Action Plan

Graded Response Action Plan for Delhi & NCR

In pursuant to the Hon'ble Supreme Court's order dated December 02, 2016 in the matter of M. C. Mehta vs. Union of India regarding air quality in National Capital Region of Delhi, a Graded Response Action Plan has been prepared for implementation under different Air Quality Index (AQI) categories namely, Moderate & Poor, Very Poor, and Severe as per National Air Quality Index. A new category of "Severe+ or Emergency" has been added. Ministry of Environment, Forests & Climate Change has notified for implementation of Graded Response Action Plan through Environment Pollution (Prevention & Control) Authority vide S.O. 118 (E) dated January 12, 2017

Graded Response Action Plan

Severe + or Emergency (ambient $PM_{2.5}$ or PM_{10} concentration values of 300 µg/m³or 500 µg/m³ respectively persist for 48 hours or more)	Agency responsible/Implementing Agency
Stop entry of truck traffic into Delhi (except essential commodities)	Municipal Corporations and Traffic Police of Delhi and NCR Towns
Stop construction activities	Delhi Pollution Control Committee/Municipal Corporations of Delhi and NCR towns
Introduce odd and even scheme for private vehicles based on license plate numbers and minimize exemptions	Secretary cum Commissioner of Transport Department, NCT of Delhi, and Transport Commissioners of NCR towns
Task Force to take decision on any additional steps including shutting of schools	

Graded Response Action Plan

Severe (ambient $PM_{2.5}$ or PM_{10} concentration value is more than 250 µg/m^3 or 430µg/m^3 respectively)	Agency responsible/Implementing Agency
Close brick kilns, Hot Mix plants, Stone Crushers	Chairpersons Delhi Pollution Control Committee, State Pollution Control Boards of Haryana, Rajasthan, and Uttar Pradesh
	Superintendent of Police and Deputy Commissioner of respective districts
Shut down Badarpur power plant and maximize generation of power from existing natural gas based plants to reduce operation of coal based power plants in the NCR.	Chairpersons Delhi Pollution Control Committee, State Pollution Control Boards of Haryana, Rajasthan, and Uttar Pradesh
Intensify public transport services. Introduce differential rates to encourage off-peak travel.	Secretary cum Commissioner of Transport Department, NCT of Delhi, and Transport Commissioners of NCR towns
	Chairperson, Delhi Metro Rail Corporation (DMRC)
	Chairpersons, State Transport Corporations

Graded Response Action Plan

Severe (ambient $PM_{2.5}$ or PM_{10} concentration value is more than 250µg/m^3or 430µg/m^3 respectively)	**Agency responsible / Implementing Agency**
Increase frequency of mechanized cleaning of road and sprinkling of water on roads. Identify road stretches with high dust generation.	All road owning agencies including Municipal Corporations of NCT of Delhi and NCR towns, Public Works Departments and National Highway Authority of India

Graded Response Action Plan

Very Poor (ambient $PM_{2.5}$ or PM_{10} concentration value is between 121-250µg/m^3 or 351-430 µg/m^3 respectively)	Agency responsible/Implementing Agency
Stop use of diesel generator sets	Chairpersons Delhi Pollution Control Committee, State Pollution Control Boards of Haryana, Rajasthan, Uttar Pradesh
Enhance parking fee by 3-4 times	Municipal Commissioner
	Municipal Corporations of NCT of Delhi and NCR towns
Increase bus and metro services by augmenting contract buses and increasing frequency of service	Principal Secretary, Department of Transport of NCT of Delhi
	Delhi Transport Corporation (DTC)
	Delhi Integrated Multi-modal Transit System Ltd (DIMTS)
	Delhi Metro Rail Corporation (DMRC)
	State Transport Corporations in NCR towns
Stop use of coal/firewood in hotels and open eateries	Municipal Corporations of NCT of Delhi and NCR towns
Residential Welfare Associations and individual house owners to provide electric heaters during winter to security staff to avoid open burning by them	Resident Welfare Associations
Alert in newspapers/TV/radio to advise people with respiratory and cardiac patients to avoid polluted areas and restrict outdoor movement.	Chairpersons, Delhi Pollution Control Committee, State Pollution Control Boards of Haryana, Rajasthan, and Uttar Pradesh

Graded Response Action Plan

Moderate to poor (ambient $PM_{2.5}$ or PM_{10} concentration value is between 61-120 µg/m3 or 101-350 µg/m3 respectively)	**Agency responsible/Implementing Agency**
Stringently enforce/stop garbage burning in landfills and other places and impose heavy fines on person responsible	Municipal Commissioner Municipal corporations of Delhi and NCR towns
Close/stringently enforce all pollution control regulations in brick kilns and industries	Chairpersons, Delhi Pollution Control Committee, State Pollution Control Boards of Haryana, Rajasthan, and Uttar Pradesh

Graded Response Action Plan

Moderate to poor(ambient $PM_{2.5}$ or PM_{10} concentration value is between 61-120 µg/m^3 or 101-350 µg/m^3 respectively)	**Agency responsible/Implementing Agency**
Stringently enforce pollution control in thermal power plants through PCB monitoring	Plant in-charge of power plants in NCR, and Delhi Pollution Control Committee and State Pollution Control Boards of Haryana, Rajasthan and Uttar Pradesh
Do periodic mechanized sweeping on roads with heavy traffic and water sprinkling also on unpaved roads every two days	Municipal Commissioner, Municipal Corporations of NCT of Delhi and NCR towns
	Commissioners, Traffic Police of Delhi and NCR towns to identify roads with heavy traffic and provide information to respective Municipal Commissioners
	Chief Engineers of officers in charge of CPWD, PWD of Delhi and NCR towns to identify unpaved roads with heavy traffic and provide information to respective Municipal Commissioners
Strict vigilance and no tolerance for visible emissions – stop plying of visibly polluting vehicles by impounding or heavy fine.	Commissioner or Officer in Charge, Transport Department and Traffic Police of NCT Delhi and NCR towns
Strict vigilance and enforcement of PUC norms	

Graded Response Action Plan

Moderate to poor(ambient $PM_{2.5}$ or PM_{10} concentration value is between 61-120 µg/m^3 or 101-350 µg/m^3 respectively)	**Agency responsible/Implementing Agency**
Stringently enforce rules for dust control in construction activities and close non-compliant sites	Commissioner or Officers in charge of Police Departments of Delhi and NCR towns
Deploy traffic police for smooth traffic flow at identified vulnerable areas	Commissioners Traffic Police of Delhi and NCR Towns
Strictly enforce Supreme Court order on diversion of non-destined truck traffic and ensure only trucks registered after 2005 are allowed entry into Delhi	Municipal Corporations of NCT of Delhi and NCR towns
	Traffic Police of NCT of Delhi and NCR towns
Strictly enforce Supreme Court ban on firecrackers	Chief Controller of Explosives
	Petroleum and Explosive Safety Organizations (PESO) Commissioner of Officer in charge of licensing in the police departments of Delhi and NCR
Ensure fly ash ponds* are watered every alternate day during summer months (March – May).	Plant in charge of Power Plants in Delhi and NCR towns

Graded Response Action Plan

Moderate to poor(ambient $PM_{2.5}$ or PM_{10} concentration value is between 61-120 µg/m^3 or 101-350 µg/m^3 respectively)	**Agency responsible/Implementing Agency**
Information dissemination Social media, mobile Apps should be used to inform people about the pollution levels, contact details of control room, enable them to report polluting activities/sources to the concerned authorities, and actions that will be taken by government based on the level of pollution.	Chairpersons, Delhi Pollution Control Committee, State Pollution Control Boards of Haryana, Rajasthan, and Uttar Pradesh

Emissions Trading Scheme Theory and Practice

BACKGROUND AND EXAMPLES

1. Background
2. Command-and-Control
3. Emissions Trading
4. Simple Example of ETS
5. Real-World Example of ETS

1. Background

Without regulations, industries produce to make the most **profit**, without thinking of **emissions**

Emissions costly for others, through ambient water and air quality (a **negative externality**)

Thus, the “cost” of pollution is not accounted for by the industry (this is called a **market failure**)

Regulation a way to make industry account for this cost

1. Background

To correct for this, two broad policy options exist:

Command-and-control measures

Market-Based Instruments

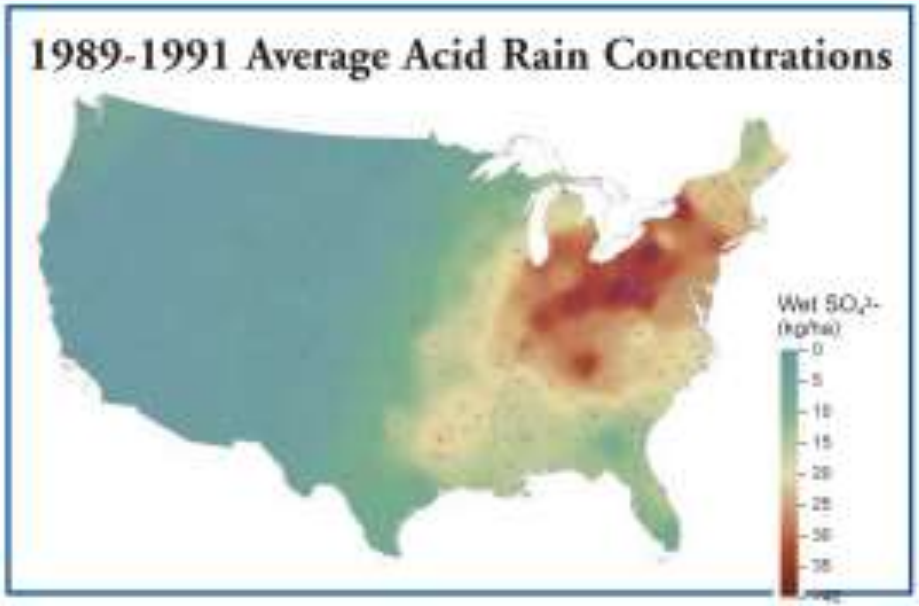
Input/Emission Taxes (Water Cess, Coal Cess)

Emissions Trading

Emissions Trading System: Main Elements

1. CAP total amount of emissions
2. PERMIT industries to emit some amount under this cap
3. Industries may TRADE permits among themselves
4. COMPLY by having permits >= emissions.

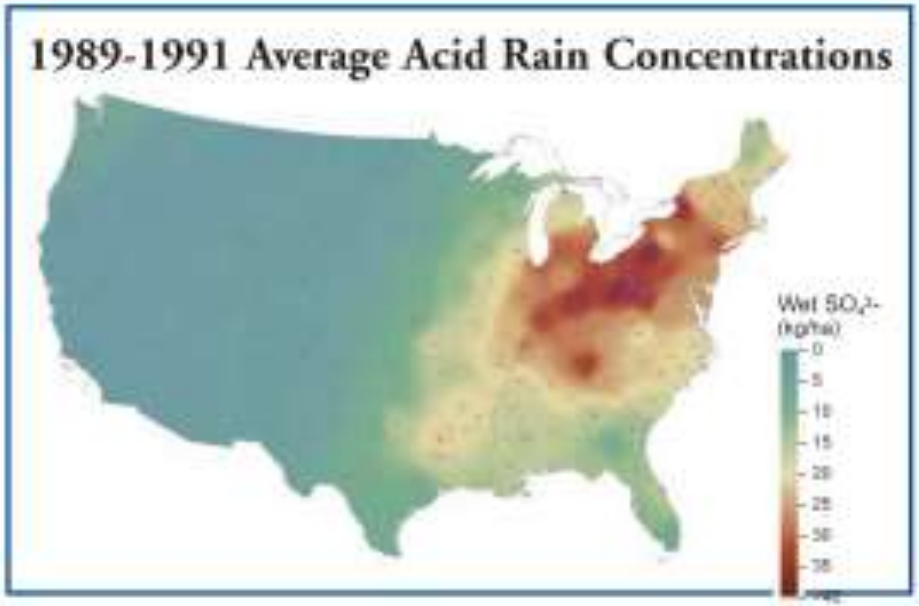
US Acid Rain Program (SO_2) Example

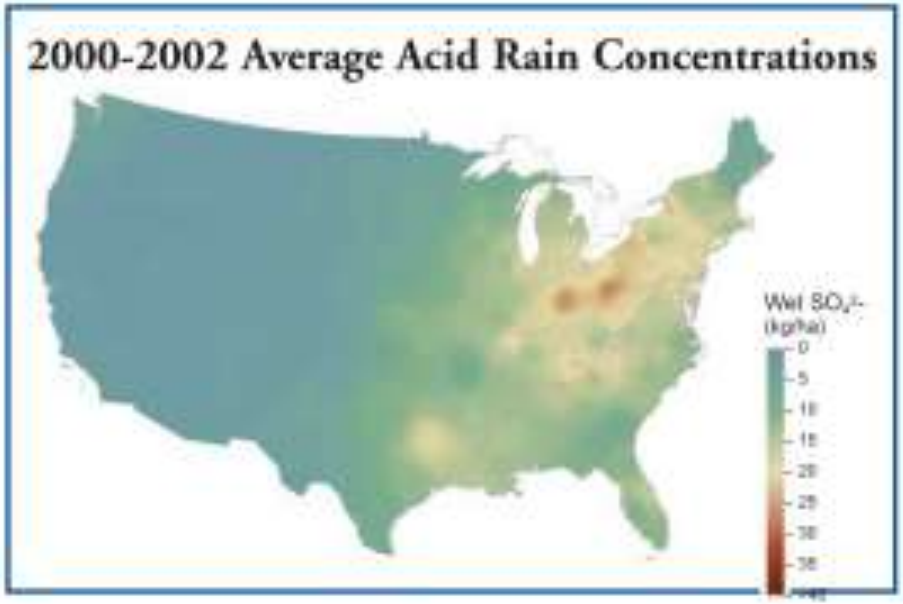


Source: EPA
(http://www.epa.gov/capandtrade/documents/ctresults.pdf)

- Deposition of acid rain from SO_2
- Most emissions in power sector

US Acid Rain Program (SO_2) Example



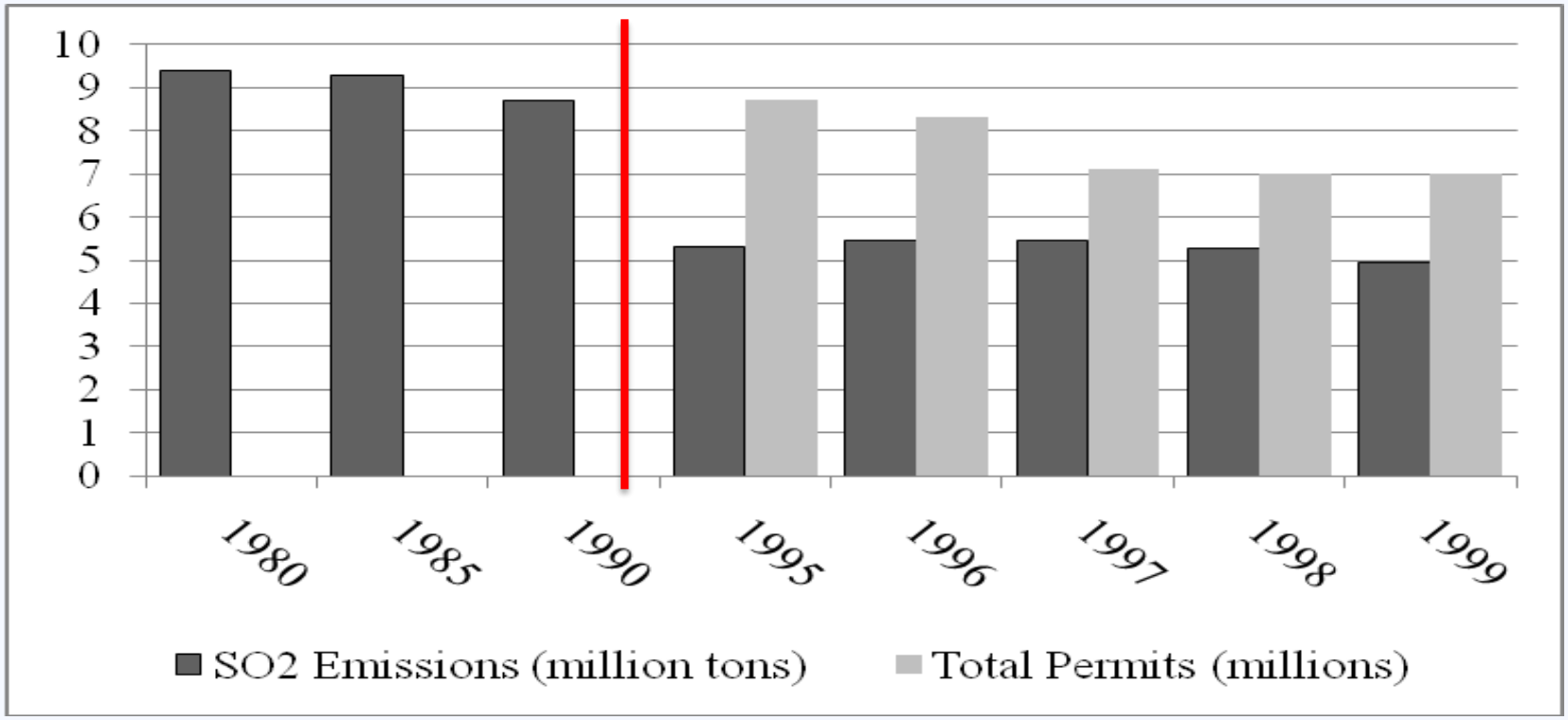


Source: EPA
(http://www.epa.gov/capandtrade/documents/ctresults.pdf)

- Large and uniform reductions in acid rain

US Acid Rain Program (SO_2) Example

- Large and immediate reductions in emissions



2. Command-and-Control

Fixed orders regarding pollution control levels or methods (e.g., concentration norms, equipment)

The cost of meeting existing norms may vary widely between industries, based on existing equipment, manpower, and other industry-specific characteristics.

Industries shoulder similar shares of total emissions reduction burden (known as **abatement),** regardless of their respective costs of doing so

Results in higher overall compliance cost

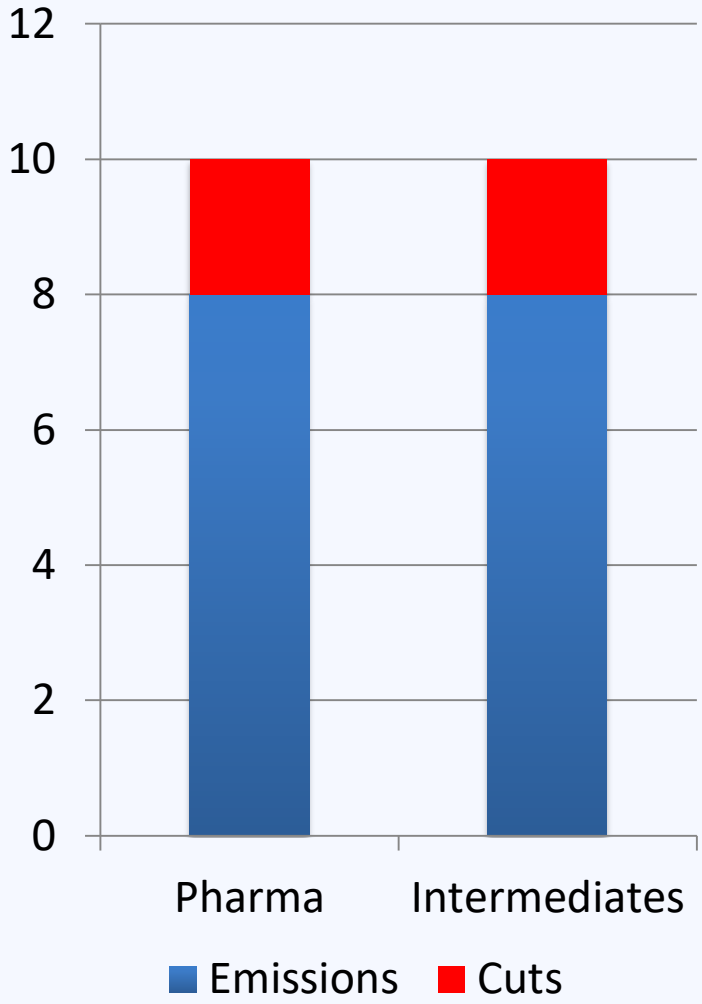
Industries have widely varying costs

US Example:

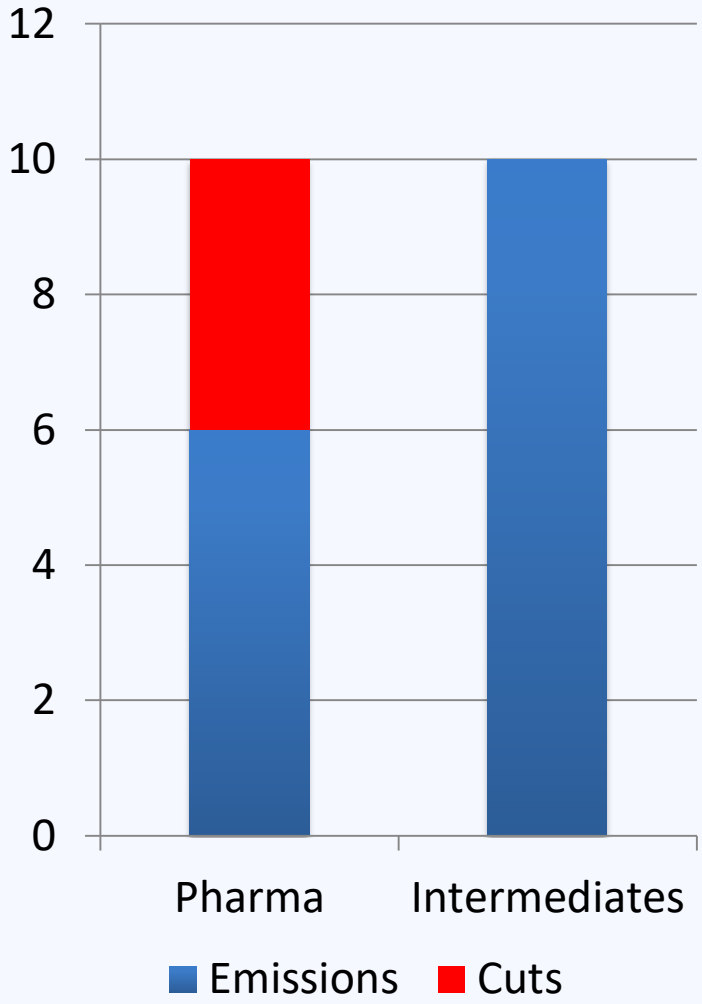
"Because of differences in location, design, and utilization rate, existing generating units differ considerably in the ease and cost with which they can switch to lower-sulfur fuel or accommodate scrubbers" (Schmalensee et al., 1998)

Indian Example at right:

Industries have widely varying costs



Industries have widely varying costs



3. Emissions Trading Scheme (ETS)

Designed to encourage abatement by putting a price on emissions

- Differences between industries' abatement costs produces gains from permit trading

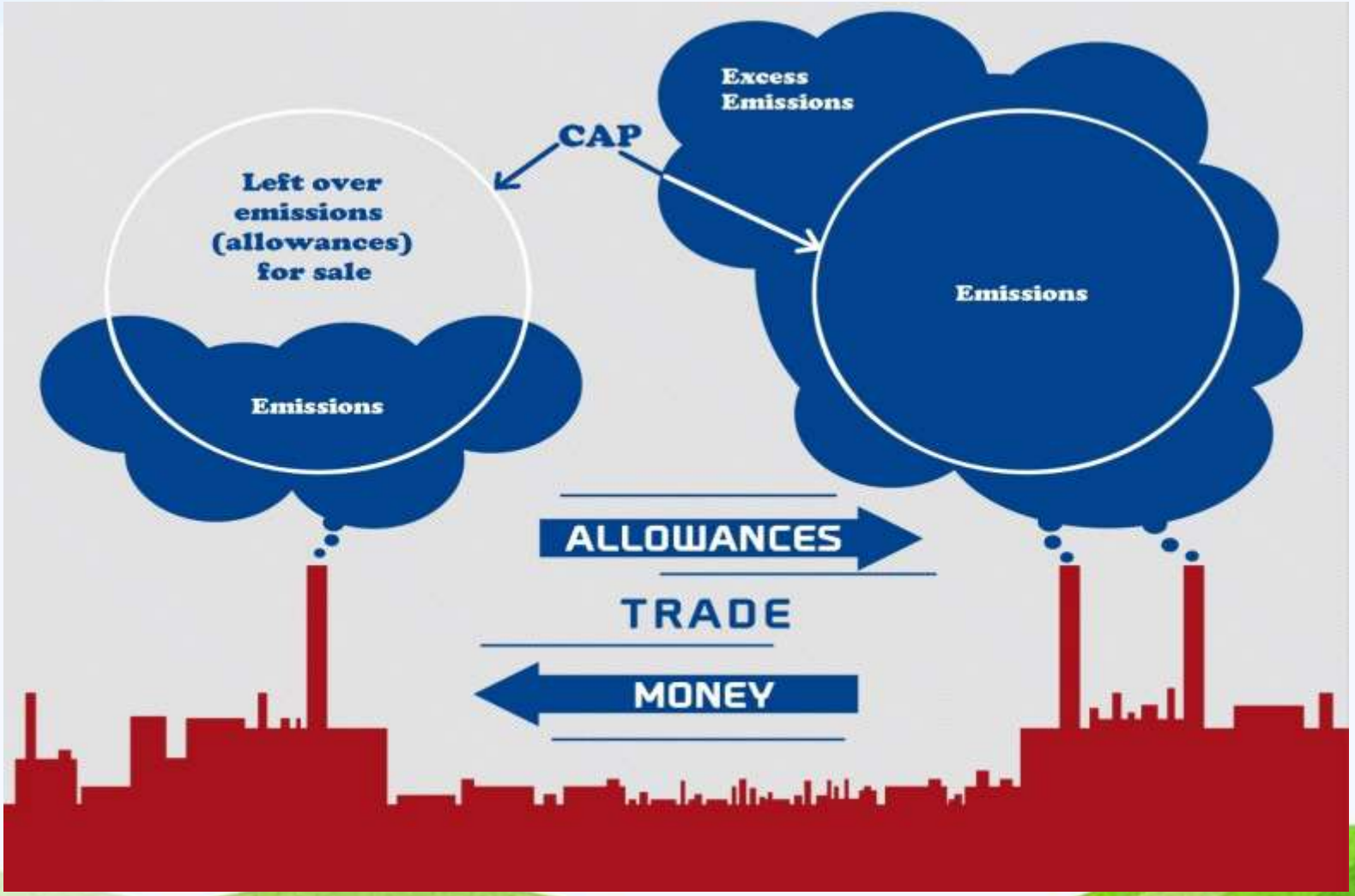
Abatement achieved at lowest cost

- Industries with cheapest ways to reduce emissions achieve more of total reductions

Powerful incentives to adopt better abatement technologies

- Pays to clean up a bit more if a sufficiently low-cost method can be identified and adopted

Emissions Trading Scheme Simplified



Command-and-Control vs. ETS

Status Quo: Command & Control	Emissions Trading
Norms fixed for industry	Cap set for total emissions
Compliance meeting norms for concentration	Compliance having permits to cover emissions
Industries have single option, regardless of costs	Flexibility to lower costs and incentive to keep reducing emissions
Monitoring based on manual sampling	Monitoring based on CEMS

For Industry:
Cost savings and regulatory certainty

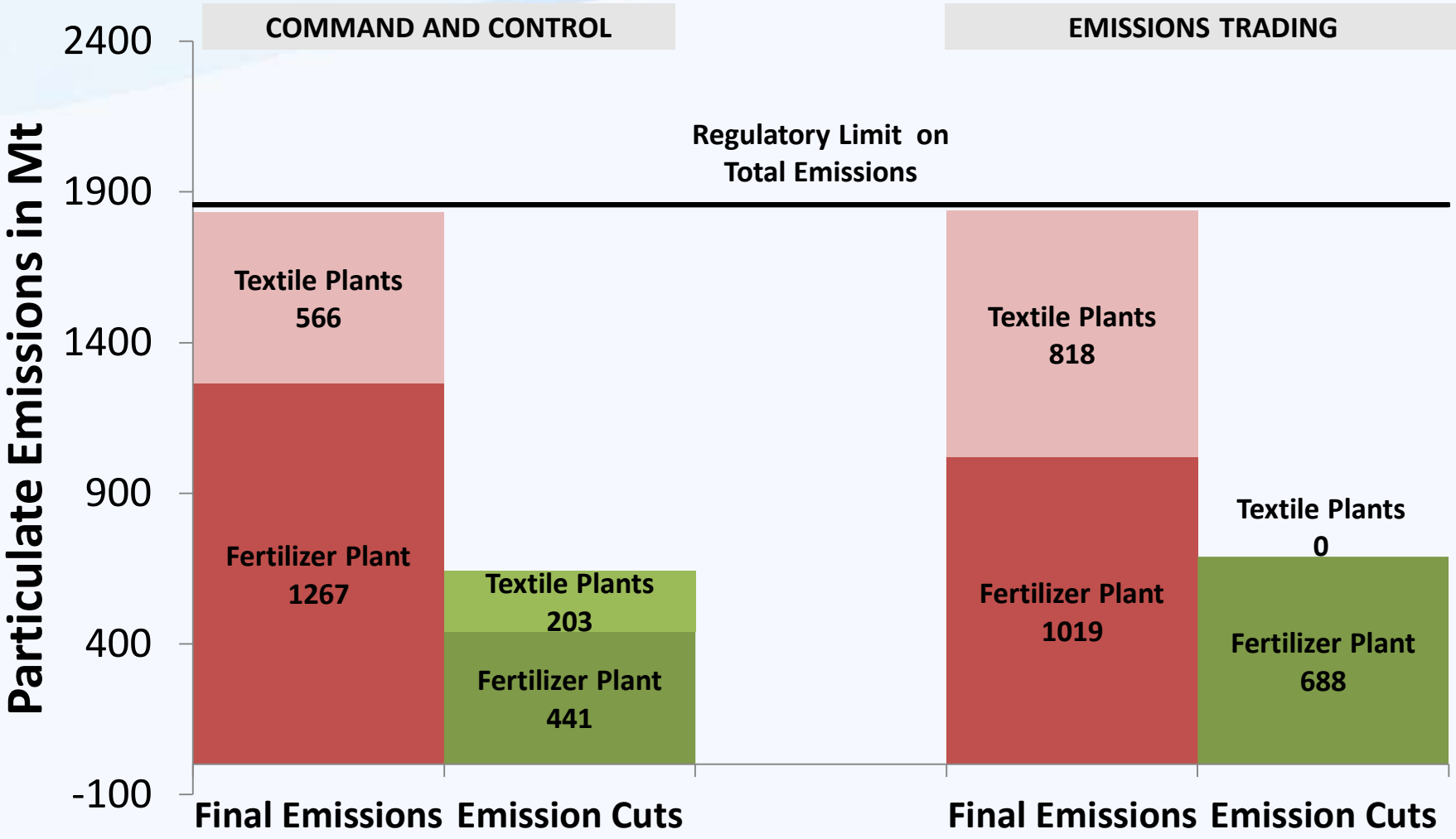
Consider two group of industries using different fuels

- Group A with 1 unit using 8500 Mt / month of FO and emitting 1700 kg of particulates each year
- Group B with 3 units using primarily husk and emitting 600 kg of particulates each year

Figures based on actual data from fertilizer plant and textile unit

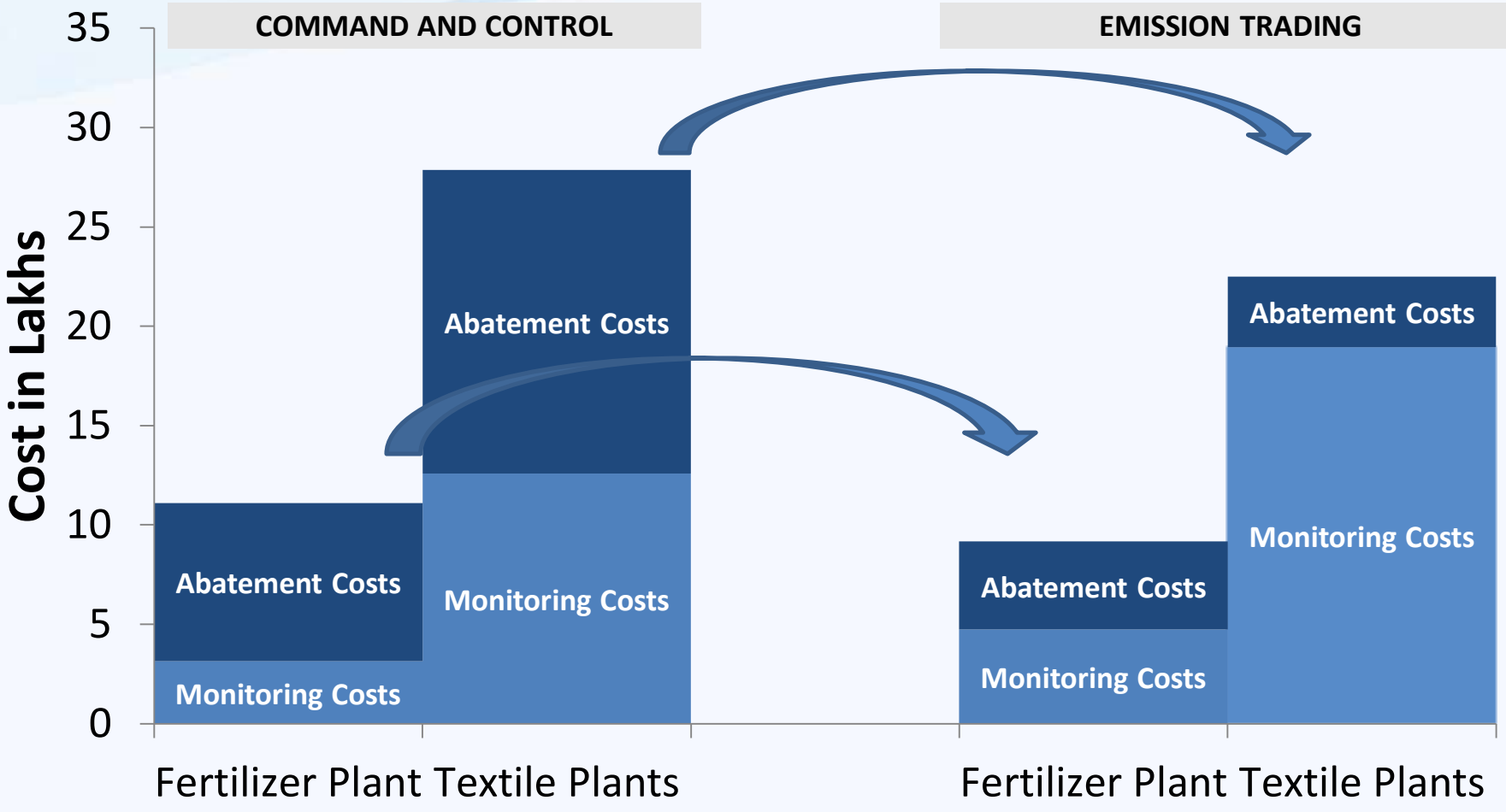
Group A higher emissions but lower abatement cost

Scheme Limits Total Emissions



- Market-based scheme has far lower abatement and total cost
- All units achieve lower cost through emissions market

ETS Lower Cost for All Industries



- Market-based scheme has far lower abatement and total cost
- **All** units achieve lower cost through emissions market

THEORY AND PROGRAM DESIGN

1. Basics of ETS
2. Components of ETS
    1. Emissions Cap
    2. Allocation of Permits
    3. Permit Trading
    4. Monitoring
    5. Compliance
3. Putting it Together

1. Basics of ETS

Regulator sets total emissions amount but does not decide what any particular source will emit

- Industries face price for their emissions and can buy and sell permits to emit under the cap
- Price of emissions makes pollution costly and gives incentive to cut back

Industries have flexibility to design own compliance strategy

- Abatement through technology upgradation, or permit trading
- Flexibility allows units with low cost of reductions to emit less and sell their right to emit to others, lowering overall compliance costs

2. Components of an ETS

Basic components same for all schemes

Cap on overall emissions from a group of sources

Allocation of emissions to pollution sources

Trading system to allow exchange of permits

Monitoring of emissions from each industry must be reliably and continuously monitored with high integrity

Compliance system to enforce permit holding

2.1 Emissions Cap

Total limit on **mass** emissions, set by the government to meet environmental goals.
Must be neither so high that no reductions achieved nor so low as to be prohibitively costly to firms.
Baseline emissions monitored for 6 months before trading and cap set below baseline levels
Precise level of cap will be informed by a study of abatement costs.

- If industry abatement costs are low, cap will be more stringent, and vice versa

Emissions Cap: Concentration vs. Load

Emissions cap (and therefore, permits) based on load standards because:

- health and environmental outcomes typically influenced by mass/volume of pollutants and not directly by concentration
- Higher pollution load normally translates into higher ambient concentration while limit on concentration may still allow for a high total load to be emitted
- Increase compliance options available to industry
  - e.g. total load reduced by decreasing operating hours, but this is not helpful for an industry complying with concentration standards.

Link: Aside on Marginal Abatement Costs

2.2 Allocation of Permits

Cap divided into fixed number of permits and allocated to regulated sources

Permits allocated through an auction, with revenues rebated in proportion to baseline emissions

- Firms submit incremental bids
- Provides greatest amount of information about firm abatement costs
  - A higher bid price implies higher abatement costs
- Result in a unique price for permits at the start of the scheme

2.3 Permit Trading

Intermediated by an exchange

- Matching buy and sell orders according to their prices, processing payments, recording unit IDs and permit IDs and submitting information to the SPCBs

Permits valid for one compliance period only

Give 1-month after each compliance period (usually a year) where units may continue to trade in order to fulfill permit holdings (known as the **true-up period)**.

2.4 Emissions Monitoring

Emissions will be monitored continuously

- Real-time information
- Enables use of load standards (vs. concentration)
- Transparency and Openness
- Emissions reductions made at lower cost

A DAHS system will analyze and store emissions data in a central server

- This information will be used to reconcile permit holdings with total emissions after compliance period

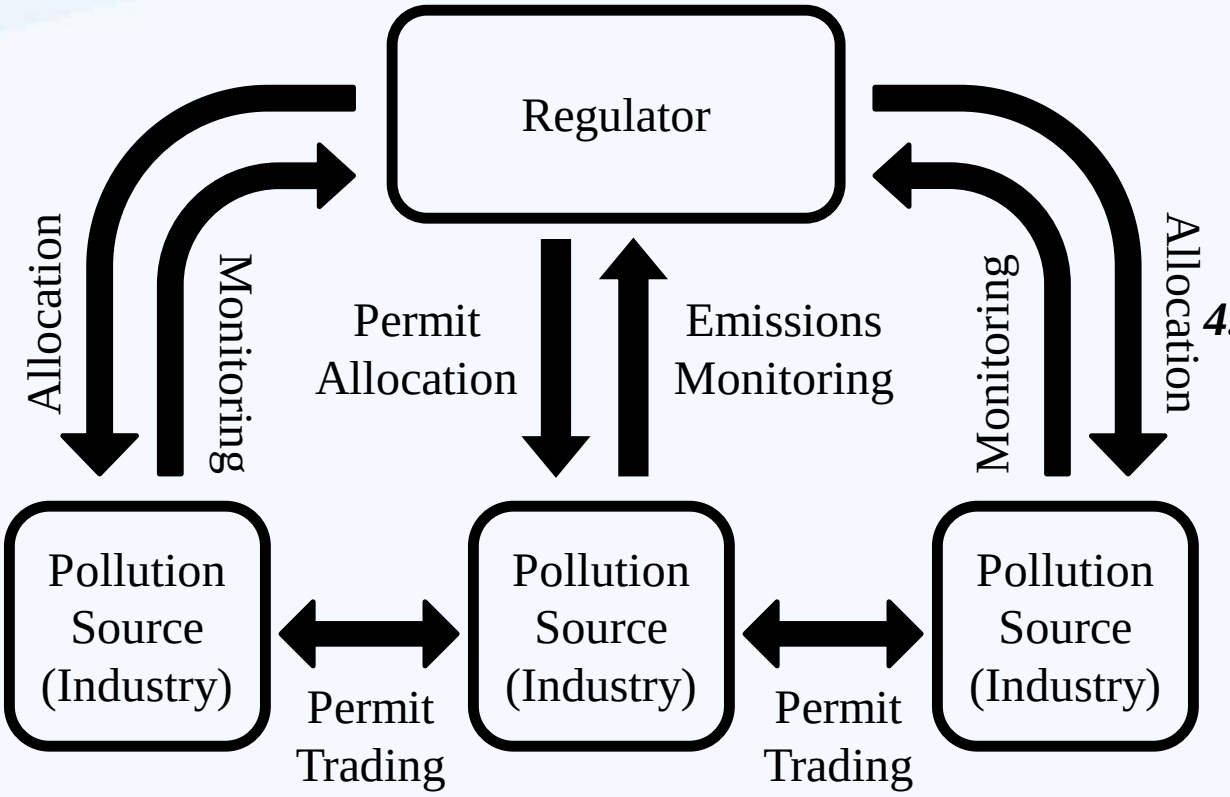
2.5 Compliance

After compliance period, difference between aggregate emissions and permit holdings is calculated

- No exceedance → in compliance
- Exceedance→ excess emissions used to calculate penalties

Fine is calculated as 2 times the maximum permit price during true-up period

3. Putting it Together



1. ***Allocation.*** Regulator sets overall cap and allocates permits.

2. ***Trading.*** Industry buys more permits or sells excess and adjusts emissions to be below permit holdings.

3. ***Monitoring***. Regulator monitors total emissions of targeted pollutant.

4. ***Compliance.*** Regulator checks that all sources have enough permits for emissions.

CROSS COUNTRY EXPERIENCE

1. ETS Around the World
2. U.S. Acid Rain Program
3. Sample of Existing ETS
4. Sample of Proposed Programs

1. ETS Around the World

ETS has been quite successful in practice, achieving desired reductions at lower-than-expected cost.

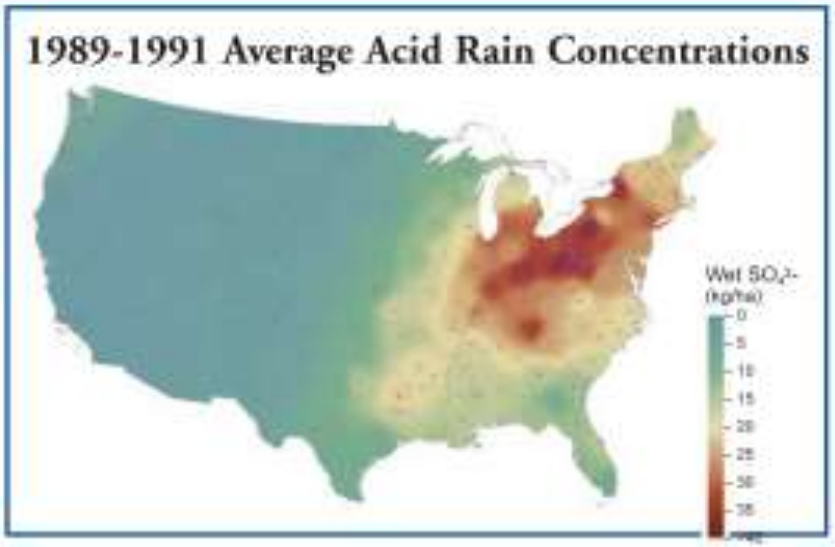
Applied to wide range of air and water pollutants

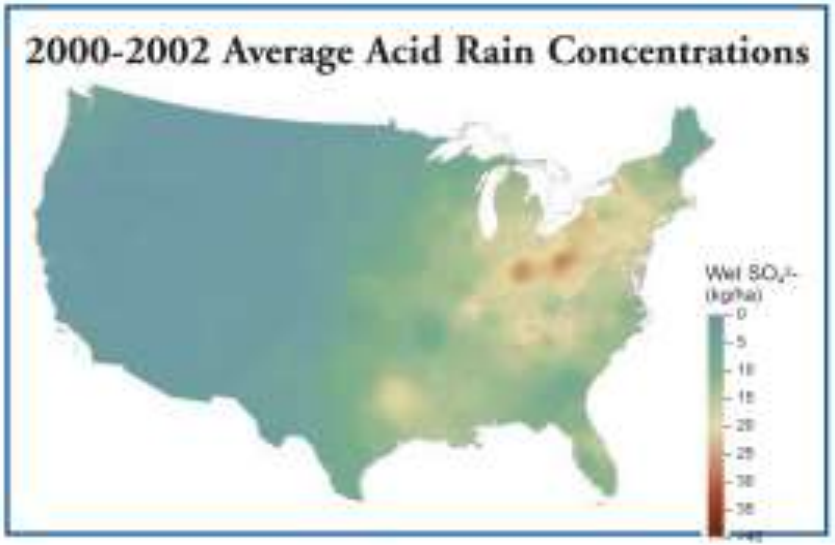
Pioneered by US EPA and adopted by regulators in Canada, Europe, China, etc.

Consider several examples . . .

2. U.S. Acid Rain Program

In 1995, total emissions fell from 8 to 5 million tons.
Switch to low-sulfur coal and using scrubbers to remove SO2 from stack gases
Estimated savings to firms was $225-$374 million





3. Existing ETS

US – several including:

- Acid Rain Program – SO_2
- Regional Greenhouse Gas Initiative (RGGI) – CO_2

New Zealand – All GHGs

Canada – several, covering all GHGs and other pollutants such as VOCs, NOx, SO_2

EU ETS – CO_2

- Linked programs in Norway, Iceland, Liechtenstein

4. Proposed Programs

India – PM emissions
China – SO2
Republic of Korea – CO2

THANK YOU !

CHIRAG BHIMANI
chirag@bhimani.in
+91- 98796 52844

Existing Market-Based Programs

Country / Region		Scheme name	Design	Year	Covers	Effects/Target
European Union		EU ETS	ETS	2005-present	CO2	21 % cut below 2005 levels by 2020
	Norway	Norway ETS	Linked to EU ETS	2005-present	CO2; NO2	Same as EU ETS
	Iceland	Iceland ETS	Linked to EU ETS	2005-present	CO2	Same as EU ETS
	Liechtenstein	Liechtenstein ETS	Linked to EU ETS	2005-present	CO2	Same as EU ETS
United States		Emissions Trading Program	ETS	1974-pres.	Criteria Air pollutants covered in Clean air act.	Performance unaffected; savings = $5-12 billion
		Acid Rain program	ETS	1995-Present	SO2 emission reduction credits	SO2 reductions achieved ahead of schedule; savings of $1 billion/year
	CT, DL, ME, NH, NY, VT, MA, RI , MD	Regional Greenhouse Gas Initiative (RGGI)	ETS	2005-pres.	CO2	10% cut below 2009 levels by 2018
	United States (27 eastern states)	Clear Air Interstate Rule (CAIR)	ETS	2005-pres.	SO2; NOx	61% reduction from 2003 levels
		RECLAIM Program	ETS	1994-pres.	SO2; NOx	NOx emissions fell by 60%; SOx emissions by 50 per cent.

Existing Market-Based Programs

Country / Region	Scheme name	Design	Year	Covers	Effects/Target
Switzerland	Swiss ETS	Combination of CO2 tax and ETS. Planned link to EU ETS	2008-pres.	CO2	N/A
New Zealand	New Zealand Emissions Trading Scheme	ETS	2008-pres.	All GHG's	Between 10 and 20% cut below 1990 levels by 2020
New South Wales	New South Wales Green House Gas Abatement Scheme (NSW GGAS)	Rate-Based Scheme	2003-pres.	All GHG's	N/A
Japan	Japan Voluntary Emissions Trading Scheme (JVETS)	ETS	2005-pres.	CO2	25% cut below 1990 levels by 2020
Chile	Santiago Air Emissions Trading	ETS (emission rights trading among stationary sources)	1995-Present	Total suspended particulates	Low trading volume; decrease in emissions since 1997 not definitively tied to TP system

Existing Market-Based Programs

Country/Region		Scheme Name	Design	Covers	Target	Launch Date
Australia		Clean Energy Bill (carbon pricing mechanism)	Carbon tax	CO2	Reduction by at least 5 per cent compared with 2000 levels by 2020	2012 (under development)
United States/Canada						
	California (USA), B.C.(Can), Manitoba (Can), Ontario (Can), and Quebec (Can.)	Western Climate Initiative (WCI)	Carbon Offset Program	All GHG's	Cut emissions 15% below 2005 levels by 2020	January 2013
	United States (28 states)	Cross-State Air Pollution Rule (CSAPR)	ETS	SO2; NOx		To replace CAIR Jan 2012, Implementation plan Jan 2013
	California	California Global Warming Solutions Act (AB 32)(Part of WCI)	ETS	All GHG's	Cut to 1990 levels by 2020	Emissions permit auction in November 2012
	Quebec (Canada)	Quebec ETS (Part of WCI)	ETS	All GHG's	20% reduction below 1990 levels by 2020	First compliance period in 2013. Will run from 2013-2020

Existing Market-Based Programs

Country / Region		Scheme name	Design	Year	Covers	Effects/Target
Canada		Regulatory Framework for Air Emissions	Rate-based system: contribute to a technology fund, emissions trading, or offsets		All GHG's	industrial emission-intensity reduction of 26% by 2015
		ODS Allowance Trading	ETS	1993-1996 1996-Present 1995-Present	CFCs and Methyl Chloroform HCFCs Methyl Bromide	Low trading volume, except among large methyl bromide allowance holders
		Pilot Emissions Reduction Trading (PERT)	ETS	1996-Present	NOx, VOCs, CO, CO2, SO2	N/A
		Greenhouse Gas Emissions Reduction Trading (GERT)	ETS	1997-Present	NOx, VOCs, CO, CO, SO2	N/A
	Alberta	Climate Change and Emissions Management Act	Facilities make operating improvements, buy credits, or contribute an Emissions Fund		All GHG's	reduce emissions vis-a-vis GDP to 50% of 1990 levels by 2020

Proposed Programs

Country/Region	Scheme Name	Design	Covers	Target	Launch Date
India	**Pilot Emissions Trading Scheme for Particulate Matter**	**ETS**	**Particulate Matter (PM)**	**N/A**	**Trading to begin in 2014**
China	Pilot Emissions Trading Schemes in several cities and provinces	ETS	CO2	40-45% reduction of carbon-intensity below 2005 levels by 2020.	Pilots to begin in 2013/14. Nation scheme in 2015
Republic of Korea	National Emissions Trading Scheme	ETS	CO2	30 % reduction below forecast "business as usual" levels by 2020	2015
Taiwan	Taiwan Carbon Offset Scheme	Carbon Offset	CO2	Cut to 2005 levels by 2020	Unknown