

## Air Quality in Mumbai

### Introduction

Air quality is poor in many cities, especially in the less economically developed nations. Change is not all one way and many city authorities are engaged in ameliorative measures. This exercise uses a news item about a policy change in Mumbai (Bombay) as a lead into a discussion about the quality of that decision and the use or abuse of evidence to critique the decision.

### Method

#### Activity 1 The decision

Distribute the summary policy decision (Resource 1).

Ask students to discuss, in pairs or small groups, based on oral questions, e.g. What is this about? What is the problem? Why the changes and why so quickly? What evidence would you like to help you decide if this was a good policy decision?

*5 minutes*

#### Activity 2 Is this a good policy decision?

In this second and more important activity following on from activity 1, the teacher supplies information on request to groups. There are six pieces of information available (Resource 2 A-F). Many students will ask only general questions such as 'What is happening in the city then?' and groups need to be encouraged to be more precise, to reflect on the question a little. With only six items of information available, not all questions can be accommodated but again this is quite realistic - we are always working with information which is incomplete or inadequate.

Each group feeds back on the responses they have after discussion of the resources. Their feedback is guided by the questions under the photograph of resource 1.

Information available:

- A In Mumbai, CNG or Nothing
- B Ambient Air Quality at Traffic Junctions in Mumbai During 2001
- C Asian Brown Cloud
- D Car numbers and Population over time
- E Air Pollution Health Studies and their relationship to vehicle technology
- F Delhi's struggles with reducing pollution -news clips

#### References

##### Textbook

Chapter 11 pg 143-154

##### Specification

10.3 Air Quality

12.1a, b

12.5d

#### Method

##### *Use small group discussion because*

- Students enjoy it
- It allows active involvement by everyone
- One loud or quicker thinking student cannot dominate the class
- The shy and less articulate are more able to contribute
- Students learn from each other
- Everyone gets more practice at expressing their ideas
- A two way discussion is almost always more creative than individual thoughts
- Social skills are practiced in a "safe" environment
- It helps individuals clarify arguments for a topic where there are no "right answers"

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*Hint***Running small group discussion**

- Make sure that the task is clear and has a definite product which has to be communicated back
- Make sure students have enough knowledge and resources to complete the task
- Don't let it run for too long - Some groups will stray off task
- Drop in on groups for short periods with support or challenge as appropriate
- Make sure that seating allows everyone in the group to see each other, best round a table not side by side
- Do not allow one group to become too noisy - they will attract interest from other groups, who will then lose their own identity
- Normally groups work best with friends because they trust them but be prepared to break up groups which are not working - some members will be pleased
- Allow time for feedback at the end and value the contributions of all groups.

Student presentations are scheduled after a suitable period of say 20 minutes – this allows the teacher to circulate, helping with information needs and also checking out the progress groups have made. The presentation should be quite general with an emphasis on how students coped with the variety and limited nature of the evidence and some comment about how this is quite routine in science itself. All of the resource items are unedited for language level some are very technical and others more newsy. Coping with this is part of the task.

*40 minutes***Activity 3 Are there other solutions?**

A follow up piece of work is to ask students in groups to consider what would constitute a better way of reducing air pollution, not only in Mumbai, but elsewhere. There is much in the Resource 2 items but a set of cards is provided under three headings; Technical; Regulatory and Economic (Resource 3). The cards are little more than prompts and a few lines and teachers may wish to expand them according to the perceived needs of the class and the time available.

**Suggested use of cards:**

Give out the cut-up cards. Ask the groups to prioritise three 'solutions' for immediate action. Students can modify or add to the cards if they wish. Groups can quickly justify why they have selected their solutions. Whole class discussion could include the nature of the solutions.

As they stand the cards promote the idea that a range of options is available and that different choices reflect not only technical possibilities but the realities of political, economic and social conditions. A 'solution' in Mumbai may not be appropriate in say London. It may surprise some to discover that the cards do not cover voluntary actions or as it is sometimes described 'doing one's bit'. It has always been a distraction, a way of displacing attention - making solutions to environmental problems a personal and moral question rather than a social, technical and political one. It is particularly inappropriate in a city like Mumbai where so many people have so little choice anyway.

*15 minutes***Cards from Resource 3****Technical (T)**

fuel cells  
biodiesel  
hypercar  
LPG

**Regulatory (R)**

car free days  
low emissions rules  
remove old vehicles  
congestion charging  
zero emissions rules

**Economic (E)**

ecotaxes  
tolls  
rebate for scrapping cars  
integrated public transport

## Resource 1

Mumbai is a very large city in India. It used to be called Bombay. In the spring of 2002 the High Court issued an order that all the diesel taxis in the city change to using compressed natural gas [CNG]. They were allowed a few months to do it under penalty of being banned from working.



A taxi being converted to use CNG

### **Task**

*What is this about? What is the problem? Why the changes and why so quickly? What evidence would you like to help you decide if this was a good policy decision? Find out and report back.*

---

**Resource 2**

A

**In Mumbai, CNG or nothing**

by Lyla Bavadam

**THE** Bombay High Court order stating that all diesel-engine Premier model taxis in Mumbai be either phased out or converted to compressed natural gas (CNG) or liquefied petroleum gas (LPG) by May 31, opened a can of worms that has, among other things, exposed the lack of infrastructure to facilitate the change... The order states that by April 30 all diesel taxis will have to go off the road and by May 31 their registration should be cancelled if they have not been converted... J.P. Cama, who represents the taximen in court, said, "The immediate implication of the order is that you are taking away livelihoods without providing any alternatives."... Taxis provide direct employment to about 1.5 lakh people and indirect employment to five lakh people in Mumbai. Of around 55,000 taxis registered in Greater Mumbai, about 15,000 run on diesel. Only around 500 of these have been converted...the conversion will involve replacing the diesel engine with a petrol one and attaching the CNG kit to it. The total cost of this is Rs.60,000. There are not enough petrol engines to meet the demand ... Taximen are thus forced to depend on the secondhand market.

"Naturally it is not possible to find 15,000 secondhand petrol engines so soon," said A.L. Quadros, general secretary of the Mumbai Taximen's Union.... At the rate of three cars a day, the 16 authorised retrofitting stations in the city can convert only 48 cars a day. With approximately 25 working days a month, this works out to 1,200 cars a month. That still leaves more than 13,000 taxis to be converted.... There are only 23 CNG stations to service the 15,000 CNG taxis (most of the petrol taxis have already been converted to CNG) in the city...Most of the refilling stations are located in the suburbs whereas the majority of the taxis ply in the island city. One cylinder lasts 60 to 70 km, and on an average a taxi covers about 90 km a day. The cylinder has to be refilled every day, and if the filling pressure is low it takes longer to fill... Many taxi-owners are still paying off loans they took to purchase their vehicles, making it impossible for them to handle the extra burden of Rs.60,000 required for the conversion to CNG.

*Frontline* Volume 19 - Issue 09, Apr. 27 - May 10, 2002\*

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B

Ambient Air Quality at Traffic Junctions in Mumbai During 2001												
	Jan 2001		Feb 2001		Mar 2001		Apr 2001		May 2001		Jun 2001	
Location:	<i>Sion</i>	<i>Mulund</i>	<i>Sion</i>	<i>Mulund</i>	<i>Sion</i>	<i>Mulund</i>	<i>Sion</i>	<i>Mulund</i>	<i>Sion</i>	<i>Mulund</i>	<i>Sion</i>	<i>Mulund</i>
<b>NOx Hrs Standard 80 ug/m3</b>												
Average	38.17	58.29	44.48	41.64	45.3	45.15	15.82	33.88	13.03	31.45	7.83	
Minimum	3 8.03	9.58	11.54	1.00	20.79	20.03	9.17	16.35	4.53	17.56	3.76	
Maximum	92.72	156.37	130.77	123.17	90.12	108.12	39.28	76.01	45.04	65.07	16.94	
95 Percent	77.80	110.37	80.69	88.08	75.08	89.18	24.22	55.10	21.14	44.41	16.37	
<b>NOx Standard 80 ug/m3 For 24 hrs.</b>												
Average	-	-	530.49	32.87	660.41	243.05	97.61	367.57	44.34	206.59	53.22	
Minimum	-	-	4.33	20.00	156.39	152.17	5.15	74.29	20.21	76.44	17.44	
Maximum	-	-	1.025	130.16	11467	40.34	531.30	1206.30	162.47	400.98	256.68	
95 Percent	-	-	956.46	53.65	996.58	447.08	260.20	1083.20	107.89	333	141.67	
<b>PM10 Standard 100ug/m3 For 24 hrs</b>												
Average	232	130	-	-	190.12	111	72.28	-	151.74	130	112.03	
Minimum	172	29	-	-	116	108	3.57	-	0.16	95	12.00	
Maximum	336	257	-	-	285	114	300.34	-	1000.00	214.00	544.00	
95 Percent	302	231.80	-	-	273.8	113.7	196.00	-	829.06	183.00	403.55	
<b>CO Standard 4 ug/m For 1 Hrs. Average</b>												
Average	37.60	641	7.96	7.29	6.47	6.09	2.43	7.06	1.15	7.63	1.3	
Minimum	5.74	5.51	3.56	6.62	5.1	5.37	0.18	5.74	0.73	6.40	0.46	
Maximum	8.83	7.95	11.28	8.46	8.13	7.13	5.80	8.39	2.29	9.13	3.34	
95 Percent	8.64	7.19	10.30	8.07	7.92	6.5	4.57	8.03	1.88	8.75	2.66	

Notes: Standard = assumed safe limit  
95 Percent = 95 percentile

C

**ASIAN BROWN CLOUD**

by Jeremy Lovell

*Reuters News Service*

A three-km (two-mile) thick cloud of pollution shrouding southern Asia is threatening the lives of millions of people in the region and could have an impact much further afield, according to a United Nations-sponsored study.

It said the cloud, a toxic cocktail of ash, acids, aerosols and other particles, was damaging agriculture and changing rainfall patterns across the region which stretches from Afghanistan to Sri Lanka.

U.N Environment Programme chief Klaus Toepfer ... said the cloud was the result of forest fires, the burning of agricultural wastes, dramatic increases in the burning of fossil fuels in vehicles, industries and power stations and emissions from millions of inefficient cookers

The report calculated that the cloud - 80 percent of which was man-made - could cut rainfall over northwest Pakistan, Afghanistan, western China and western central Asia by up to 40 percent.

Apart from drastically altering rainfall patterns, the cloud was also making the rain acid, damaging crops and trees, and threatening hundreds of thousands of people with respiratory disease.

<http://www.planetark.org/dailynewsstory.cfm/newsid/17269/newsDate/13-Aug-2002/story.htm>

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## C

## Report Urges Clean Air Policies in Mumbai, India

... In addition to illnesses and lost work hours, the report estimates that air pollution in Mumbai causes approximately 2,800 premature deaths, with health damages costing over \$500 million (Rs 18 billion) a year.

Automobiles, power plants, industry, and smoke from burning wood and garbage in Mumbai increasingly contaminate the air. The amount of lead in the air, which adversely affects blood pressure, the nervous system, and kidneys, doubled from 1980 to 1987. And nitrous oxide, which causes lung damage, increased by roughly 25 percent.

A 1990 study observed a 5-10 percent increase in respiratory problems, heart disease, and skin allergies in eastern Mumbai communities located near factories. And in two areas with considerable traffic, another study found a correlation between air pollutants and frequency of colds and loss of breath.

“In many cases, the costs of inaction exceed the costs of implementing the policy measures. For example, addressing the problem of gross polluters comes at little or no costs, but could save 50 lives, 1.2 million restricted activity days, and \$3.6 million (Rs 125 million) in annual health benefits,” says Jitendra Shah, World Bank Environmental Engineer ...and Editor of the URBAIR Greater Mumbai Report.

Policies suggested in the report include stricter emissions standards and lower prices for unleaded gasoline (only recently introduced in India) to reduce the amount of lead in the air.

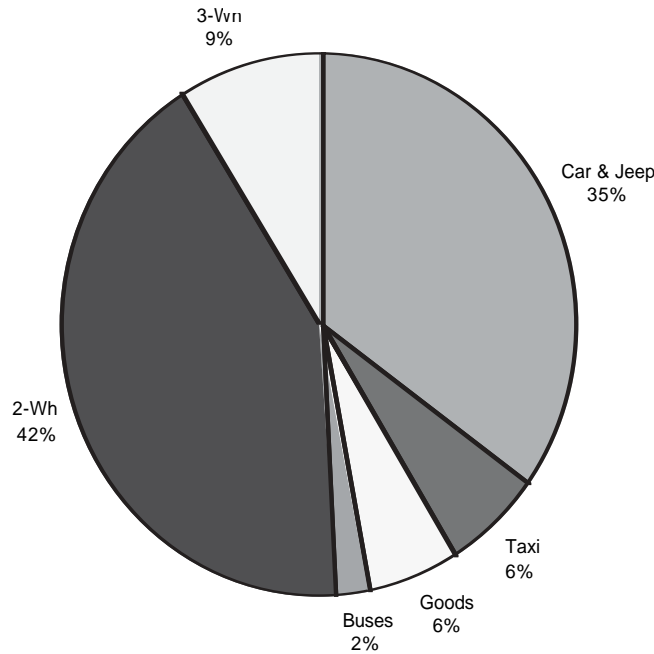
URBAIR is a program within the MEIP dealing specifically with urban air quality.

<http://web.worldbank.org/>

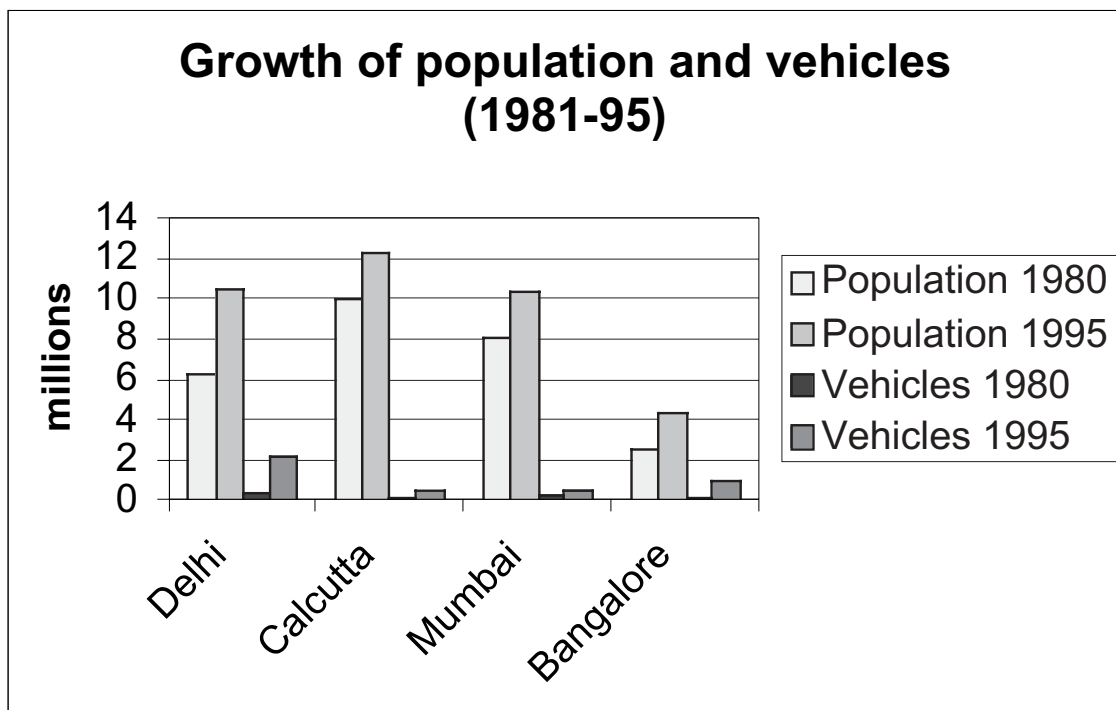
Every effort has been made to obtain permission to include this report

D

Types of vehicle in Mumbai



Note: 2 wheel vehicles are often powered by 2-stroke engines [see resource F]



## E

### **Air Pollution Health Studies and their relationship to vehicle technology**

**S.R. Kamat**

*Professor of Respiratory Medicine (retired), KEM Hospital and Seth G.S. Medical Collge, Mumbai*

Several epidemiologic studies to correct the prevailing air pollution levels in Mumbai to health morbidity have been done from 1977 by our group (1-7). Broadly we showed that in 3 urban communities, with moderately raised pollution levels (SO<sub>2</sub>, NO<sub>2</sub>, S.P.M) there was a greater morbidity for symptoms of dyspnoea, chronic and intermittent cough, frequent colds, chronic bronchitis and cardiac disease (mainly cough, high B.P. and I.H.D.), and deaths due to nontuberculous respiratory and ischaemic heart disease. There was an associated rise in respiratory deaths (SMR) in the Eastern suburbs along with increased levels of pollution (all 3 pollutants ) and cardiac deaths (associated with vehicle stagnation) in the Western suburbs.

...NO<sub>2</sub> gives long term effects with airway obstruction and bronchiolitis with possibly interstitial alveolitis, High levels of SPM inhalation leads to haemorrhagic pneumonitis in animals resulting in death after 4-6 months. In man, it causes frequent colds and chronic productive cough. When PM10 (respirable SPM), is increased, there is adsorption of hydrocarbons (PAH), POM, benzene, aldehydes to SPM which enhance carcinogenicity.

Diesel exhaust mainly liberates SPM, NO<sub>2</sub> and PAH. With development high efficiency advanced diesel engines for automobiles, there is a greater interest in this fuel. But petrol engine technology has advanced even more stringently in last 20 years. Though newer diesel engines have cleaner exhausts, due to longlife, existing heavy duty diesel engines the effect of these on human exposure will continue to be important. Thus lung cancer is likely to be about 1.5 times oftener with diesel fume exposure, as particles emitted from diesel combustion automobiles are small (90% less than 1µm) many toxic irritants and adsorbed carcinogenic substances enhance the damage.

Full story-

[http://www.indianchestociety.org/journal/jan-march/ed\\_air\\_pollution.htm](http://www.indianchestociety.org/journal/jan-march/ed_air_pollution.htm)

**F****Ban on heavy vehicles can reduce pollution by 55%**

Banning vehicles that do not adhere to Euro II norms is a proposition promising enough. Research shows that prohibiting these vehicles from plying can lead to a 55 per cent cut in the pollution level. According to a study carried out by the Centre for Science and Environment (CSE), if the 65,000 non-Euro II-compliant trucks and goods vehicles are removed from the Capital's roads, the emission level would drop from 1,700 tonnes to 800 tonnes, a reduction of nearly 55 per cent.

The Tribune, New Delhi, 22nd July, 2002

**2-Stroke engines a menace**

Transport Minister Ajay Maken, said that the Delhi Government has taken a decision to get rid of two-stroke vehicle including auto rickshaws as per the direction of Supreme Court. 2-stroke engines running on petrol emit 35 per cent more pollution than any other type of engine.

The Pioneer, New Delhi, 13th may, 2002

**With diesel buses off roads, Delhi air has become cleaner**

Commuters on Delhi roads may be a harried lot ... but at least they are breathing much cleaner air. According to the Central Pollution Control Board figures (CPCB), for the first time respirable suspended particular matter (RSPM) levels on Monday dropped to their lowest-ever in the Capital. It stood at 189 microgramme per cubic metre (MPCM) at ITO crossing. "Since the past three to four years, the RSPM level has never been so low in the months of March and April," said Sunita Narain, Director Centre for Science and Environment.

The Hindustan Times, New Delhi, 10th April, 2002

## Resource 3

### Ways of Reducing air pollution

#### T1 *Hydrogen fuel cells*

Electricity [renewables?] used to split water into hydrogen and oxygen. In a fuel cell hydrogen combines with air to create electricity to power cars (and homes?). No emissions except water vapour.

#### R1 *Car free days*

Cars are banned on certain days, for example Sundays or holidays.

#### T2 *Biodiesel*

Diesil engines can run on vegetable oils, even waste cooking oil using a cheap conversion. They always could do this...

#### R2 *Low emissions rules*

Laws demanding tough emissions targets. Regular checks carried out. Can apply to fuel quality as well.

#### T3 *Hypercar*

A very light car, but strong, advanced materials. Can achieve excellent fuel economy and last a long time. Example 'Ecobasic' idea from FIAT.

#### R3 *Remove old/dirty vehicles*

2 stroke engines, old truck engines, old car engines can be banned and scrapped.

#### R4 *Congestion charging*

Define areas of the city which are subject to charges.

#### T4 *LPG*

Liquid petroleum gas [LPG] lower emissions and cheaper. Petrol engines can be converted quite easily. Cars can still run on petrol if needed. LPG still a fossil fuel.

#### R5 *Exempt vehicles*

Encourage use of alternative fuels by making them exempt from congestion charging or other regulations.

*E1 Ecotaxes*

Increase taxes on fuels which are most polluting and/or at the same time reducing taxes on cleaner fuels

*E2 Tolls*

Congestion or road use charges -  
more use = more payments

*E3 Rebate for scrapping cars*

Encourage the removal of older vehicles by providing a rebate for scrapping them and/or public transport vouchers

*E4 Integrated low cost public transport*

Getting from A-B is cheap, comfortable and convenient whether by bus, bus/train or cycling/ bus etc