SCIENCE AND ENVIRONMENT FORTNIGHTLY

DownToEarth

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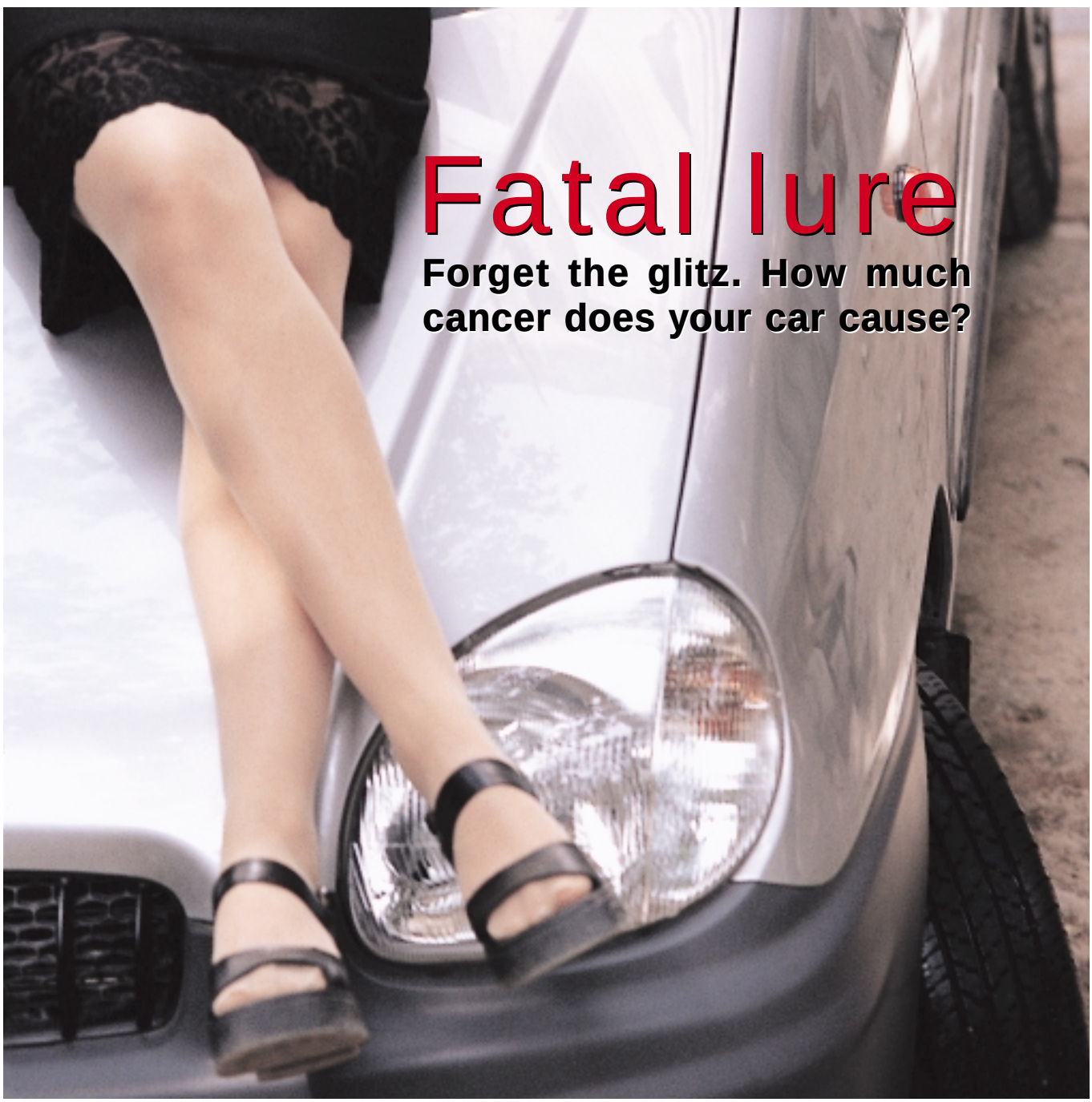


Fatal lure

Forget the glitz. How much cancer does your car cause?

Drought in Gujarat: a result of water mismanagement

Local Agenda 21 in Germany: progress despite glitches

Win some, lose some: ivory trade a case in point

PHOTOGRAPHS: AMIT SHANKER / CSE

How carcinogenic is your CAR?

Do you want a country full of cars? Cars cause cancer. Scientists can even measure the cancer potency levels of the cars we ride. The so-called cancer potency index has emerged as an important tool for risk assessment the world over. But think twice before you buy a diesel car over a petrol car. Swedish consultants at Ecotraffic found potency levels of diesel exhaust from Indian cars to be more than twice that from petrol. A German government finds diesel cars to be even worse. Meanwhile, more evidence has emerged that diesel emission is not only cancer-causing but can also trigger serious allergies and affect the poor the most. DOWN TO EARTH *presents the findings of the three studies on the subject*

In a study conducted for the Centre for Science and Environment, Swedish consultants Peter Ahlvik and Ake Brandberg at Ecotraffic have found that after taking into account all the toxic components in emissions the cancer potency level of diesel cars is double that of petrol cars in India. If only particulate emissions are compared from different car models then the cancerous effect of diesel particulate matter (PM) from one new diesel car is equal to that of 24 new petrol cars and 81 compressed natural gas (CNG) cars on roads.

The results of this study are further supported by evidence from another study conducted by the German Federal Environment Agency (UBA). They have found diesel to be several dozen times more cancer-causing than petrol. Diesel particles alone constitute as much as 95 per cent of the cancer-causing potential of all diesel emissions, it reported. Differences in the cancer potency of vehicles can arise because of different fuel quality, engine technology and local temperatures.

Following the spate of epidemiological studies linking PM from diesel exhaust to increased lung cancer risk, the California Air Resources Board (CARB) in 1998 labelled diesel particles as 'toxic air contaminant and probable human carcinogen'. The United States Environmental Protection Agency (US EPA) is also in the process of making a similar declaration. A recent study from the South Coast Air Quality Management District of California concluded that vehicles were responsible for approximately 90 per cent of the cancer risk in the South Coast Air Basin, but 70 per cent of the total cancer risk was attributable to diesel particulates.

Alarmed by these findings, the State and Territorial Air Pollution Programme Administrators (STAPPA) and the Association of Local Air Pollution Control Officials (ALAPCO) have sought to extend the evaluation of cancer risk from diesel particulate to other cities across the country and to estimate how many cancers nationwide are the result of exposure to diesel particulates. Their findings are no less frightening: the soot spewed by diesel engines is responsible for a shocking 125,000 cancers in the US.

What further adds to the risk from diesel fumes is their ability to trigger and exacerbate a wide range of non-cancerous effects including allergy, asthma, and other respiratory problems. A summary of scientific evidence prepared by Susannah Foster for the Boston Public Health Commission and Harvard Medical School, USA, clearly shows why diesel exhaust is a cause of concern, especially for the poor.

Unfortunately, the evolving science of pollution has completely eluded Indian air quality regulators. They have failed to develop precise strategies to phase in cleaner fuels and technology by taking into account these health parameters of risk assessment.

CARCINOGENICITY OF INDIAN CARS

Of cars that kill

The cancer-causing potential of diesel cars is more than twice that of petrol cars in India

Cancer potency of diesel exhaust is more than double than that of petrol cars in India. In other words, one diesel car is equivalent to two petrol cars if all gases emitted by the vehicles are taken into consideration. However, if only particulate emission is considered, the carcinogenic effect of one new diesel car is equivalent to 24 new petrol cars on the road, according to a study conducted by Peter Ahlvik and Ake Brandberg at Ecotraffic.

Diesel exhaust has traces of over 40 substances that are listed by the US EPA as hazardous air pollutants and by CARB as toxic air contaminants. Based on epidemiological studies, different countries have ascribed different estimates for cancer potencies to these compounds which is measured as unit risk. Unit risk of a compound indicates the risk of developing cancer due to lifetime (that is, 70 years) exposure to one microgramme per cubic metre (µg/cum) of that compound.

With the help of unit risk, scientists can determine the cancer potency of each chemical substance in the exhaust separately. To make the task of comparison simpler, benzene — a known carcinogen — was taken as the standard carcinogenic compound and the cancer potency of other compounds — 1,3 butadiene, formaldehyde, acetaldehyde, ethene and propene — were estimated in comparison to benzene. It was found that, for instance, 1,3 butadiene was 20 times more carcinogenic than benzene according to the Swedish standards, while the US EPA considers it 36 times more dangerous. (see table: *Compounding cancer*).

Emission test data for vehicles representing model year 1993 and 1994 (or Euro I vehicles — roughly representative of current Indian standard) were also collected. To be able to calculate the effect during the vehicles' lifetime, several parameters such as climatic conditions, ageing of the engine and emission control systems, driving patterns and several other effects were also taken into consideration and corrected keeping in mind specific conditions in India.

However, effects of temperature on emissions were not taken into account because while Sweden being a cold country the ambient temperature at the start of the engine is important as it could lead to higher emissions, in India the effect is most likely negligible.

To simplify the presentation, the compounds were grouped into several groups of carcinogenic compounds — alkenes, benzene, aldehydes, particulate matter, and polycyclic aromatic compounds (PAC).

Two types of engines were taken into account. Spark ignition (SI) engines which are used for petrol, ethanol, methanol and methane and compression ignition (CI) engine for diesel fuel.

Finally, to find out the potency levels of Indian cars, the unit risk factor (Swedish standards) for each compound was multiplied with the emission of that compound from vehicles.

Summed up, these gave the total cancer potency of a fuel. These results were, in turn, used as an index taking petrol as the reference fuel. The Ecotraffic study compared the cancer

The contribution from the very much-debated compound benzene, a known carcinogen, is small when compared to other compounds

Behind all the glitz and glamour, lies a mission impossible: getting rid of the cancerous particulates in diesel exhaust

If only particulate emission is taken into consideration, the carcinogenic effect of one new diesel car is equal to 24 new petrol cars on road

potency of cars running on a wide range of fuels — such as diesel, petrol, methane (CNG is 80 per cent methane) and alcohols (methanol and ethanol).

The most alarming finding of the study is that the cancer potency of diesel particulate is much higher compared to the total effect of all carcinogenic compounds present in petrol vehicles (see table: *The cancer index...*).

ANANDA BANERJEE / CSE

If we consider the break up, the relative cancer potency of particulates from diesel exhaust is alone higher (121.5) than that of the total cancer potency of emissions from other engine/fuels.

Total cancer potency of aldehydes is five times more and that of PACs is double in the case of diesel exhaust than from petrol exhaust. In petrol cars, alkenes and benzene predominate and these together with other polyaromatic compounds add to the carcinogenicity of petrol. It is noteworthy that the contribution from the very much-debated compound benzene is small in comparison to other compounds. In Delhi, public attention has focussed on the high levels of benzene but not on the other compounds.

After taking these aspects into consideration, the cancer potency of petrol is still much less compared to diesel exhaust as aldehydes, particulate matter, and PACs are present in much greater amount in diesel exhaust than in petrol exhaust.

The conclusion was that diesel engines have the highest cancer risk index (235). The level is double that from petrol (100) and much higher than from other fuels (see graph: *... and the difference*).

Ethanol, methanol and methane (CNG) are definitely the cleaner options compared to diesel and petrol. The results confirm that although fuels like ethanol and methanol are cleaner than petrol and have lower cancer potency, the best option still is methane/CNG.

However, liquefied petroleum gas has not been investigated but it is likely that this fuel would be somewhere between alcohols (methanol and ethanol) and CNG, say Ahlvik and Brandberg.

Compounding cancer

The cancer potency level of some of the chemical compounds found in diesel and petrol emissions as designated by various environmental institutes

Compound	US EPA 1990	US EPA 1999	CARB	CAPCOA	Sweden
Benzene	1	1	1	1	1
1,3-butadiene	34	36	6	10	20
Formaldehyde	1.6	1.67	0.2	0.45	6
Acetaldehyde	0.27	0.28	0.1	0.1	0.25
Ethene	–	0.64	–	0.5	4.5
Propene	–	0.02	–	0.2	1.2

NOTE:
The cancer potency of each compound has been calculated in relation to the cancer potency of benzene, a known carcinogen

US EPA: United States Environmental Protection Agency; **CARB:** California Air Resources Board; **CAPCOA:** California Air Pollution Control Officers Association; **Sweden:** University of Stockholm

Source: Peter Ahlvik and Ake Brandberg 1999, Cancer Risk Index for Passenger Cars in India, *Ecotraffic R&D AB, Stockholm, Sweden*

WHERE'S THE DEVIL? Ahlvik and Brandberg have also tried to find out whether the engine type (spark ignition for petrol cars and compression engine for diesel cars) or the type of fuel is of most importance to estimate the cancer risk. Simply put, whether the devil is in the tank or the engine? While in the case of diesel cars the problem lies in both engine and fuel, in petrol cars the problem can be dealt with by improving the quality of fuel and engine.

The cancer index...

The relative cancer potency of particulate matter from diesel exhaust is higher than the total carcinogenic potential of emissions from petrol vehicles

	Particulates	Benzene	Alkenes	Aldehydes	PAC	Total
Gasoline (SI)	5.1	2.0	61	3.7	28	100
Ethanol (SI)	2.3	0.8	22	10.3	19	55
Methanol (SI)	1.9	0.4	3	22.0	19	46
Methane (SI)	1.5	0.1	2	3.0	13	19
Diesel (CI)	121.5	0.4	23	18.4	72	235

NOTE:
PAC: Polycyclic aromatic hydrocarbons
Source: Peter Ahlvik and Ake Brandberg 1999, Cancer Risk Index for Passenger Cars in India, Ecotraffic R&D AB, STockholm, Sweden

In a diesel engine, the combustion system itself leads to high emissions soot and particles. Even if petrol is substituted in a diesel engine, the smoke and particulate emissions would be almost as high. The only possible solution to significantly reduce particulate emissions would be to use particulate filter. However, since such filters are not likely to be introduced in a larger scale in Europe before 2005 — and presumably later in India — this drawback for diesel cars will persist for the next decade. The only option therefore would be to limit the market share of diesel cars.

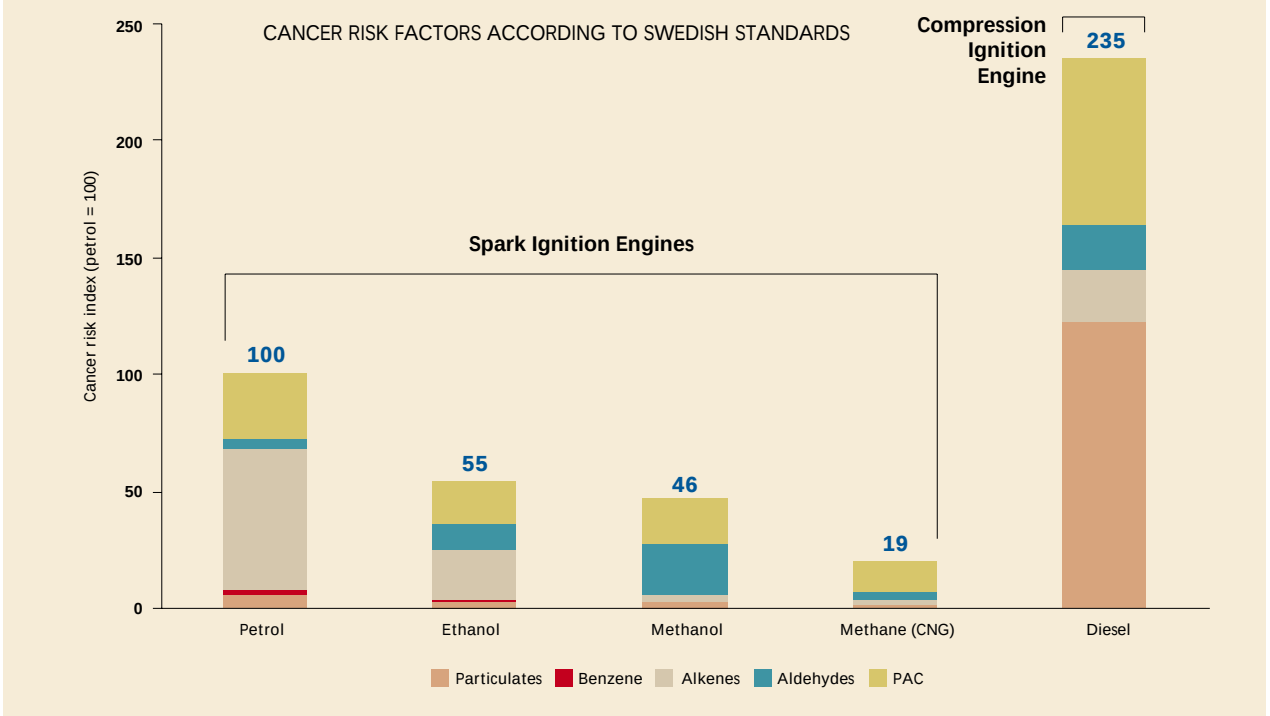
Moreover, the quality of diesel also contributes in a major way to emissions. Polycyclic aromatic hydrocarbons (PAH) — a major component of PACs — content in contemporary European diesel, which is much better than that used in India, is more than 10 times higher than in petrol. A significant improvement in diesel quality is needed to reduce the cancer risk from such vehicles.

In the case of SI engine for petrol cars, it was found that SI engines running on alternative fuels emitted a lot less than petrol. However, improving quality of fuel can go a long way to reduce emissions from petrol cars as well. Reducing the benzene content in the petrol would almost certainly reduce benzene content in the exhaust as well as PAHs. Moreover, improving SI engine to Euro III norms will reduce cancer potency levels by a factor of three.

The article is based on excerpts from a study conducted for the Centre for Science and Environment by Swedish consultants Peter Ahlvik and Ake Brandberg at Ecotraffic

... and the difference

Diesel engine fuelled with diesel oil has the highest cancer risk index (235) among all the fuels. The level is more than double than for petrol (100). The cleanest option is methane (CNG is 80 per cent methane), followed by methanol and ethanol



Source: Peter Ahlvik and Ake Brandberg 1999, Cancer Risk Index for Passenger Cars in India, *Ecotraffic R&D AB, STockholm, Sweden*

CARCINOGENICITY OF GERMAN CARS

More evidence...

... from a German study confirming the carcinogenicity of the devil in the tank and the engine

WHAT harms people and the environment less — diesel or petrol engines? An aware consumer in Germany has a difficult choice to make. Should one buy a diesel car because it saves money and also generates lesser carbon dioxide (CO_2) or should one buy a petrol car with a catalytic converter (CC) because it emits lesser cancer-causing particles?

In Spring 1997, the German Federal Environmental Agency (UBA) set up a Research Advisory Group for Diesel Engine Emissions whose members included representatives from the UBA and external experts in toxicology, epidemiology and occupational medicine from institutes like the Fraunhofer's Institute for Technology and Aerosol Research (ITA) in Hannover, Institute for Energy and Environment Research in Heidelberg, University of Duesseldorf and Freiburger Research and Constancy Institute for Hazardous Substances.

In the last three years, the research group has, among other things, studied the comparative risk of emissions from diesel and petrol engines with regard to their carcinogenic and non-carcinogenic effects.

The result, in brief, is that since the mid-1980s, emission levels from both diesel and petrol engines have drastically fallen. Both diesel and petrol engines emit three main hazardous substances — particulate matter, formaldehyde and nitrogen dioxide (NO_2). But diesel engines with their significantly higher level of particles emissions have by far the highest potential for carcinogenic effects, says Inge Mangelsdorf, project head of ITA. According to the study, it is almost 10 times higher than that from cars with petrol engines without CCs. Further, the hardly soluble soot fraction emitted by diesel engines constitutes 95 per cent of the cancer-causing potential of all diesel emissions.

The assumption that vehicles running on diesel contribute considerably towards saving energy and reducing CO_2 emissions is also false, said Rudolf Petersen, an expert from the Wuppertal Institute for Energy, Climate and Environment in Bonn.

Vehicles running on diesel make up to 13.5 per cent of the entire fleet of vehicles that was under study but they emit only four per cent lesser CO_2 than petrol vehicles. The overall result is a reduction of CO_2 emissions of only 0.7 per cent.

Playing around with scenarios concerning emission reductions if drivers switch to more efficient diesel cars is unrealistic, says Petersen. A close look at the number of vehicles registered in 1998 speak a different language since more and more people opt for more powerful and larger diesel vehicles. The smaller, more efficient ones are less preferred, he says. In reality, this is leading to almost the same fuel consumption for diesel and petrol engines and with it the same level of CO_2.

The carcinogenic effect of diesel is almost exclusively due to particulate matter. Only introduction of filter traps and better technology can minimise emission of particulate matter and thereby decrease the cancer potency of diesel. Taking the carcinogenic potency of diesel engine emissions in the 1980s as 100 per cent, the risk will drop to a mere 11 per cent in the already implemented and future emission standards. The introduction of particulate traps would result in a further reduction of the cancer potential to 1.4 per cent the original level (see graph: *Trapping the dust*).

Through the use of catalytic converters, the levels of benzene and PAH emitted by petrol engines can also be reduced considerably. Researchers also compared the petrol and diesel engines. They found that the carcinogenic potency of petrol emissions in Euro II, III, IV standard cars is at least 10 times lower than with comparable diesel engines. Only the introduction of particulate traps will reduce the particle emission per kilometre driven and thus the carcinogenic potency to a low level comparable to that of petrol engines.

FIltering the risk

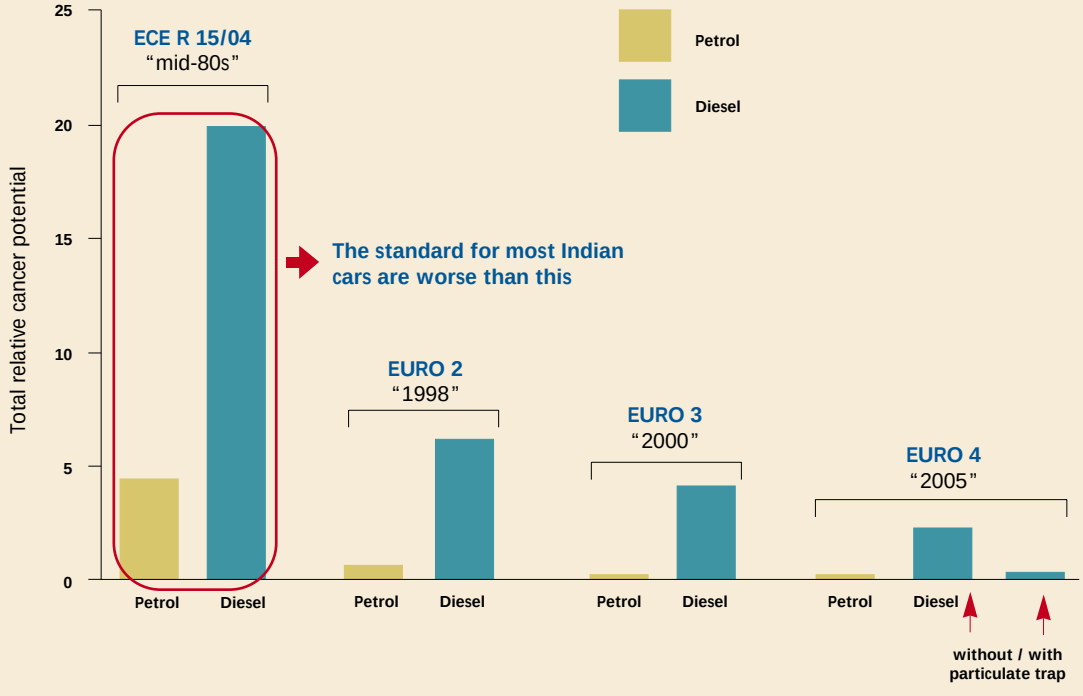
A few companies have already developed particulate filter

RUSTAM VANIA

The assumption that vehicles running on diesel contribute considerably towards saving energy and reducing carbon dioxide emissions is false

Trapping the dust

Particulate emissions from petrol vehicles have registered a decline over the years with the introduction of stronger standards. However, diesel vehicles continue to spew the dangerous particulates because of the lax standards assigned to them. Filter traps can reduce particulate emissions significantly. From 100 per cent in 1980s, it can be brought down to 1.4 per cent in Euro IV models but only if European politicians strengthen the standards for diesel cars



Source: German Federal Environmental Agency, 1999

technologies and engines fitted with CCs allowing a much cleaner operation of diesel vehicles. For example, in 1998 Siemens introduced filters which could reduce oxides of nitrogen (NO_x) emissions in heavy commercial vehicles by 80 per cent and particulate matter by 40-65 per cent. A filter developed by another company, HJS Menden, when fitted in a diesel vehicle, reduces gaseous harmful emissions and particles by 90 per cent.

However, despite the developments in filter technology, due to absence of political will, such technologies have not seen the light of the day in Germany. Political pressure is lacking, says Jurgen Zurbig of Siemens. "Politicians favour diesel over petrol," he adds.

Carcinogenic potency of Euro II, III and IV petrol cars is at least 10 times lower than with comparable diesel engines

MICHEL WAINBERGH

Firstly, emission norms for Euro III (starting in 2000) and Euro IV (starting in 2005) are stricter for petrol vehicles than they are for diesel vehicles. "The norms should be equally strict for diesel vehicles," demands Petersen. "Only then will the filter technology be acceptable," he adds. The Euro IV norms will only be met with improved engine designs.

Secondly, experts suggest abolishment of the fiscal subsidies for diesel fuel. Fiscal taxes on both diesel and petrol engines should be done on the basis of their specific weight, which takes into account the CO_2 emission potential. The vehicle tax should also be based on the engine's nominal power and not the engines specific displacement volume.

Taking all the factors into consideration, introduction of filter traps only seem to be a theoretical proposition as of now. Diesel engine standards are as of now not strong even up to Euro IV (that is 2005). Hence, automobile manufactures are under no pressure to improvise on their engine standards. Only if the standards are made stricter will the future perhaps see a rush for further development of filter traps and a reduction in harmful emissions.

The article is based on excerpts from the article "Way Out of Diesel Dilemma", *which appeared in the October 15, 1999, issue of* VDI nachrichten

DIESEL AND DISEASES

Asthma and allergy

There's more to diesel than cancer. And at the receiving end is poor people

During the last two decades, many scientific studies have documented the link between air pollution and human health. Pollutants such as PM10 and (particles less than 10 and 2.5 microns in size), nitrogen oxides (NO_x), sulphates, ozone, and acid aerosols have been found to be associated with death, asthma, cardiovascular and respiratory diseases, says Susannah Foster in a study prepared for the Boston Public Health Commission and Harvard Medical School.

Additionally, ultrafine particles (less than 2.5 microns in size), which are found in diesel exhaust, have been directly associated with an increased risk of premature death. These particles have hundreds of chemicals adsorbed onto their surfaces, including many known or suspected mutagens and carcinogens, and because the are so small, they can be inhaled deep into lung tissue.

Quantitative knowledge of the health effects of particulate air pollution dates back to 1952 when London was covered in a thick smog from coal emissions. Forty-one years later, in December 1991, another high-pressure system set in over London. This time, it was not coal emissions, but automobile emissions that were trapped into the atmosphere. During this unusual week, there was a 10 per cent increase in mortality, and a 14 per cent increase in cardiovascular disease. For the elderly, hospital admissions for respiratory disease increased by 19 per cent and 43 per cent for obstructive lung disease.

The landmark study of six US cities in 1993 found that, after taking into account other risk factors, mortality was 26 per cent higher in the most polluted city versus the least polluted one.

Diesel engines are one of the biggest polluters in US cities. They account for 44 per cent of NO_x emissions and 69 per cent of particulate emissions from transportation. Emissions from

In Indian cities (below) the levels of particulates reach more than 800 microgrammes per cubic metre (µg/m³), when respiratory problems have been found among those exposed to only 310 µg/m³. This means more visits to medical centres to check lung capacity (above)

diesel engines contain 40 times the amount of NO_x as compared to petrol engines.

Diesel exhaust as compared to other sources of pollution is emitted in close proximity to where people live and work. Many studies have demonstrated a correlation between how close one lives to a major road or highly-trafficked area and increased symptoms of asthma and respiratory disease. Researchers estimate that nationwide, tens of thousands of people die prematurely each year as a result of particulate pollution. Diesel engines are a major contributor to the problem, releasing particulates directly into the air and emitting NO_x and sulphur oxides and transform into particulates in the atmosphere. Overwhelmingly, the results indicate a connection between air pollutants and decreased human health:

DIESEL AND ASTHMA: Perhaps the most perceptible effects is the rising number of asthma patients. In 1980, an estimated 6.7 million Americans suffered from asthma. By 1994, that number had risen to 13.8 million. At best, asthma causes discomfort, at worst, it can lead to premature death. The association is clear: PM10s are small enough to be deposited deep into the lungs, irritating our breathing function. The mechanism makes sense.

DIESEL AS A CARCINOGEN: Particulates from diesel emissions are considered by many to be carcinogens. Several national and international organisations have concluded that PM from diesel exhaust should be regarded as a potential or probable human carcinogen. These include the National Toxicology Programme, the California Environment Protection Agency (CEPA), the International Programme on Chemical Safety, the National Institute for Occupational Safety, and the California Air Resources Board. The US Environmental Protection Agency is currently considering a similar classification. These classifications are based on more and more scientific studies which have shown that exposure to high levels of diesel exhaust causes lung tumours in rats, and that humans who are routinely exposed to diesel exhaust have a higher risk of developing lung cancer. The CEPA estimates that 450 in every one million Californians is at risk of developing cancer because of exposure to diesel exhaust.

DIESEL AS AN ALLERGEN: In addition to being directly associated with increased risk of respiratory diseases, studies reveal that diesel exhaust particles may act as carriers for allergens, allowing the allergens to be deposited deeper into the lungs and aggravate allergy and asthma in humans. About 25 per cent of the us population suffer from hay fever or allergenic asthma. Several laboratory studies have demonstrated that many common allergens (grass pollen, cat, dog, and birch pollen) will bind with diesel exhaust particles. This suggests a mechanism by which allergens can remain suspended in the air and then become deposited into human lungs.

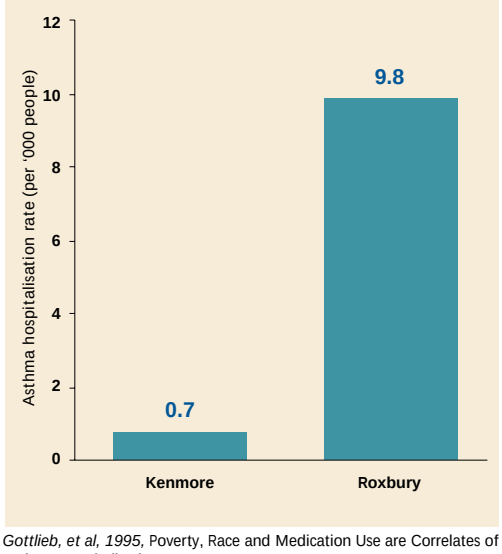
Scientists now believe that diesel exhaust plays a major part in exacerbating allergies and allergenic asthma in our cities. A current research project also demonstrated that where the CO_2 levels are very high (700 parts per million), ragweed plants produce 61 per cent more pollen. If anthropogenic CO_2 emissions continue to rise, this CO_2 environment is not very far off.

DIESEL IN A WARMER WORLD: Beyond the direct effects of air pollution on human health lie many indirect effects that are of increasing concern. As we continue to emit carbon dioxide, we experience increases in the frequency and intensity of extreme weather events including hurricanes, flooding, drought, and heat waves. As ice sheets melt, the Earth is at risk of being thrown into a completely different climate regime. In Boston, intense flooding has not only caused major property damage, but encourages fungal growth in indoor environments, exacerbating asthma and allergy. A wetter environment is also associated with growth in insect population and associated diseases. Greater humidity from atmospheric and ocean warming increases heat indices, leads to a rise in heat wave-related diseases and could exacerbating allergies. In Chicago, several intense heat waves have cost many lives. There are also links between air pollution and climate change. The conversion of NO_x to ozone in the atmosphere is temperature dependent and the rate will increase as the temperature rises. With the potential for more pollen in the air as a result of increased CO_2 levels, there may be more pollen-diesel encounters, which would cause more pollen to be deposited deep into the lungs.

DIESEL AND THE POOR: Finally, because air pollution and particularly diesel exhaust is most prevalent in the cities, it is the residents of our cities that take the brunt of the impact. Within the US cities, the highest density of buses and bus stations are found in the poorest sections. Many studies have examined relationships between poverty, race and asthma rates. In the early to mid-1980s, the asthma mortality rate among black residents living in the suburbs of the US, aged 5 to 34 years, was three to five times higher than the rate among whites. One study was done in Boston and found that the asthma hospitalisation rate for the city of Boston in 1992 was 4.2 per 1,000 persons, twice the state rate of 2.1 per 1,000. Within the city of Boston, there was great variation as well, from a low of 0.7 per 1,000 persons in the richer Kenmore area to a high of 9.8 per 1,000 in the poorer Roxbury area (see graph: *Environmental injustice?*). The connection between diesel and human health is yet another case of environmental injustice. ■

Environmental injustice?

Asthma rates in the poorer, more diesel-exposed Roxbury area in Boston, are much higher than in elite Kenmore



Gottlieb, et al, 1995, Poverty, Race and Medication Use are Correlates of Asthma Hospitalisation

The article is based on excerpts from Air Pollution and Human Health: A Summary of the Scientific Evidence *by Susannah Foster*