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RESEARCH ARTICLE

Annoyance of Air Pollution Frailty Globally

Bina Rani[1], Bhanwar Lal Jat[2], Sabiha Khan[3], Himakshi Verma[4], Ashish Kumar[5], Naresh Kumar Verma[6], Rajnee[7] and Raaz K. Maheshwari[8]

[1.] Department of Engineering Chemistry & Environmental Engineering, PCE, Sitapura, Jaipur
[2.] Department of Botany, SBRM Govt PG College, Nagaur, Rajasthan
[3.] Department of Zoology, Govt. PG College, Ajmer, Rajasthan
[4.] Department of Chemistry, JN Vyas University, Jodhpur, Rajasthan
[5.] Department of Botany, Veer Teja Mahila Shiksha & Shodh Sansthan, Mundwa, Nagaur
[6.] Department of Geography, SBDT PG College, Lakshman Garh, Sikar, Rajasthan
[7.] Department of Physiology, SN Medical College, Jodhpur, Rajasthan
[8.] Department of Chemistry, SBRM Govt. PG College, Nagaur, Rajasthan
Email: gcacs60@gmail.com, nstaie14@gmail.com

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ABSTRACT

Excessive air pollution is often a byproduct of unsustainable policies in sectors such as transport, energy, waste management and industry. Air pollution deaths are most commonly from heart disease, strokes or COPD. One of the main risks of pollution is that tiny particles can get deep into the lungs, causing irritation. The adverse effects of air pollution are more pronounced in the developing countries. On the one hand, the developing countries are grappling with the environmental problems associated with inadequate economic developments, the hallmarks of which are malnutrition, poor sanitation and lack of basic human needs. On the other hand, in their pursuit for rapid economic development, the developing countries are confronted with a newer set of environmental problems due to increasing air pollution on account of industrialization, urbanization and motorization. Women & children- especially those living in poor countries- often bear the brunt of the risks from indoor pollution "since they spend more time at home breathing in smoke and soot from leaky coal and wood cooking stoves. Outdoors, air is mainly polluted by vehicles, power generation, industrial and agricultural emissions and residential heating and cooking. Outdoor air pollution exposure levels have risen significantly in some parts of the world, particularly in countries with large populations going through rapid industrialization, such as China & India. It is with mostly up to governments to curb pollution through measures like legislation, moving power stations away from big cities and providing cheap alternatives to indoor wood and coal stoves. One could reduce their exposure to harmful fumes by avoiding traveling at rush hour or by taking smaller roads. In most cases, healthier strategies will also be more economical in the long term due to health care cost savings as well as climate gains. Policies to reduce air pollution, which would improve health and reduce humans' impact on climate change are to be enforced. This article delineates impact of air pollutants, resulted clinical manifestations and their preventive & mitigation strategies.

Key Words: *COPD, Ecological alarm, Heavy metals, Hypertension, MO_x, Neurophysiological symptoms, NO_x, $PM_{1.0,2.5,5,10;}$ Economic development; Autism*

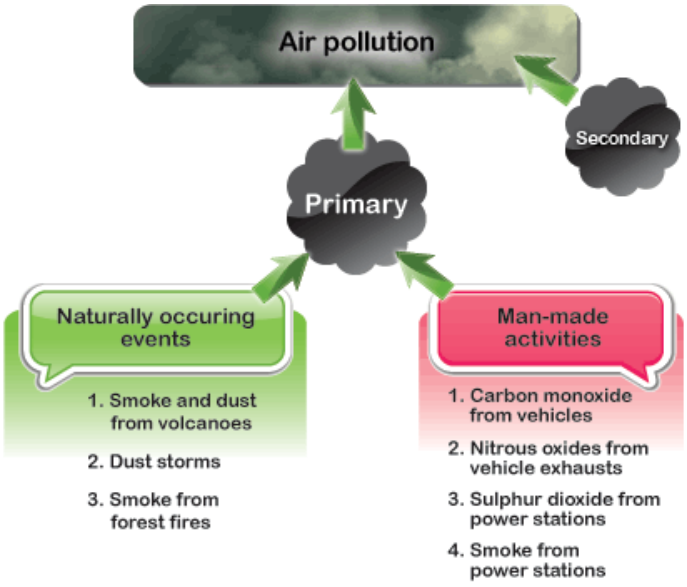
INTRODUCTION

Air pollution encompasses a diverse array of natural and anthropogenic emissions, including gaseous constituents, volatile chemicals, aerosols (particulate) and their atmospheric reaction products. Ambient air acts as an atmospheric sink, where all emissions are released. Many such emissions are in such small quantities that they get immediately dissipated and absorbed but continuous release of these pollutants build up in the air and pose hazards to human health[1-4]. Despite pollution control effects, the air quality has been threatened to alarming levels in several cities throughout the world (Fig. 1).

Fig.1: Heavy pollution load in mega cities

In accordance with WRI estimates that as many as 1.4 billion urban residents in the world breathe air exceeding the WHO air quality guidelines. The health consequences of exposure to dirty air are considerable. On a global basis, estimates of mortality due to outdoor air pollution (Figure 2) is estimated to be around 2.0 to 5.7 lac, representing about 0.4 to 1.1 % of total annual deaths. The adverse effects of air pollution are more pronounced in the developing countries5-8.

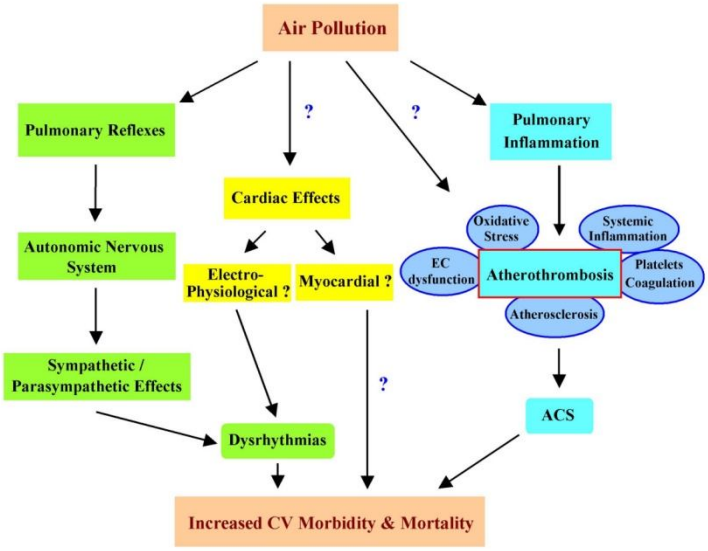
Fig. 2: Anthropogenic & Natural Events causing outdoor air pollution



On the one hand, the developing countries are grappling with the environmental problems associated with inadequate economic developments, the hallmarks of which are malnutrition, poor sanitation and lack of basic human needs. On the other hand, in their pursuit for rapid economic development, the developing countries are confronted with a newer set of environmental problems due to increasing air pollution on account of industrialization, urbanization and motorization. Last year the WHO's cancer agency classified air pollution as a carcinogen, linking dirty air to lung and bladder cancer (Fig. 3). Poor and middle-income countries in Southeast Asia and the western Pacific region had the largest air pollution-related burden in 2012, with 3.3 million deaths linked to indoor air pollution and 2.6 million deaths to outdoor air pollution. The WHO estimates that about 2.9 billion people worldwide live in homes using wood, coal or dung as their primary cooking

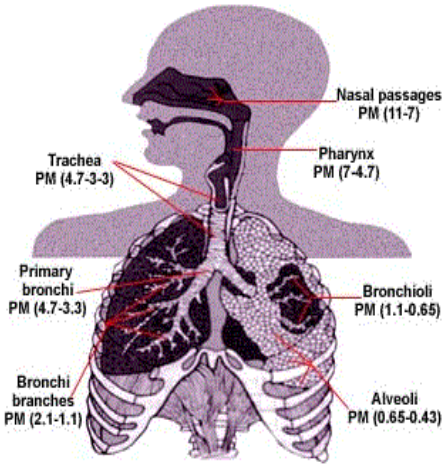
fuel. The public and policy makers mayn't be aware that every citizen of our nation is under grip of invisible killers –outdoor as well as indoor. WHO estimated IARC, USEPA, the EIOSH and CSE have all consistently agreed on the relationship between diesel exhaust exposure and lung cancer. Numerous independent analyses of the data by leading researchers have come to the same conclusions. From the scientific evidences it's clear: diesel exhaust is a complex mixture of hazardous particles and vapors, some of which are known carcinogens and other probable carcinogens. The IARC has reclassified diesel exhaust and removed it from Group 2A list of 'probable carcinogens' to its Group 1 list of substances that have definite links to cancer- thus changing its status to carcinogen. Diesel exhaust is now in the same class of deadly carcinogens as asbestos, arsenic, or tobacco among others. The WHO's recent GBD assessment estimates that outdoor pollution causes 620,000 premature deaths per year in India, ma 6 fold increase since 2000[9-11].

Fig. 3: Clinical manifestations caused by air pollution



The main culprits are growing emissions of particulate matter [PM_{10} & $PM_{2.5}$ (Fig. 4)] emissions from transport vehicles and power plants. GBD in this analysis ranked air pollution as the 6th most dangerous killer in South Asia and 5th leading cause of deaths in India. Cancers as a group account for~ 13% of all deaths each year with the most common being: lung cancer (1.3 million deaths). Besides this, problem is exaggerated as diesel consumption is increasing year / year in our country.

Fig. 4: PMx & affected respiratory system



CHRONOLOGICAL AIR POLLUTION CALAMITIES

Severe air pollution episodes during last century have shown that breathing dirty air can be dangerous and at times deadly. A strong atmospheric inversion got settled over Meuse Valley on December 1, 1930 and remained until December 5. Effluents from several factories in the valley, chiefly oxides of S-, various inorganic acids, MOx, and soot were then trapped in the stable atmosphere. Sixty three people (generally the old and infirm) died, and several hundred others deemed ill. Although many suspected SO_2 and HF, the actual lethal substance could not be proved. Donora, Pennsylvania is an industrial town on the banks of the Monongahela River about 30 miles south of the heart of Pittsburgh. The major industrial installations were steel and wire mill, a zinc smelter and a H_2SO_4 plant. During a particularly calm and meteorologically stable period from October 27 to 31, 1948, air pollutants accumulated because of this many people were hospitalized and 20 died. Illness of several thousand persons was blamed on the episode, and over 130 separate lawsuits were filed. The causative agent of the deaths and illness could never be determined incontrovertibly but S-compounds were present in the air in abnormally high quantities. Historically, the longest record of intermittent air pollution problems belongs to the city of London, England. The notorious pea-soup fogs become especially offensive when mixed with coal smoke. The word smog (smoke and fog) was coined to describe this foul condition. In 1661, John Evelyn got published his well-known pamphlet, '*Fumifugium*: or The Inconvenience of the Air and Smoke of London Dissipated'. His major recommendation had been the removal of all smoke-producing plants from London. But London did little about it until the famous London smog of December 1952, truly a major air pollution disaster. The smog lasted 5 days from 5th to 9thDecember and caused 4000 deaths (principally among the old, the infirm, and those with respiratory diseases)[35].

The onset of fog was followed by acute respiratory symptoms. Almost exactly ten years later, December 3 to 7, 1962 London experienced another black fog, with 340 excess deaths. The improvement over the 1952 episode was laid to smoke reduction brought about by the Clean Air Act and public awareness of the harmful effects of smog, which restrained many respiratory cripples from going outdoors. The MIC-gas leak in Bhopal during 1984 has been regarded the worst industrial accident in India, which is related to air pollution. Around 200000 people were affected by the leak of poisonous Methyl isocyanate gas from a pesticide plant. The actual scenario of what went wrong at the Bhopal plant just after the midnight on the morning of December 3, 1984 is not exactly known. But several circumstantial evidences point to the total breakdown of the essential safety provisions within the plant. MIC can react with almost any chemical to generate considerable heat and CO_2. The heat released accelerates the reaction and pressure goes on building up till it reaches an explosive level. The gas emitted from the factory spread over some 40km^2 area and affected people seriously as distant as 5 km. MIC is invariably accompanied by $COCl_2$. The toxic effect of MIC is enhanced by $COCl_2$. Since then, many countries have adopted ambient air quality standards to safeguard SPM, ground level O_3, NO_2, CO & Pb, which are directly or indirectly released by the combustion of fossil fuels. Although substantial investments in pollution control in some countries have lowered the levels of these pollutants in many cities, poor air quality is still a major concern throughout the industrialized world[12-34].

AIR POLLUTION SOURCES MAJOR INDOOR AIR POLLUTANTS

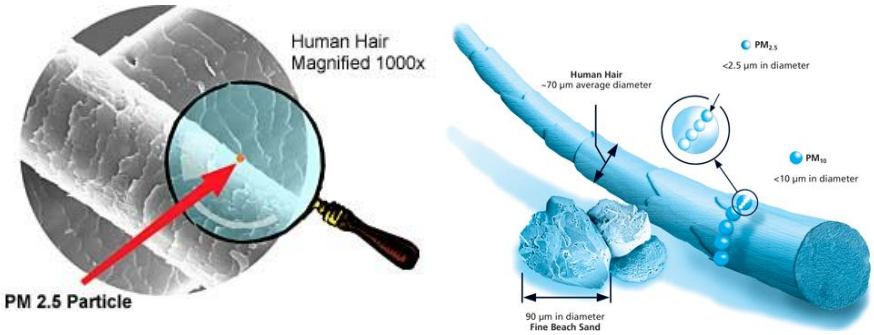
There are four principal sources of pollutants in indoor air viz. combustion, building material, the ground under the building and biological agents.

As dangerous as polluted outdoor air can be to health, indoor air pollutants can pose even a greater health risk. Indoor air pollution is a concern where energy efficiency improvements sometimes make the house relatively air tight thereby reducing ventilation and raising indoor pollutant levels. Indoor air pollution is usually associated with occupational situation particularly through combustion of biomass fuels. The greatest threat of indoor pollution exists where the people continue to rely on traditional fuels for cooking and heating. Burning

such fuels produces large amounts of smoke and other air pollutants in the confined space of home, a perfect recipe for high exposures[36-39].

[PM - big particles are between 2.5 and 10 micrometers (~ 25 to 100x thinner than a human hair). These particles are called PM10 (we say "P M ten", which stands for Particulate Matter up to 10 micrometers in size). These particles cause less severe health effects. PM - small particles are smaller than 2.5 micrometers (100x thinner than a human hair). These particles are called PM2.5 (we say "P M two point five", as in Particulate Matter up to 2.5 micrometers in size). Fig. 4 &5]

Fig. 5: Human hair & its comparison with PMx



Liquid and gaseous fuels such as kerosene and bottled gas although not completely pollution free is many times less polluting than unprocessed solid fuels. In these circumstances, exposure to pollutants is often far higher indoors than outdoors. The health problems due to indoor air pollutants are more widespread than those caused by outdoor air pollutants for the following reasons. (i) The exposed persons are in close proximity to the source of indoor air pollutants; (ii) A recent report of WHO asserts 'the rule of 1000 which states that a pollutant released indoor is one thousand times more likely to reach the lungs than a pollutant released outdoors (Fig.4); (iii) Women and children, particularly those in rural sector spend more time indoors than outdoors (iv) In rural areas, indoor air pollution is responsible for much greater mortality than ambient air pollution[40-42].

Epidemiological studies have linked exposure to indoor air pollution from dirty fuels with at least four major categories of illness. These are: (i) ARI in children; (ii) COPD such as asthma and bronchitis; lung cancer and (iii) pregnancy related problems**.** Of these, ARI appears to have the greatest health impact in terms of the number of people affected .Traditional biomass fuels amount for 80% of domestic energy consumption in our country. When these fuels are burnt in simple cook stoves during meal preparation, air inside homes get heavily polluted with smoke that contains large amounts of toxic pollutants such as carbon monoxide, oxides of nitrogen NOx, SO_2, aldehydes, dioxins, PAH & RSM. The resulting human exposures exceed the permissible norms by a factor in multiples.

Fig. 6: Non Smoker's and Smoker's (active & passive)Lungs

In addition, particulates may be the carriers of hazardous liquid or gaseous substances. S-dioxide, a major air pollutant, is frequently absorbed by particulates and can react with moisture to form sulphates which react with moisture in the air or in the respiratory tract to form a corrosive H_2SO_4 that irritates delicate membranes and slow down the body's ability to remove harmful bacteria, increasing the possibility of infection.

Residing in an area with high levels of air pollution may increase a woman's chances of having a child with autism, according to the first national study to date that investigates the possible link. "Women who were exposed to the highest levels of Pb/ or Hg in the air were twice as likely to have a child with autism as women who lived in the cleanest parts of the sample," study author Andrea Roberts, a research associate with the HSPH told *The Huffington Post.*

In accordance with the latest study, published in the journal Environmental Health Perspectives recently, draws on a large sample of women across the whole country. Researchers crossed USEPA data on the level of air pollutants from year to year with data from the NHS, one of the longest running investigations of women's health in the US. They looked for associations between levels of pollutants in the time and place that a woman was pregnant and whether that woman went on to have a child with a DASD. The researchers split up the locations into fifths, and women who lived in the most polluted sections -- those with the highest levels of diesel particulates or Hg in the air -- were twice as likely to have a child with autism compared to those in the cleanest sections. Other types of air pollution, including Pb, Mn and other heavy metals, were also linked to a greater risk of autism, although the risk was not quite as high.

All of the chemicals studied are known neurotoxins. They are also known to pass from mother to baby while a woman is pregnant. It's very plausible that the 'stuff' the mother is taking in through the air is affecting her baby's brain development. But the researcher cautioned against reading too much into the results, particularly with regard to Hg. Many parents continue to worry that the form of Hg sometimes used in vaccines is linked to autism-- although that claim has been repeatedly disproven by research efforts. An another proof that declining air prominence in India is affecting people's health, a study has found than Indians have 30% inferior lung function as compared to Europeans. Chattels could get worse if immediate steps aren't taken to curb vehicular emission. The study was conducted on 10,000 healthy, non - smoking individuals in Jaipur, Pune, Hyderabad, Kolkata and Kashmir. PEFR the rate at which a person exhales was measure to assess lung function.

North Indians fared slightly better than South Indians but overall the results were appalling and lung function in Indians was 30% lower than Europeans, in accordance with the finding of Pune-based CRF, who led the study. Similarly alarming results were seen in an international study on lung function in 17 countries, including India, by Canadian researchers. Indians were found to have the worst lungs (Fig. 6)in the study which measured the volume of air exhaled one second after a forceful exhalation. The test is called FEV. Air pollution is the main reason for worsening lung health of India. In accordance with the findings of Pune-based CRF, the number of motor vehicles is a major contributor to air pollution. In Indian cities has gone up from 37.2 million in 1997 to 100 million in 2012. In 1951, there were just 0.3 million motor vehicles. Even cars and buses running of CNG which touted as a green fuel, release ultra-fine particles (<10 in diameter).

These can enter into the lungs and other organs and probably cause more harm. Lungs health in metros has deteriorated sharply, increasing in ailments viz. chronic bronchitis, allergies, persistent cough and inflammation of airways in the last few years. When air pollution levels peaks such as on Diwali, the number of emergency admissions from respiratory problems and heart disorders increases sharply.

People who smoke are at double risk for compromised lung function. Many smokers - aged between 25 - 30 years - reported posses lung function equal to that of 70 year old[43-45].

Projected premature annual deaths due to urban air pollution, Total & by Economic Groups or Regions [2001 - 2020]

Regions – Established market economies; Former socialist economies; Chine, India, East Asia & the Pacific; Latin America & the Caribbean; Middle East Crescent; Sub-Saharan Africa; World: Premature Deaths– 20; 200; 590; 460; 150; 130; 120; 90; 60; 1,810 respectively. [Source-World Bank]

The WHO estimated that there were about 4.3 million deaths in 2012 caused by indoor air pollution, from using wood, coal and biomass stoves for cooking and heating. It said there were about 3.7 million deaths from outdoor air pollution in 2012, of which nearly 90 % were in developing countries. The new estimates are more than double previous figures and were based mostly on modeling. The increase is partly due to better information about the health effects of pollution and improved detection method[42-44].

The large majority of today's cars and trucks travel by using internal combustion engines that burn gasoline or other fossil fuels. The process of burning gasoline to power cars and trucks contributes to air pollution by releasing a variety of emissions into the atmosphere. Emissions that are released directly into the atmosphere from the tailpipes of cars and trucks are the primary source of vehicular pollution. But motor vehicles also pollute the air during the processes of manufacturing, refueling, and from the emissions associated with oil refining and distribution of the fuel they burn. Primary pollution from motor vehicles is pollution that is emitted directly into the atmosphere, whereas secondary pollution results from chemical reactions between pollutants after they have been released into the air. Despite decades of efforts to control air pollution, at least 92 million Americans still live in areas with chronic smog problems. The USEPA predicts that by 2010, even with the benefit of current and anticipated pollution control programs, more than 93 million people will live in areas that violate health standards for O_3 (urban smog), and more than 55 million Americans will suffer from unhealthy levels of fine-particle pollution, which is especially harmful to children and senior citizens. While new cars and light trucks emit about 90 % fewer pollutants than they did three decades ago, total annual vehicle-miles driven have increased by more than 140 % since 1970 and are expected to increase another 25 % by 2010. The emission reductions from individual vehicles have not adequately kept pace with the increase in miles driven and the market trend toward more-polluting light trucks, a category that includes SUVs sports utility vehicles. As a result, cars and light trucks are still the largest single source of air pollution in most urban areas, accounting for one-quarter of emissions of smog-forming pollutants nationwide[45].

DON'T BREATH YET

Exposure to diesel exhaust for a couple of hours a day is enough to give birth to blood vessels that feed tumors. Experiments on mice showed that exposure to diesel exhaust caused a 6-fold increase in blood vessel formation in diseased mice and 4-fold increase in healthy mice breathing diesel fumes. There was no such increase in mice breathing filtered air. The exhaust activated a chemical signal and a protein associated with new blood vessel development. It lowered activity of an enzyme that can suppress tumor growth. The findings were published in *Toxicology letters*, online August 14, 2009.

THE DAWN OF AIR POLLUTION

Health enthusiasts residing near freeways should minimize their outdoor timings during the early morning hours; they should also keep their windows shut through the night. It has been found that the level of air pollution to be really high during the pre-sunrise hours in the Interstate 10 freeways in Santa Monica, California. Researchers from University of California, Los Angeles and CARB equipped an electrical vehicle with no emissions of its own, with instruments to measure gaseous and particulate air pollutants, a global poisoning system, video monitor and instruments to measure temperature and winds. For pre-rise measurement, the vehicle was driven on a fixed route over 2 days in the summer and 3 days in the winter of 2008 between 4 to 7am. Covering a distance of 3,600m this route passed

through a dense residential neighborhood below the freeway. Air pollution concentrations were also measured on the freeway and streets transecting the route. During pre-sunrise hours, the traffic volume was to be 30 to 80% lower compared to the morning or afternoon hours. However, the ultrafine particle concentrations were significantly high. This was due to unique meteorological conditions exiting in dawn. "Pre-sunrise, though traffic is relatively calm due to low wind speed and possible shallow temperature inversion, causing the pollutant to trapped near the surface instead of being fixed and carried away.

During the day traffic sources are more and strong mixing occurs" added Hu. During temperature inversion, temperature increases with height- a reversal of the normal pattern. Due to specific wind direction, area south of the airways is down-wind/ hence the impact of air pollution was found to be down south (as far as 2,000m) during pre-sunrise hours. Further north (unwind), it extended up to only 600m. In accordance with CASc, IIT, Delhi states, "These conditions can occur at sunrise causing a huge build up of pollutants at the ground level. But this situation mayn't be last for long because the heat from the sun is strong enough to cause complete mixing of pollutants." Such wide pollutant-impact area downwind of a major roadway has much worse effects. Earlier researches, verified adverse conditions such as asthma and even morbidity associated with high pollutant concentrations in the vicinity of freeways. The impact zone was identified to be 300m downwind side during daytime. Research pursued by Hu revealed much longer impact distance during pre-sunrise hours. This meant more people residing in the vicinity of roadways have to be affected by freeways emissions (Fig. 7).

RETINA VISUALS CAPTURE HEART

Digital photographs of the retina have revealed that healthy people exposed to high levels of air pollution have narrower retinal blood vessels. While past studies linked a increase in air pollution to a higher risk of death and hospitalization from heart disease, the study published in November 2010 issue of PloS Medicine, is the first to establish that air pollution may adversely affect tiny blood vessels in the human body like that those that supply blood to the heart and brain. A study conducted in US citied led by researchers from University of Washington took retinal photographs of participant to measure retinal vessel diameter. They studied 4,607 people aged 45 to 84 years from the MESA to investigate the progression of subclinical and clinical cardiovascular disease. Nearly 30% of the participants were residing near a major roadway and none of them had a bad heart history. Fine particle matter levels were measured at participants' home over two years preceding the eye examination an on the eve of the eye examination. It was found that people exposed to fine particulate pollution had narrow retinal blood vessels, longer the exposure, narrower the vessels. In people exposed to greater air pollution for a short period, the vessels constricted as much happens with 3 years of aging. "An increase, of 3 $/m^3$ in long-term fine particulate levels was linked to a 1% decrease in arteriolar diameter. The difference in blood vessel size of a person residing in an area of high air pollution would be the same as the difference between vessels of a person at 70 as compare to when they were 63", explained the study from the University of Michigan in US. In case of short-term pollution, one can expect a 0.5% decrease in thickness of normal retinal arteriole. In case of short-term pollution, one can expect 0.5% decrease in the thickness of retinal arteriole, the same amount of change as for a difference of 3 years in age, was added. Narrowing of blood vessels in other organs can lead to a reduced blood flow to the heart and brain and be linked to angina, heart attacks and stroke, was cautioned. . .

TRAFFIC DRIVEN DIABETES

Stress, frustration, rising blood pressure and breathing blood problem are common in motorists who spend hours in traffic jams. Now researchers found another health consequence of traffic snarls- diabetes. Researchers from GDC and the IEMR at Heinrich University, Germany, claim traffic related air pollution could raise a women's risk of developing type 2 diabetes. The study included 1,775 healthy women, all 55 years old. They

were from the industrialized Rhur district of West Germany and nearby non-industrialized towns. It was examined that the participants again between 1990-2006 and found that 187 of them had developed diabetes. Data from environmental studies was collected to determine each woman's exposure to air pollution. Residing within 100 meters of busy roads more than doubled the risk of diabetes. Components of traffic pollution, particularly NO_2 and particulate matter, were significantly associated with a higher risk of disease, was added. The more pollution a woman encountered, the larger was her chance of developing diabetes, the researchers concluded in the September, 2010 issue of *Environmental Health Perspectives.* Further, it was called additional confirmatory research so that preventive measures could be taken. The relevance of our study may be greater in some Asian countries, including India, because air pollution there is 10x higher than Germany." India is a capital of 50 million diabetics. The study is interesting and preliminary in Indian context.

AIR POLLUTION AFFECTS FLOWER SCENT

The attractiveness of a flower diminishes when it doesn't emit fragrance. And not just we human beings, insects also stop taking interest in such a flower. Researchers from the University of Virginia in US, have sounded out a warning that fragrance in flowers may be short-sustained due to air pollution. This is crucial because that the color and the fragrance attract insects towards flowers, thus helping pollination. The study shows the increasing levels of NOx in air react with and degrade HCs responsible for fragrance in flowers. HCs react with NO and NO_2 present in the air to form O_3. This restricts the fragrance from travelling long distances – 200 meters – thus making it difficult for insets to find flowers. Simulation studies showed that preindustrial levels of air pollution, the fragrance of flower could travel several kilometers. The HCs breakdown even they can be carried out by the wind the findings were published in March 2008 issue of the *Atmospheric Environment.* The researchers used mathematical models to understand how common fragrance HCs - linalool, myrcene and ocimene – disperses in air. In the highly polluted conditions 74% of the fragrance gets diminished within 200-300meters of the source plant. This could mean that insects will take longer time to find isolated flower patches and so their efficiency as pollinator could reduce. Besides, the ability of insects to differentiate between scents could also affect since flower scents are a combination of various HCs, the researchers stated in the paper. "Pollution affects all aspects of biology, so it's not surprising that a flower's fragrance is also altered. This could affect reproductive success in small populations. It could also led in loss to genetic variation due to breeding.

INCREASE IN ULTRAFINE PARTICLES DUE TO ACCELERATION

When vehicles accelerate after stopping at a traffic light or a bus stop, the concentration of ultrafine particles increases, States a Hong Kong study. Ultrafine particles < 0.1 in diameter, are a fraction of particulate matter. It's considered as a significant human health concern because of its small size, large and their ability to enter the respiratory tract and the circulatory system. The study aimed to evaluate the exposure of pedestrian to vehicular emission of ultrafine particles while walking near several high volume pedestrian walkways. The findings were published in *Aerosol and Air Quality Research,* Vol.8, No. 1, 2008. Researchers choose 3 locations around a busy intersection in the city. It was found that the highest particle count in one of the locations and super imposed traffic patterns on particle count versus time data for that location. The effect of super imposing particle counts with traffic patterns supports correlation of traffic with heightened particle count. For light-duty vehicles acceleration, many of the observed spikes of particle counts were small and lasted for around 1o to 45s. It reached a maximum of $1.6x\ 10^5$ particles/cm^3 before descending rapidly. In case of heavy-duty vehicles large peaks with high and prolonged particle counts rose to $5.4x\ 10^5$ particles/cm^3 after which it slowly descending over the next 35s till the next red light. Sudden acceleration quickly emits a large number of particles. Heavy-duty vehicles such as trucks and buses are more likely to be using diesel and have higher levels of incomplete fuel combustion. A study conducted on the LAF, which highest %age of diesel

vehicles (25%) has also reported such peaks. Vehicle acceleration causes much higher particle emission than idling vehicles because acceleration in the vehicles burn fuel in order to move. While these resulted are preliminary, it was clearly suggested that reducing congestion would contribute to improved air quality in the area by diminishing pedestrian exposure to toxic ultrafine particles.

BIOGENIC EMISSIONS LEADING TO AIR POLLUTION

While we are yet to ascertain whether aerosols are warming or cooling our planet, a scientific team has traced a new source: deciduous trees. These are plants that shed their leaves seasonally. So for aerosols were described as particles of pollutants like SO_2, black carbon (soot) and sea salt that remain suspended in air. Deciduous plants around 500 tg (1tg equals 10^{12}gm) of carbon each ear in the form of isoprene, an organic compound. The chemistry of what happens to the compound as it forms aerosol particles has, so far, been unclear. The team from CalTech in the US, University of Otego, New Zealand and University of Copenhagen in Denmark, found isoprene is repeatedly oxidized in the atmosphere to form an epoxide, hithertounknown, called dihydroxyepoxide. Epoxides are generally synthesized in the chemical industry. It's rare to find such huge quantities of an epoxide, produced normally by plants. "Nothing is known by its fate in atmosphere. Given the tendency of this epoxide sticking to acidic particles, it's likely to form aerosols under pristine conditions. Mixing emissions from the city with the emissions from plants, interact to alter the chemistry of the atmosphere. Higher concentration of aerosols, human induced or otherwise, foggier is the visibility in the area. Further it was stated that air quality regulatory agencies mainly pay attention to the effect of emissions from the cars and industries; less is known biogenic emissions. Hence their visibility predictions as well as other climatic predictions aren't accurate. This study published in 8 August 2009, issue of *Science* explains from where the Great Mountains are covered by one of the largest patches of deciduous forests in North America.

BURNING LESS FUEL

The key to burning less fuel is making cars and trucks more proficient and putting that efficiency to work in improving fuel economy. The US federal government sets a fuel-economy standard for all passenger vehicles. However, these standards have remained mostly constant for the past decade. In addition, sales of lower-fuel-economy light trucks, such as SUVs, pickups, and minivans, have increased dramatically. As a result, on average, the US passenger-vehicle fleet actually travels less distance on a gallon of gas than it did twenty years ago. This has led to an increase in heat-trapping gas emissions from cars and trucks and to an increase in smog-forming and toxic emissions resulting from the production and transportation of gasoline to the fuel pump. This trend can be reversed through the use of existing technologies that help cars and trucks go farther on a gallon of gasoline. These include more efficient engines and transmissions, improved aerodynamics, better tires, and high strength steel and Al. More advanced technologies, such as hybrid-electric vehicles that use a gasoline engine and an electric motor plus a battery, can cut fuel use even further. These technologies carry with them additional costs, but pay for themselves through savings at the gasoline pumps.

Air pollution kills about 7 million people worldwide every year and is now the single biggest environmental health risk, with more than half the fatalities due to fumes from indoor stoves, according to a new report from the WHO. The evidence signals the need for concerted action to clean up the air we all breathe risks from air pollution are now far greater than previously thought or understood, particularly for heart disease and strokes. The toll, a doubling of previous estimates, means 1 of every 8 global deaths in 2012 was linked to polluted air and shows how reducing pollution inside and outside people's homes could save millions of lives in the future. The WHO estimated that there were about 4.3 million deaths in 2012 caused by indoor air pollution, from using wood, coal and biomass stoves for cooking and heating. It said there were about 3.7 million deaths from outdoor air pollution in 2012, of which nearly

90 % were in developing countries. The new estimates are more than double previous figures and were based mostly on modeling. The increase is partly due to better information about the health effects of pollution and improved detection methods.

Fig. 7: Dawn of air pollution

STATUS OF AIR POLLUTION IN INDIAN CITIES

Air quality data generated by the CPCB for 2007 under the NAMP presents deadly facts about air pollution levels in Indian cities. CES has analyzed the official data to assess the state of air quality and trend in Indian cities. The most widely monitored pollutants in India are PM, NO_2, SO_2, and on a limited scale CO. Some of the worst forms of air pollutions are found in Indian cities. The CPCB considers air to be 'clean' if the levels are below 50 % prescribed standards for pollutants. During 2007 only 2 % cities have low air pollution on the basis of PM_{10}. In about 80 % of cities (of a total of 127 cities/towns monitored under the NAMP at least one criteria pollutant exceeded the annual average ambient air quality standards. This has serious public health implications. There are very few cities, which can be termed clean keeping PM_{10} levels as criteria however over the years SO_2 levels have fallen sharply in many cities but the NO_2 levels are increasing in many cities.

PM10 WAFT

Almost half of the total cities monitored under NAMP have critical levels of PM_{10}. CPCB classifies cities as critically polluted if the levels of criteria pollutants are >1.5x the standards. Levels up to 1.5x the standards are labeled high. Levels that reach up to 50 % of the standards are moderate. And lower than that is low. In 2007 data of 121 cities has been analyzed and only three cities Dewas, Tirupati, Kozhikode recorded low pollution level. - Indian cities are reeling under heavy particulate pollution with 52 % of cities (63 cities) hitting critical levels (exceeding 1.5x the standard), 36 cities with high levels (1–1.5x the annual standard) and merely 19 cities are at moderate levels, which is 50 % below the standard. The PM_{10} levels remain persistently high in the northern region. In the NCR towns Noida, Faridabad including NCR Delhi has high levels of PM_{10} and in past two years the levels have increased. Only in hill towns such as Shimla, Gajraula and Parwanoo have low PM_{10} levels. In western and eastern India, there is usually a mixed trend. Eastern cities, including Shillong, Angul, Rourkela and Howrah, show an increasing trend and in the west PM_{10} levels have declined in some cities like Ahmedabad, Solapur, Nagda and Jamnagar but increased in Mumbai, Kota and Satna. In southern India, though the cities generally have lower PM_{10} levels compared to the northern ones, some cities show an increase. In cities such as Hyderabad, Visakhapatnam, Tuticorin, and Bangalore there is an increasing trend. A sharp declining trend has been noted in Thiruvanthapuram, Kochi and Mysore during 2000-2007 PM_{10} levels are gradually reducing.

NOx WAFT

NOx (measured as NO_2) is emerging as the new national challenge and a growing problem. The NO_2 levels during 2007 at seven monitoring stations exceeded the annual average standard in residential areas and NO_2 level at one monitoring stations in industrial areas exceeded annual average standard. - The seven monitoring stations in residential areas that exceeded the standard are located at Town Hall (82/ µg/m³), Sarojini Nagar (65 µg/m³) in Delhi, Salt lake (66µg/m³)in Moulali (76 µg/m³), Minto Park (65 µg/m³) in Kolkata, Gandhi Maidan (67 µg/m³) in Patna and Ghuseri (68 µg/m³) in Howrah. One monitoring stations in industrial areas where annual average standard was exceeded is located at Bandhaghat 91 µg/m³), (Howrah). - In North India, cities such as Delhi (where traffic areas record high levels and often exceed the standards), Dehradun, Yamunanagar and Ludhiana show a rising trend. Eastern cities, including Howrah, Kolkata, Dhanbad, Jamshedpur and Jharia, have much higher levels compared to northern cities. In many cities in this region the levels declined up to 2004 however there is an increasing trend observed again in past 2 years. Southern Indian cities show a rising trend especially in Visakhapatnam, Hyderabad and Thiruvanthapuram. Cities in western India are relatively better off with almost constant to declining NO_2 levels, though the levels indicate an increasing trend in Mumbai, Nagpur, Nashik, Pune and Chandrapur. Pune after showing high levels till 2003 showed sharp decline till 2005. One of the reasons attributed to lower levels being recorded in Pune is the shifting of the monitoring stations away from heavy traffic sites.

SO_2 waft

Sulfur dioxide is not considered a problem in India any more. Its levels in most cities are already very low and declining. However, there are still some cities such as Khurja, Nashik, Jamshedpur and Chandrapur have moderate levels, the maximum levels was recorded at Khurja with 45 µg/m³. During 2007 NAAQS (annual average) was not exceeded at any monitoring station in residential and industrial areas. SO_2 levels at 79 % of the monitoring stations in industrial areas and 93 % the monitoring stations in residential areas were less than 20 µg/m³. The highest concentration in residential area was observed at monitoring station located at Nashik and highest concentration in industrial area was observed at monitoring station located at Khurja (UP) during 2007, although SO_2 levels at none of the monitoring stations exceeded the annual average standard.

SITUATION IN METROPOLITAN CITIES

In the cities like Ahmedabad, Varanasi, Chennai, Pune, and Kolkata the PM_{10} levels have reduced µin 2007 compared to 2002 levels. However in the cities like Mumbai, Faridabad, Lucknow, Bangalore and Delhi the PM_{10} annual average levels have increased in 2007 over 2002. The nitrogen dioxide levels in the cities like Solapur, Ahmedabad, Pune and Kolkata has reduced. According to CPCB, although various interventions have taken place to mitigate ambient NO_2 levels but at the same time numbers of vehicles have increased exponentially. The vehicles are one of the major sources of NO_2. Measures taken to mitigate ambient NO_2 levels are introduction of improved vehicular technology in the form of Bharat Stage - III vehicles, banning of old vehicles in some cities, improved traffic management, etc. There is huge leap in availability of diesel variant vehicles for last few years. Dieselization has taken off at a maniacal pace with state subsidies. Despite recession, diesel cars have clocked 34% growth last year and are close to 60% of new car sales.

On the other hand, the IARC-WHO has urged worldwide efforts to reduce exposure to diesel fumes as much as possible. Also, in accordance with the WHO, across the G-20 economies, 13 of the 20 most polluted cities are in India and over 50% of the sites studied across India had critical levels of PM_{10} pollution. These findings are indeed worrisome. Average annual concentration in Delhi for example is about 120µg/m³, as against a study conducted at Clark University among a million people exposed chronically to µ/m³ of diesel exhaust, 90% confidence range indicates that 34 to 650 people might be expected to develop lung cancer. The USEPA's "negligible risk" levels as well as deadly when exposure is 60xmore to most of

the urban residential areas in our country. In a city Delhi, more than 55% of its 17 million people live within 500 meters of major roads and are directly affected by traffic emissions. India's cancer registry says cancer is taking on an epidemic form that demands immediate action to cut environmental risk.

A World Bank supported study on source apportionment of $PM_{2.5}$ in selected Indian Cities, released in 2004, shows that depending on the season, the contribution of diesel fuel to the total $PM_{2.5}$ ambient concentration can be as high as 61% in Kolkata, 23% in Delhi and 25% in Mumbai. The cancer-causing potential of diesel exhaust is several times higher than of the worst known air toxics. For instance, the number of excess cancer/million people/$\mu g/m^3$ diesel particulate emissions concentration over a 70-year lifetime exposure is 300. This is several times higher than dangerous toxics like 1, 3 Butadiene which is 170. Smoking has been banned in public places but are we aware that diesel exhaust shares carcinogens with smoking fumes? Certainly emission by bulky diesel engines is many folds higher and inhaled everyday by almost every one of us. According to IARC diesel exhaust is potential enough for various forms of DNA damage, including bulky adducts, oxidative damage, strands breaks, unscheduled synthesis, mutations, sister chromatid exchange morphological cell transformation in mammalian cells, and mutation in bacteria. Increased expression of genes involved in xenobiotic metabolism, oxidative stress, inflammation, antioxidant response, apoptosis, and cell cycle regulation in mammalian cells is also observed. Positive genotoxicity biomarkers of exposure and effect are another observations in human beings exposed to diesel engine exhaust.

That all these findings are certainly a wake-up call to India which in the grip of rapid dieselization, under-priced and under-taxed tox ic level and facing failure of government agencies and the state owned enterprises in discharging their Constitutional and Statutory duties. Not only cancer available evidence indicates that current exposure levels are high enough to lead to other adverse health effects. Diesel exhaust can affect the immune system, respiratory system, produce allergic reactions. Some reports of individuals in the workplace and in clinical studies exposed acutely to high concentrations of diesel exhaust have shown neurophysiological symptoms such as headache, lightheadedness, nausea, vomiting, and tingling of the extremities. There has been some evidences from animal studies indicating possible neurological and behavioral effects. There have also been some evidences a few studies in animals showing sperm abnormalities, neurobehavioral effects in pups and other effects on reproduction as well as on sex ratio. The particulate matters of 2.5µm size ($PM_{2.5}$) emitted in diesel exhaust are potent threat to human hearts and is leading cause of heart attacks worldwide. The school children are forced to travel in heavily polluting auto-rickshaws every day and fall prey to early cardiovascular diseases like hypertension that later come under higher risks for heart attacks at young age. This trend wasn't visible earlier when diesel consumption was comparatively very low in our country. Thus, nation is facing health emergency due lack of clean and safe air. Are health professionals and policy makers are smelling the epidemic and listening to this ecological alarm?

Epidemiological studies suggest that more than 500,000 Americans die each year from cardiopulmonary disease linked to breathing fine particle air pollution study conducted by the University of Birmingham has shown a strong correlation between pneumonia related deaths and air pollution from motor vehicles. Worldwide more deaths per year are linked to air pollution than to automobile accidents. In accordance with a study, 310,000 Europeans die from air pollution annually. Causes of deaths include aggravated asthma, emphysema, respiratory allergies. The USEPA estimates that proposed set of changes in diesel engine technology (Tier 2) could result in 12,000 fewer immature mortalities, 15,000 fewer heart attacks, 6,000 fewer emergency room visits by children asthma, and 8,900 fewer respiratory-related hosp[ital admissions each year in the US. The worst short term civilian pollution crisis in India was the 1984 Bhopal Disaster. Leaked industrial vapors from the UCF, belonging to Union Carbide, Inc., killed more than 25,000 people outright and injured anywhere from 150,000 to 600, 000. The UK suffered its worst air pollution event when the

December 4 Great Smog of 1952 formed over London. In 6 days more than 4,000 died, 8,000 more died within the following months.

An accident leak of anthrax spores from a biological warfare laboratory in the former USSR in 1979 near Sverdlovsk is believed to have been the cause of hundreds of civilian deaths. The worst single incident of air pollution to occur in the US of America occurred in Donora, Pennsylvania in late Octo0ber 1948, when 20 people died and over 7,000 were injured. Individual reactions to air pollutants depend on the type of pollutant a person is exposed to, the degree of exposures, the individual's health status and genetics. A new economic study of health impacts and associated costs of air pollution in the LAB and SAV of Southern California shows that more than 3800 people die prematurely (~ 14 years earlier than normal) each year because air pollution levels violet federal standards. The number annual premature death is considerably higher than the fatalities related to auto collisions in the same area, which average fewer than 2,000 per year.

A study from around the years of 1999 to 2000, by the University of Washington, showed that patients near and around particulate matter air pollution had an increased risk of pulmonary exacerbations and disease in lung function. Patients were examined before the study for amounts of specific pollutants like *Pseudomonas aeruginosa* or *Burkhoolderia cenocepacia* as well as their scocioeconomic standing. Participants involved in the study were located in the US in close proximity to an EPA. During the time of the study 117 deaths were associated with air pollution. Many patients in the study lived in or near large metropolitan areas in order to be close to medical help. These same patients had higher level of pollutants found in their system because of more emissions in larger cities. As cystic fibrosis patients already suffer from decreased lung functions, every day pollutants such as emissions from automobiles, tobacco smoke and improper use of indoor heating devices could further compromise lung function. A 2005 scientific study for the BCLA showed that a small improvement in air quality (1% reduction of ambient $PM_{2.5}$ and some ozone concentration) would produce a $ 29 million in annual savings in the Metro Vancouver region in 2010. The findings were based on health evaluation of lethal (death) and sublethal (illness) effects.

CPCB'S COMPLILATION OF EMISSION FACTORS

Air pollutant factors are representative values that people attempt to relate the quantity of air pollutant released in ambient air with an activity associated with the release of that pollutant. These factors are usually expressed as the weight o0f pollutant divided by a unit weight, volume, distance, of duration of the activity emitting the pollutant (e. g. kilograms of particulate emitted/ megagram of coal burned).

Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages. The USEPA has published a compilation of air pollutant emission factors for a multitude of industrial sources.[A1] The UK, Australia, Canada and many others countries have published similar compilations, as well as the EEA. A2, A3, A4, A5 Despite petrol's benzene content being lowered from 3% to 1% in 2000-2001, there has been no significant effect on the current ambient levels of this carcinogen. In accordance with CPCB's Highlight 2005, the benzene levels in air continue to be high.

Annual maximum concentration of benzene in ambient air at Delhi's Sirifort area was as high as 17.9µh/m^3; the mean concentration of benzene was observed at 9.1µg/m^3 and a *Current Science paper*, Vol. 91 (10) 2006) by researchers of Nagpur-based NEERI. There is no prescribed safety limits for benzene till now, in India. In 2005, CPCB intended to set the limit at 10µg/m^3, which was progressively reduced to 5 µg/m^3 in 2010. The result of 10 years of air pollution interventions could be summarized as a mixed bag for Indian citizens. While the levels of noxious pollutants like SO_2 and nitrogen oxide are down, lung-ailing pollutants like SPM have maintained a constant level, thanks to the booming auto industry. This is what a comparative study of air pollution in 17 cities by CPCB has found. RSPM and SPM in cities

like Agra, Ahamdabad, Delhi, Faridabad, Jharia, Jodhpur, Kolkata, Lucknow and Mumbai are still above national standards in all these cities, the vehicle pollution has increased by about 40% since 2000.

A new study carried out by Junfeng Liu of Princeton University and a team of researchers, has determined that unseen and odorless, microscopic particles of air pollutants wafting overseas and across continents kill some 380,000 people each year. Exhaust from diesel engines, S- from coal fired power plants, and desert dust swirl into an insidious cocktail of tiny particles that can spend weeks airborne. The harmful are the smallest, < 2.5µm in diameter. When inhaled, they can irritate the lungs or pass directly into the bloodstream and damage arteries, in accordance with the findings published in *Discovery News.* Following a recent study on environmental of industrial clusters across the country, the UMoEF has decided to put a brake on all development projects that need a clearance from it. For Rajasthan, the 4 industrial clusters of Bhiwadi, Jodhpur, Pali and Jaipur were chosen. While the first 3 were found to be "critically polluted" with their CEPI being 82.71, 75.19 and 73.37 respectively, the CEPI for Jaipur stood at 66.82 with the study terming it as "severely polluted".

It's after this study that the ministry issued the memorandum in an effort to restore environmental balance in these clusters. The study has termed all clusters with CEPI higher than 70s critically polluted while those between 60 and 70 has been termed as severely polluted. The study recommended surveillance and pollution control measures for the severely polluted areas while urging detailed investigations in terms of damage and formulation of appropriate policy for critically polluted clusters. The ministry's decision followed a study by CPCB with the IIT, New Delhi, on environmental assessment, of industrial clusters across the country based on CEPI, The index is measure of the air, water and land polluted cluster.

Air pollution from growing vehicular traffic, cutting down trees to build express highways and flyovers and the hazards from industrial effluents have sharply increased the incidence of a range of diseases, from asthma to cancer to mental retardation, caused by increasing levels of Pb in the blood stream. Air pollution has become a devastating child killer throughout Asia.

Children living in cities are unintended victims of the rapid industrialization and urbanization of most of Asian countries, poisoned by breathing air polluted by motor vehicle exhausts and industrial smokestacks. But kids in rural areas don't escape harm either. Children die every year from breathing smoke from fires and turn their own homes into death traps. Because disease tied to environmental factors can have more than one cause, it's impossible to state flatly how many children are victims of air pollution. But combines statics from WHO, private health groups, medical journals and hospital officials point to an inescapable conclusion: from teeming cities to tiny rural villages, every year at least 1 million Asian children are dying or suffering life-shortening diseases, such as respiratory infections and pneumonia, that are brought on by toxic air. Throughout Asia, the signs of a huge problem are inescapable.

In New Delhi, a survey of 20 thousand school children found that one in every 8 had asthma. For children in China's cities, just breathing is the equivalent of smoking 2 packs of cigarettes a day. Respiratory matter isn't the only problem brought out by air pollution. In Bandung, Indonesia, examinations of 62 children found that nearly half had dangerously high levels of Pb in their blood from air polluted motor vehicles. The threat begins even before birth. A Taiwanese study found a correlation between maternal exposure to SO_2 during the first trimester of pregnancy and lowered birth rate. Newborns in Philippines are showing high levels of Pb, Hg, Cd and Cu in their blood. And in Bangkok, physicians have found deadly particles in the umbilical cords of newborn babies. This has become a major health problem, especially in developing countries. But less clear is the effect that air pollution generated in regions like Chine and Southeast Asia has on far-off lands, like North America. Particulate pollution borne overseas that floats into Canada, Mexico and the US accounts for 6,600 premature deaths each year.

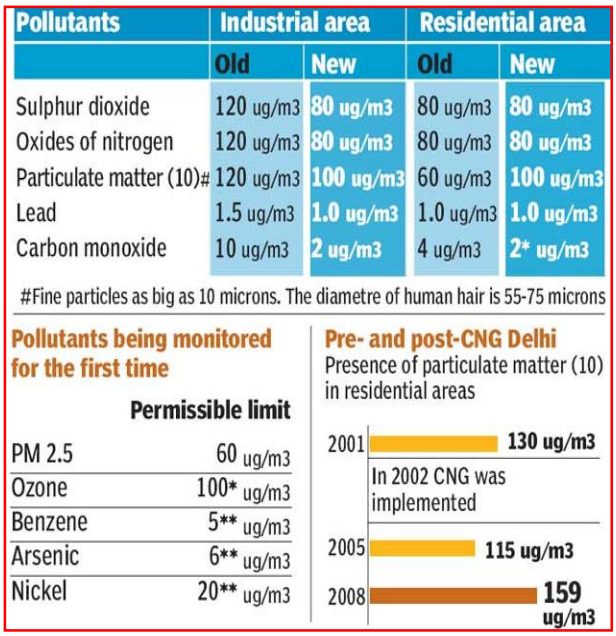
REVISED AIR QUALITY NORMS IN INDIA

With pollution levels rising across the country, India has revised the NAAQS standards after 15 years, bringing about uniform standards for residential and industrial areas. The revised ambient air quality standards provide a legal framework for the control of air pollution and the protection of public health and any citizen can approach the court demanding better air quality. The most important part of the revised standards is that distinctions between industrial and residential areas have been removed. Now industries have to conform to the same standards as residential areas and will be compelled to take necessary measures to check air pollution.

The important alterations are-

1. Air quality assessment will now be done on the basis of five new parameters - Ozone, Arsenic, Nickel, Benzene, Benzopyrene- that have been included for the first time under NAAQS.
2. Area classification based on land-use has been done away with so that industrial areas have to conform to the same air pollution standards as residential areas.
3. New Air Norms: Same for Residential & Industrial Area as well [Figure 8]
4. Act as a whistleblower for automobile companies as it will compel them to switch to fuel efficient engineering.
5. The standards shall be applicable uniformly with the exception of stringent standards for NO_2 & SO_2 in 9 ecologically sensitive areas in the country to protect the rare and endangered flora and fauna.
6. The standard for nitrogen oxide has been made more stringent, from the existing 60 / m^3 it has been tightened down to 40 / m^3.
7. The standards have brought two deadly pollutants - PM 2.5 and ozone - within the ambit of regulation. Both of these have begun to rise in cities. Delhi, particularly, has already begun to experience ozone pollution.
8. Suspended Particulate matter as parameter has been replaced by fine PM 2.5 which is more relevant for public health.

Fig. 8: Same Norms of air Quality for Residential & Industrial Sectors*



Pollutants	Industrial area		Residential area	
	Old	New	Old	New
Sulphur dioxide	120 ug/m3	80 ug/m3	80 ug/m3	80 ug/m3
Oxides of nitrogen	120 ug/m3	80 ug/m3	80 ug/m3	80 ug/m3
Particulate matter (10)#	120 ug/m3	100 ug/m3	60 ug/m3	100 ug/m3
Lead	1.5 ug/m3	1.0 ug/m3	1.0 ug/m3	1.0 ug/m3
Carbon monoxide	10 ug/m3	2 ug/m3	4 ug/m3	2* ug/m3

($PM_{2.5}$ are tiny particles in the air that reduce visibility and cause the air to appear hazy when levels are elevated. Exposure to fine particles can cause health effects such as eye, nose, throat and lung irritation, coughing, sneezing, runny nose and shortness of breath. It can also affect lung function and worsen medical conditions such as asthma and heart disease Source: IANS)

CONCLUSION AND DISCUSSION

The gasoline and diesel fuel in use today contains significant amounts of sulfur and other compounds that make it harder for existing control technology to keep vehicles clean. Removing the sulfur from the fuel and cutting down on the amount of light hydrocarbons helps pollution-control technology to work better and cuts down on evaporative and refueling emissions. Further large-scale reductions of other tailpipe pollution and CO_2 can be accomplished with a shift away from conventional fuels. Alternative fuels such as natural gas, methanol, ethanol, and hydrogen can deliver benefits to the environment while helping to move the United States away from its dependence on oil. All of these fuels inherently burn cleaner than diesel and gasoline, and they have lower carbon content- resulting in less CO_2. Most of these fuels are also more easily made from renewable resources, and fuels such as natural gas and methanol help provide a bridge to producing hydrogen for fuel-cell vehicles. As more cars and trucks are sold and total annual mileage increases, improving pollution-control technology and burning less fuel continues to be vital, especially in rapidly growing urban areas. However, eliminating emissions from the tailpipe goes even further to cut down on harmful air pollutants.

Hydrogen fuel-cell and electric vehicles move away from burning fuel and use electrochemical processes instead to produce the needed energy to drive a car down the road. Fuel-cell vehicles run on electricity that is produced directly from the reaction of hydrogen and oxygen. The only by product is water—which is why fuel-cell cars and trucks are called zero-emission vehicles. Electric vehicles store energy in an onboard battery, emitting nothing from the tailpipe. The hydrogen for the fuel cell and the electricity for the battery must still be produced somewhere, so there will still be upstream emissions associated with these vehicles. These stationary sources, however, are easier to control and can ultimately be converted to use wind, solar, and other renewable energy sources to come as close as possible to true zero-emission vehicles.

Vehicular emissions that contribute to air quality problems, smog, and global warming can be reduced by putting better pollution-control technologies on cars and trucks, burning less fuel, switching to cleaner fuels, using technologies that reduce or eliminate emissions, and reducing the number of vehicle miles traveled. There are various air pollution technologies and land use planning strategies available to reduce air pollution. At its most basic level land use planning is likely to involve zoning and transport infrastructure planning. In most developed countries, land use planning is an important part of social policy, ensuring that land is used efficiently for the benefit of the wider economy and population as well as to protect the environment. Efforts to reduce pollution from mobile sources includes primary regulation (many developing countries have permissive regulators), expanding regulation to new sources (such as cruise and transport ships, farm equipment, and small gas-powered equipments such as lawn trimmers, chainsaws, and snowmobiles), increased fuel efficiency (such as through the use of hybrid vehicles), conversion to cleaner fuels (viz. bioethanol, biodiesel,, or conversion to electric vehicle).

For gasoline vehicles, “three way” catalysts, precise engine and fuel controls, and evaporative emission controls have been quite successful. More advanced versions of these technologies are in some cars and can reduce smog-forming emissions from new vehicles by a factor of ten. For diesel vehicles, “two-way” catalysts and engine controls have been able to reduce hydrocarbon and carbon monoxide emissions, but nitrogen oxide and toxic particulate-matter emissions remain very high. More advanced diesel-control technologies are under development, but it is unlikely that they will be able to clean up diesel to the degree already achieved in the cleanest gasoline vehicles. Added concerns surround the difference between new vehicle emissions and the emissions of a car or truck over a lifetime of actual use. Vehicles with good emission-control technology that is not properly maintained can become “gross polluters” that are responsible for a significant amount of existing air-quality problems. New technologies have also been developed to identify emission-equipment control failures, and can be used to help reduce the “gross polluter” problem.

ABBREVIATIONS

AAP	Ambient Air Particulate	**IEMR**	Institute for Environment Medical Research
AM	Alveolar Macrophage	**IQ**	Intelligence Quotient
AQM	Air Quality Monitoring	**LAB**	Los Angeles Basin
ARI	Acute Respiratory Infection	**LAF**	Los Angeles Freeway
BCLA	British Columbia Lung Association	**MESA**	Multi-Ethnic Study of Atherosclerosis
BRIC	Brazil, Russia, India & China	**MIC**	Methyl Isocyanate
CARB	California Air Resource Board	**Mn**	Manganese
CASc	Centre for Atmospheric Sciences	**MOx**	Metallic Oxides
Cd	Cadmium	**NAAQS**	National Ambient Air Quality Standard
CEPI	Comprehensive Environmental Pollution Index	**NAMP**	National Air Quality Monitoring Programme
CNG	Compressed Natural Gas	**NBD**	National Burden of Disease
CNG	Compressed Natural Gas	**NCR**	National Capital Region
CO	Carbon Monoxide	**NEERI**	National Environmental & Engineering
$COCl_2$	Phosgene	**NHS**	Nurses' Health Study
COHb	Carboxy Haemoglobin	**NNAQ**	National Ambient Air Quality
COPD	Chronic Obstructive Pulmonary Disease	**NOx**	Nitrogen Oxides
CPCB	Central Pollution Control Board	**O_3**	Ozone
CRF	Chest Research Foundation	**OSHA**	Occupational Safety & Health Administration
CSE	Centre of Environment & Science	**PAH**	Polycyclic Aromatic Hydrocarbon
Cu	Cuprum	**Pb**	Lead
DASD	Diagnosed Autism Spectrum Disorder	**PEF**	Peak Expiratory Flow
DNA	De-oxyribo Nucleic Acid	**PEFR**	Peak Expiratory Flow Rate
EEA	European Environmental Agency	**PM**	Particulate Matter
EIOSH	Environmental Institute of Occupational Safety & Health	**PM_{10}**	Particulate Matter <10µm
ETS	Environmental Tobacco Smoke	**PPB**	Parts Per Billion
FEV	Forced Expiratory Volume	**RSPM**	Respirable Suspended Particulate Matter
FEV_1	Forced Expiratory Volume in 1 Second	**SAV**	San Joaquin Valley
FVC	Forced Vital Capacity	**SO_2**	Sulphur- Dioxide
GBD	Global Burden of Diseases	**SPM**	Suspended Particulate Matter
GDC	German Diabetes Centre	**SUV**	Small Utility Vehicle
H_2SO_4	Sulphuric Acid	**TB**	Tuberculosis
HAPs	Hazardous Air Pollutants	**TEPP**	Three Environmental Policy Packages
HC	Hydrocarbon	**UCF**	Union Carbide Factory
HF	Hydrofluoric Acid	**UMoEF**	Union Ministry of Environment & Forest
Hg	Mercury	**USEPA**	US Environmental Protection Agency
HSPH	Harvard School of Public Health	**VOC**	Volatile Organic Compound
IANS	Indo-Asian News Service	**WHO**	World Health Organisation
IARC	International Agency for Research & Cancer	**WRI**	World Resource Institute

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