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Major Air Pollutants and their Effect on Health

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Abstract—*Clean air is a basic need of every human being and air pollution is one of the major environmental health threat to the human population. Millions of pre mature deaths are due to poor air quality. Air pollution is a major health risk after high blood pressure, poor diets and smoking . Carbon monoxide, lead, nitrogen dioxide, ozone, sulphur dioxide, particulate matter such as PM 10 and PM 2.5 are present in the air and are called ambient air pollutant. The three air pollutant such as particulate matter (PM), sulphur oxides and nitrogen oxides are mainly responsible for impacts of air pollution to the environmental health directly or by converting into other pollutants by undergoing chemical reactions. Emissions from energy sector is also linked with health and air pollution. Inefficient fuel combustion for energy use is another major source of air pollutant emissions. Adverse effects of air pollutants ranges from nausea, difficulty in breathing and skin irritations, to birth defects, and cancer. Moreover, the severity of health problems associated with air pollution exposure is not uniform within populations. Sources of air pollution may vary from industrial, vehicular to domestic . Several communities reside on land in close proximity to pollution sources. New air quality legislation can be implemented to protect the health of people. The new air quality management plans, air quality monitoring programmes and projects can be implemented for controlling air pollution. Air quality monitoring and evaluation tools can be created for the health management of the people. For effective protection of human health, information on air pollution source, type and concentration can be collected and different types of health indicators can be created to map in detail the scale, causes and effects of the problem due to air pollution.*

Introduction

Outdoor air pollution is a major environmental health problem affecting everyone in this developed and developing world. Identification investigation and monitoring of the air pollutants, their sources of emissions can be mapped and their effects on health can be observed.

The energy production, inefficient fuel combustions and emissions from transport sector are important sources of air pollutant emission. Industrialization, population growth and globalization are main factors causing air pollution Small particulate pollution have health impacts even at very low concentrations. The three major air pollutant, particulate matter (PM), sulphur oxides and nitrogen oxides are mainly responsible for impacts of air pollution to the environmental health directly or by converting into other pollutants by undergoing chemical reactions. There are serious risks to health from exposure to ozone (O3), nitrogen dioxide (NO2) and sulfur dioxide (SO2).

An inventory of air pollutants is a first step to control of air pollution. Air pollutants can be primary or secondary depending upon their formation mechanism. Ambient air quality monitoring is required to determine the existing quality of air, evaluation of the effectiveness of control programme and to identify areas in need of restoration and their priortization

Major air pollutant and their health effects

Particulate matter PM 10, Particulate matter PM 2.5, nitrogen dioxide, sulphur dioxide, ozone, carbon monoxide, lead, are present in the air and are called ambient air pollutant. Guideline values of major ambient air pollutants as given by WHO are given in in table 1

Guideline values of Major Ambient air Pollutants
Table 1

$PM_{2.5}$	10 µg/m3 annual mean 25 µg/m3 24-hour mean
PM_{10}	20 µg/m3 annual mean 50 µg/m3 24-hour mean
NO_2	40 µg/m3 annual mean 200 µg/m3 1-hour mean
SO_2	20 µg/m3 24-hour mean 500 µg/m3 10-minute mean
O_3	100 µg/m3 8-hour mean

Particulate matter

Particulate matter (PM) effects more people than any other pollutant. The major components of PM are sulfate, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water. A complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air is called particulate matter. The particles with a diameter of 10 microns or less, (PM_{10}), which can penetrate deep inside the lungs are most harmful .Chronic exposure to particles contributes to the risk of developing cardiovascular and respiratory diseases, as well as of lung cancer.

Air quality measurements are typically reported in terms of daily or annual mean concentrations of PM10 particles per cubic meter of air volume (m3). Air quality measurements are

described of such PM concentrations in terms of micrograms per cubic meter (μg/m3). Caliberated measurement tools can report the correct and exact concentrations of air pollutants in the air.

$PM_{2.5}$ includes pollutants such as sulfate, nitrates and black carbon, which penetrate deep into the lungs and in the cardiovascular system, posing the greatest risks to human health. Lower concentrations of $PM_{2.5}$ levels are generally observed in monsoon months as particulate matters are washed out due to wet deposition.

Health effects

There is a close, quantitative relationship between exposure to high concentrations of small particulates (PM_{10} and $PM_{2.5}$) and increased mortality or morbidity, both daily and over time. Conversely, when concentrations of small and fine particulates are reduced, related mortality will also go down – presuming other factors remain the same. This allows policymakers to project the population health improvements that could be expected if particulate air pollution is reduced.

If these interim targets were to be achieved, significant reductions in risks for acute and chronic health effects from air pollution can be expected. Progress towards the guideline values, however, should be the ultimate objective.

WHO air quality model confirms that 92% of the world's population lives in places where air quality levels exceed "WHO's Ambient Air quality guidelines" for annual mean of particulate matter with a diameter of less than 2.5 micrometres ($PM_{2.5}$). WHO guideline limits for annual mean of $PM_{2.5}$ are 10 μg/m3 annual mean.

The effects of PM on health occur at levels of exposure currently being experienced by many people both in urban and rural areas and in developed and developing countries – although exposures in many fast-developing cities today are often far higher than in developed cities of comparable size.

Nitrogen dioxide (NO_2)

The current WHO guideline value of 40 $\mu g/m^3$ (annual mean) was set to protect the public from the health effects of gaseous.

As an air pollutant, NO_2 has several correlated activities. At short-term concentrations exceeding 200 μg/m3, it is a toxic gas which causes significant inflammation of the airways.NO2 is the main source of nitrate aerosols, which form an important fraction of $PM_{2.5}$ and, in the presence of ultraviolet light, of ozone.

The major sources of emissions of NO2 are combustion processes in different sectors for example heating process, power generation, and engines in vehicles and ships.

Health effects

Long-term exposure to NO2 increases bronchitis in asthmatic people. and reduced lung function . High levels of nitrogen dioxide exposure can give people coughs and can make them feel short of breath. People who are exposed to nitrogen dioxide for a long time have a higher chance of getting respiratory infections. Nitrogen dioxide reacts in the atmosphere to form acid rain, which can harm plants and animals.

Sulfur dioxide (SO_2)

SO2 is a colourless gas with a sharp odour.

It is produced from the burning of fossil fuels (coal and oil) and the smelting of mineral ores that contain sulfur. The main source of SO_2 is the burning of sulfur-containing fossil fuels, power generation and motor vehicles.

Health effects

SO2 can affect the respiratory system and the functions of the lungs, and causes irritation of the eyes. Inflammation of the respiratory tract causes coughing, mucus secretion, aggravation of asthma and chronic bronchitis and makes people more prone to infections of the respiratory tract. Cardiac disease and mortality increase with exposure with higher SO2 levels. In acid rain, SO2 combines with water to form sulfuric acid; which causes deforestation.

Ozone (O3)

Ozone (O3) is a gas not usually emitted directly into the air. Ground level ozone is created by a chemical reaction between NOx and VOCs in the presence of heat and sunlight.

It is a bluish, unstable gas with a pungent odour, found in two parts of the atmosphere: the stratosphere and the troposphere

Ozone is a form of oxygen having the molecular formula O3and is formed in the air Ozone gas that can be found in two places. Near the ground (the troposphere), it is a major part of smog. The harmful ozone in the lower atmosphere should not be confused with the protective layer of ozone in the upper atmosphere (stratosphere), which screens out harmful ultraviolet rays.

Ozone at ground level causes photochemical smog. The reaction with sunlight (photochemical reaction) of pollutants, nitrogen oxides (NOx) from vehicles and industry emissions and volatile organic compounds (VOCs) emitted by vehicles, solvents and industry causes smog. As a result, the highest levels of ozone pollution occur during periods of sunny weather.

Ozone is not created directly, but is formed when nitrogen oxides and volatile organic compounds mix in sunlight. That is why ozone is mostly found in the summer. Nitrogen oxides come from burning gasoline, coal, or other fossil fuels. There

are many types of volatile organic compounds, and they come from sources ranging from factories to trees.

Motor vehicle exhaust, industrial emissions, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOCs.

Ozone can irritate lung airways and cause wheezing and coughing. Repeated exposure can cause permanent lung damage. Ozone damages leaves of trees and other plants. It decreases the ability of plants to produce and store food, and reduces crop yield. It reduces resistance to colds and infections, premature aging of lung tissue. It can and damages rubber, fabric and other materials. Smog reduces visibility

Health effects

Excessive ozone in the air causes breathing problems, trigger asthma, reduce lung function and lung diseases. Ozone is a major factor in asthma morbidity and mortality, while nitrogen dioxide and sulfur dioxide also can play a role in asthma, bronchial symptoms, lung inflammation and reduced lung function.

Carbon monoxide.

Carbon monoxide ,a colourless gas, is released when engines burn fossil fuels.

Carbon monoxide makes it hard for body parts to get the oxygen they need to run correctly. Exposure to carbon monoxide makes people feel dizzy and tired and gives them headaches. In high concentrations it is fatal. Elderly people with heart disease are hospitalized more often when they are exposed to higher amounts of carbon monoxide.

Lead.

High amounts of lead can be dangerous for small children and can lead to lower IQs and kidney problems. For adults, exposure to lead can increase the chance of having heart attacks or strokes.

Common atmospheric pollution sources and their pollutants

An inventory of air pollutants, their sources of emissions and their effects on health is necessary to monitor and control the emission of air pollutants Sources of air pollutant may vary from industrial, vehicular to domestic. Indoor exposure to pollutants from the household combustion of solid fuels on open fires or traditional stoves increases the risk of pre mature deaths. Indoor air pollution in developing countries causes several respiratory diseases, cardiovascular disease, chronic obstructive pulmonary disease and lung cancer. Several communities reside on land in close proximity to pollution sources. In Delhi the traditional use of biomass for cooking and two coal fired power plants(Badarpur and Rajghat) are the main sourse of $PM_{2.5}$ emissions in Delhi

Fires are another major source of air pollution and can lead to severe problems if the smoke is inhaled for a period of time. These fires can either be forest fires, oil well fires, burning of leaves in the backyard or as in the case of rural areas, large-scale burning of agricultural waste. Transport's contribution to climate change include: long-lived carbon dioxide (CO2) emissions and; short-lived black carbon generated primarily by diesel vehicles.

CO2 emissions

Transport accounted for about 23% of global carbon dioxide emissions in 2010 and 27% of end-use energy emissions with urban transport accounting for about 40% of end-use energy consumption. Carbon dioxide persists in the atmosphere for over a century, with long-term warming effects (IPCC, 2014).

Black carbon, a short-lived climate pollutant, is the second highest contributor to global warming after CO_2. Black carbon has a warming effect many times more powerful than carbon dioxide, but it persists in the atmosphere for only a few weeks – so measures to reduce black carbon can also have an immediate effect on slowing the pace of climate change.

Diesel transport is one of the world's major sources of black carbon (along with household biomass cookstoves). Not only does black carbon have a significant warming effect, but it is also a major component of particulate matter, the air pollutant most closely associated with increased air-pollution related mortality and morbidity.

Ground-level ozone is another short-lived climate pollutant stimulated by transport pollution. Ozone is created by a mix of are pollutants, including oxides of nitrogen (NO_x) produced by vehicle engines and methane emissions from other sources (e.g. landfills and animal waste). Ozone contributes to chronic respiratory diseases, particularly childhood asthma.

Monitoring of Air Pollutants

Air quality monitoring maps in detail the scale, causes and effects of the problem .Major Pollutant emitting sectors are transport, energy waste management, buildings and agriculture.

Central Pollution Control Board executed a nation-wide programme of ambient air quality monitoring known as N.A.M.P. N.A.M.P. is being operated through various monitoring agencies, large number of personnel and equipment are involved in the sampling, chemical analyses, data reporting etc. There are 573 operating stations in 240 cities/towns in 26 states and 5 Union Territories of the country.

The monitoring of the three air pollutants for example., Sulphur Dioxide (SO2), Nitrogen dioxides (NO2) and Respirable Suspended Particulate Matter (RSPM/PM10) pollutants is carried out for 24 hours (4-hourly sampling for gaseous pollutants and 8-hourly sampling for particulate

matter) with a frequency of twice a week, to have 104 observations in a year.

Examples of Air Pollutants in different places in different studies

Examples of Major air pollutant as observed at various places at Delhi in 2010 (Source: National Ambient Air Quality Status & Trends in India-2010)

1)Monthly average and annual average concentration of PM2.5 at various places. in Delhi 2010 (Table 2, Fig. 1)

Table 2

	A	B	C	D	E	F
Jan	143	155	197	261	148	171
Feb	30	182	148	NA	78	106
March	61	187	163	NA	106	119
April	68	107	38	65	64	68
May	57	235	70	59	61	54
June	49	131	IS?	162	79	44
July	40	63	41	30	43	44
August	58	43	100	22	67	60
Sept	36	61	59	33	50	35
Oct	112	88	100	91	102	100
Nov	117	77	127	80	130	137
Dec	132	53	167	103	94	88
Average	72	103	107	79	85	85

A Concentration of PM2.5 at Pritampura, New Delhi during 2010
B Concentration of PM2.5.at Sirifort, New Delhi during 2010
C Particulate matter with size less than or equal to 2.5 (PM2.5) at Janakpuri, New Delhi
D Concentration of PM2.5 at Nizamuddin. New Delhi during 2010
E Concentration of PM2.5 at Shahzada Bagh, New Delhi during 20I0
F Concentration of PM2.5 at Shahdara, Delhi during 2010

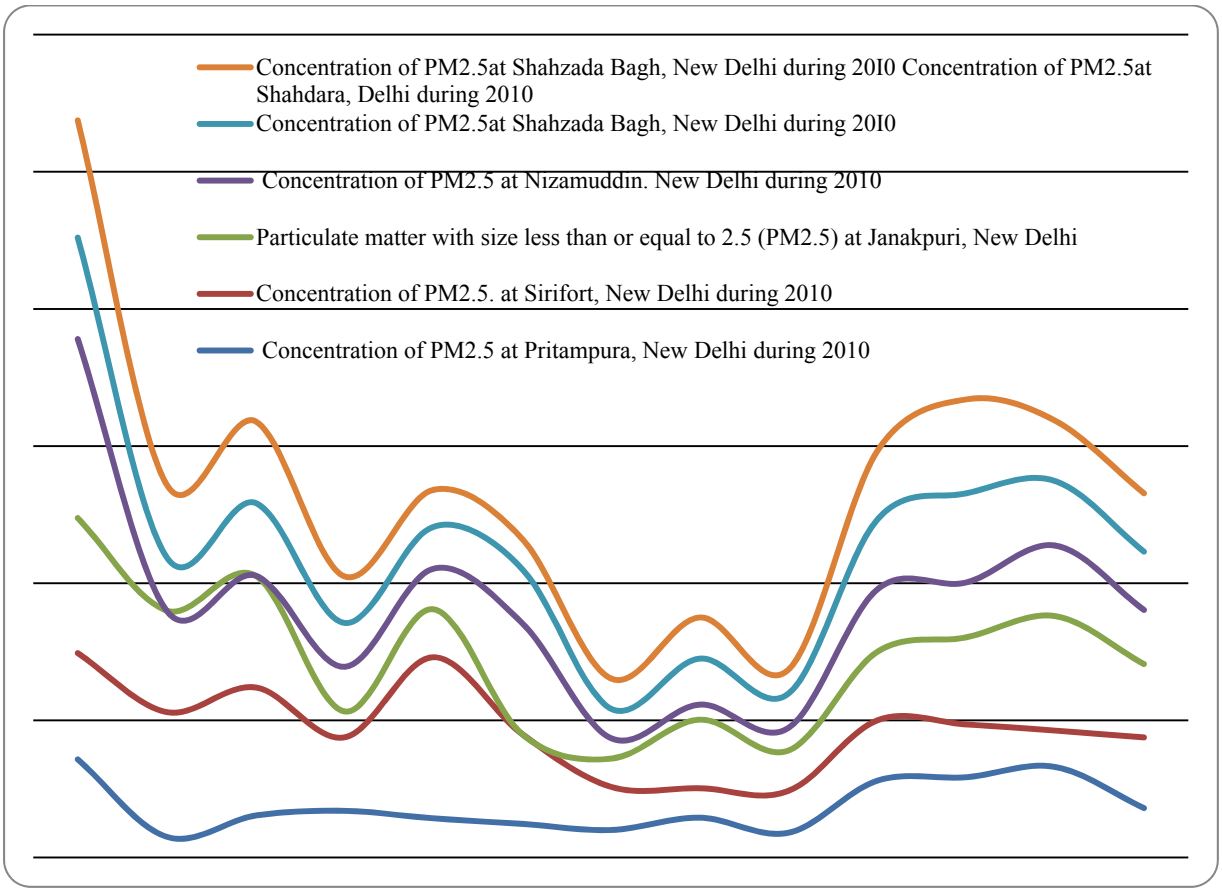

Fig. 1

Monthly average and annual average concentration of PM2.5 at various places. in Delhi 2010

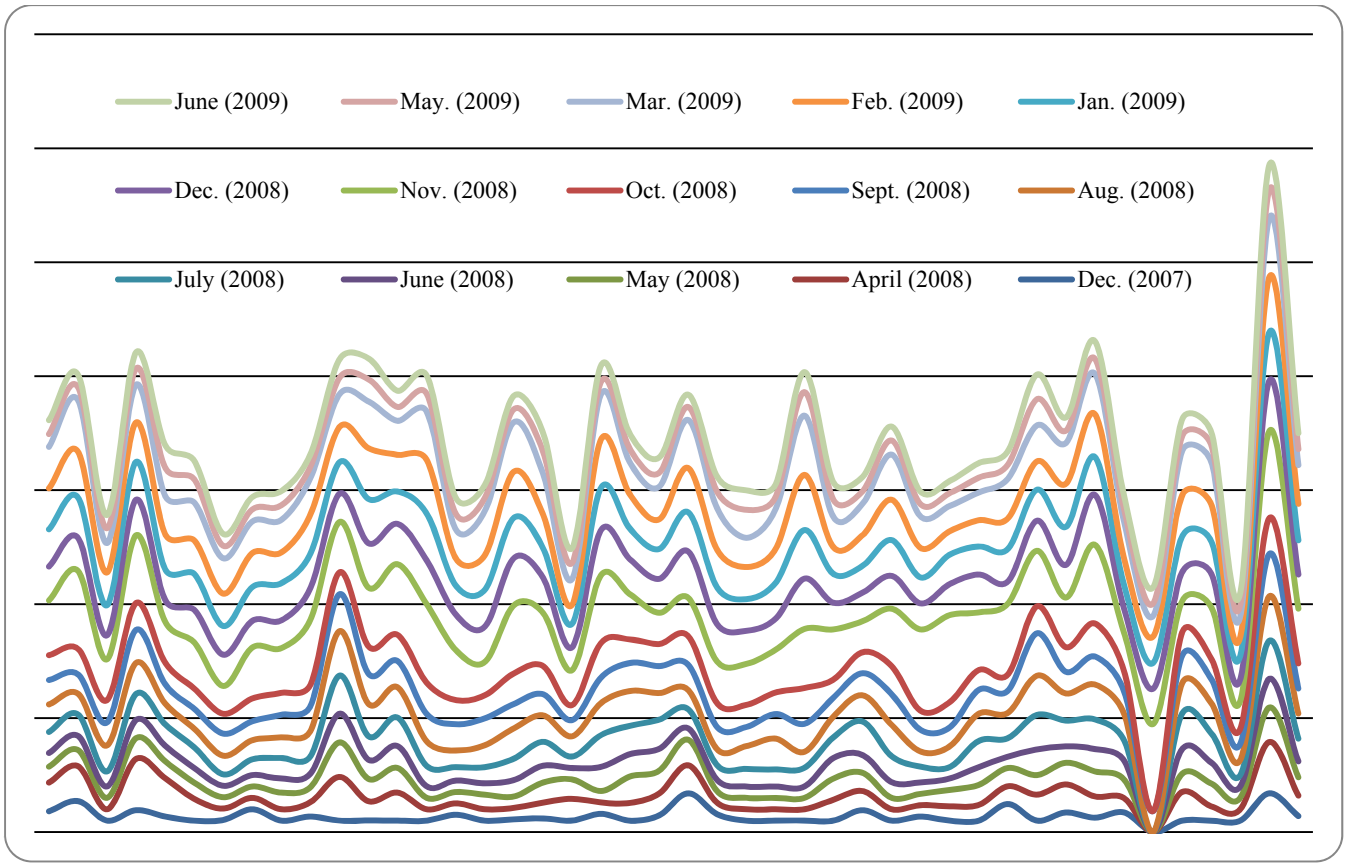

Fig. 2

Concentration of SO2 at Different Locations in Delhi 2010 in at various places in New Delhi different Years in Fig. 2 Concentration of Carbon Monoxide (CO) and ozone at various places in New Delhi during 2010(Table 3, Fig. 3, Fig. 4)

Table 3

	A	B	C	D	E
Jan	3624	1023	15	51	36
Feb	3201	1166	25	37	70
March	2660	1313	36	31	88
April	2189	789	30	26	141
May	1740	853	31	NA	91
June	1246	582	33	NA	47
July	1421	426	41	NA	46
August	1396	630	54	NA	43
Sept	1253	763	36	NA	63
Oct	1913	1132	42	30	126
Nov	2784	1930	26	28	60
Dec	1360	1391	24	24	57
Average	2072	1014	33	34	72

A Concentration of Carbon Monoxide (CO) µg/m3 at BSZ Marg, New Delhi during 2010

B Concentration of Carbon Monoxide (CO) µg/m3 at DCE, Bhawana, Delhi during 2010 in µg/m3

C Ozone Concentration at BSZ Marg (ITO) in µg/m3

D Ozone Concentration at Siri Fort, New Delhi during 2010 in µg/m3

E Ozone Concentration at DCE, Bhawana, Delhi during 2010 in in µg/m3

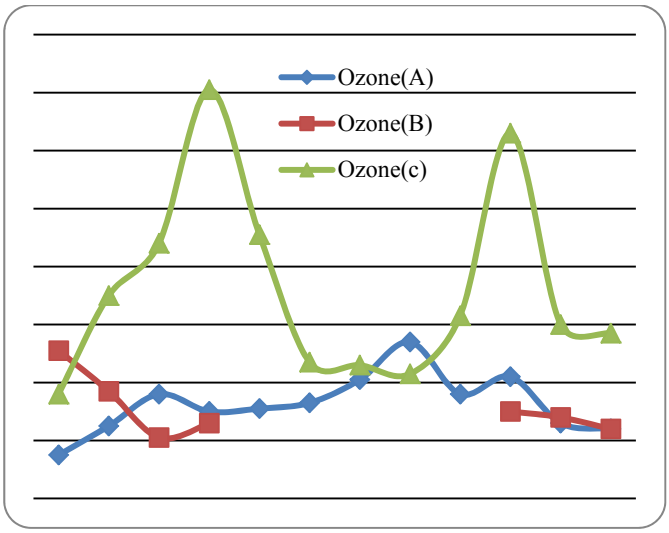

Fig. 3

Concentration of ozone (O_3) at various places in New Delhi during 2010 in Fig. 3

Concentration of Carbon Monoxide (CO) at various places in New Delhi during 2010 in Fig. 4

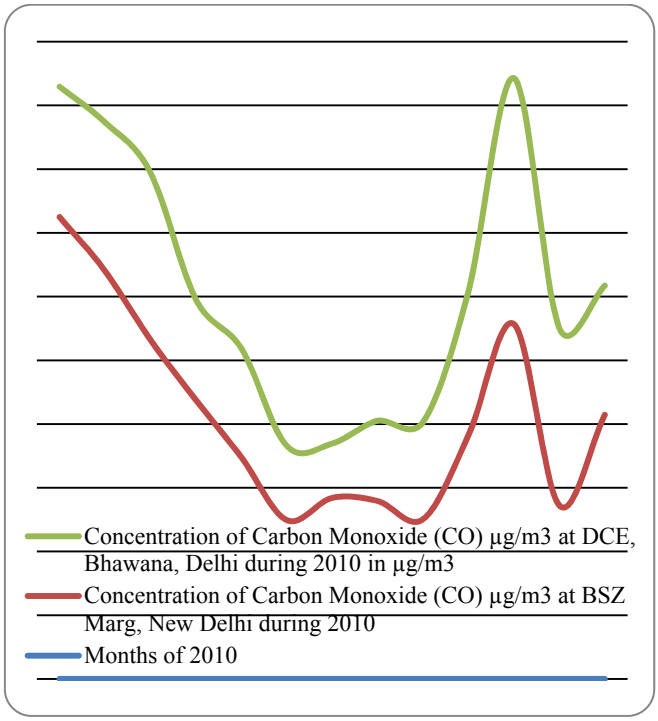

Fig. 4

2) The highest level of air pollution in Delhi 2015, according to the System of Air Quality and Weather Forecasting And Research (SAFAR), which operates under the ministry of earth sciences on 5 December and Feb 10.2015 is shown in Fig. 5

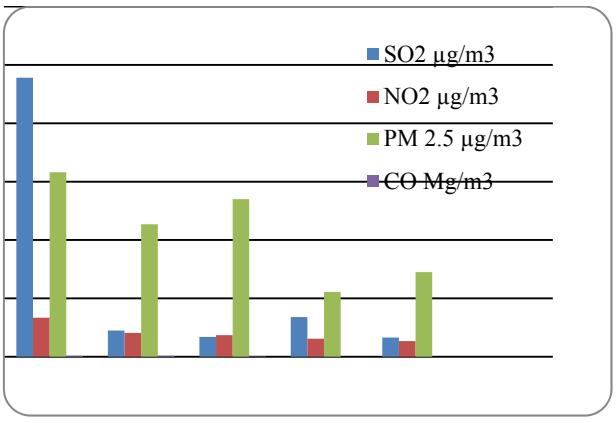

Fig. 5: Concentration of various air pollutant at different places in and around Delhi

3) The air pollution contributed in percentage by different sources are shown in Table 4

Table 4

	Pm25	So2	No2
Transport	17	2	53
Gen Sets	6	4	25
Brick klins	15	11	2
Industry	14	23	11
Construction	5	-	1
Waste Burning	8	1	1
Road Dust	6	-	-
Power Plants	16	55	7
Domestic	12	6	1

(Source: Dinesh Mohan: Dealing with pollution in our cities.Policies that are less car-centric are needed in order to improve India's urban environment, April 4, 2015

Strategies for reducing air pollution emission Levels

To control air pollution from vehicles. industries and other sources, reduction of pollutant emission is necessary. Immediate and fast solutions for reducing air pollution lies with sustainable transport in cities, solid waste management, access to clean household fuels and cook-stoves, as well as renewable energies and industrial emissions reductions." For effective protection of human health, information on air pollution source, type and concentration is essential.

Reducing pollutant emissions improves water and soil quality, crop yields and, in turn, food security. Reducing outdoor air pollution also reduces emissions of CO2 and short-lived climate pollutants such as black carbon particles and methane, thus contributing to the near- and long-term mitigation of climate change.

World energy outlook 2016 (WEO-2016) show the link between energy, air pollution and health. Energy generation, transportation, and industries emits large number of pollutants. Cities causes air pollution as they concentrate on people, energy use, construction activity and traffic. The report shows air pollution a major health risk after high blood pressure, poor diets and smoking and a major public health crisis, with many of its root causes and cures to be found in the energy sector.

Health Indicator

New air quality legislation can be implemented to protect the health of people through the implementation of air quality management plans and air quality monitoring programmes. Air quality monitoring and evaluation tools can be created to consider their application for the health management of the people. For effective protection of human health, information on air pollution source, type and concentration is essential but also different type of health indicators demographic, Socio-economic indicators can be created to prevent human health

INDC (Intended Nationally Determined Contributions (INDCs)

In its INDC, India has pledged to improve the emissions intensity of its GDP by-33% to -35% below 2005 emissions

levels by 2030. It has also pledged to increase the share of non-fossil fuels-based electricity to 40 per cent by 2030. It has agreed to enhance its forest cover which will absorb 2.5 to 3 billion tonnes of carbon dioxide (CO2, the main gas responsible for global warming) by 2030.

Conclusion

New air quality legislation can be implemented to protect the health of people through the implementation of air quality management plans and air quality monitoring programmes. Air quality monitoring and evaluation tools can be created to consider their application for effective protection of human health, information on air pollution source, type and concentration is essential but also different type of health indicators demographic, Socio-economic indicators can be created to prevent human health

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