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Review Article

Air pollutants all are chemical compounds hazardous to ecosystem

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Abstract

Smog (Smoke+Fog) hanging over cities is the most familiar and obvious form of air pollution. But there are different kinds of pollution—some visible, some invisible—that contribute to global warming. Generally any substance that people introduce into the atmosphere that has damaging effects on living things and the environment is considered air pollution. Carbon dioxide, a greenhouse gas, is the main pollutant that is warming Earth. Though living things emit carbon dioxide when they breathe, carbon dioxide is widely considered to be a pollutant when associated with cars, planes, power plants, and other human activities that involve the burning of fossil fuels such as gasoline and natural gas. In the past 150 years, such activities have pumped enough carbon dioxide into the atmosphere to raise its levels higher than they have been for hundreds of thousands of years. Other greenhouse gases include methane—which comes from such sources as swamps and gas emitted by livestock—and chlorofluorocarbons (CFCs), which were used in refrigerants and aerosol propellants until they were banned because of their deteriorating effect on Earth's ozone layer. Another pollutant associated with climate change is sulfur dioxide, a component of smog. Sulfur dioxide and closely related chemicals are known primarily as a cause of acid rain. But they also reflect light when released in the atmosphere, which keeps sunlight out and causes Earth to cool. Volcanic eruptions can spew massive amounts of sulfur dioxide into the atmosphere, sometimes causing cooling that lasts for years. In fact, volcanoes used to be the main source of atmospheric sulfur dioxide; today people are. Industrialized countries have worked to reduce levels of sulfur dioxide, smog, and smoke in order to improve people's health. But a result, not predicted until recently, is that the lower sulfur dioxide levels may actually make global warming worse. Just as sulfur dioxide from volcanoes can cool the planet by blocking sunlight, cutting the amount of the compound in the atmosphere lets more sunlight through, warming the Earth. This effect is exaggerated when elevated levels of other greenhouse gases in the atmosphere trap the additional heat. Most people agree that to curb global warming, a variety of measures need to be taken. On a personal level, driving and flying less, recycling, and conservation reduces a person's "carbon footprint"—the amount of carbon dioxide a person is responsible for putting into the atmosphere. On a larger scale, governments are taking measures to limit emissions of carbon dioxide and other greenhouse gases. One way is through the Kyoto Protocol, an agreement between countries that they will cut back on carbon dioxide emissions. Another method is to put taxes on carbon emissions or higher taxes on gasoline, so that people and companies will have greater incentives to conserve energy and pollute less.

Kyewords: Pollutants, CO, NO_2, CO_2, SO_2, O_3, NH_3, CFC, VOC, POP, DE, PAH, Smog, Radon, Greenhouse effect, Acid rain, IV radiation, Primary pollutants, Secondary Pollutants

Air pollution: It is the introduction of particulates, biological molecules, or other harmful materials into the Earth's atmosphere, possibly causing disease, death to humans, damage to other living organisms such as food crops, or the natural or built environment. The atmosphere is a complex natural gaseous system that is essential to support life on planet Earth. Stratospheric ozone depletion due to air pollution has long been recognized as a threat to human health as well as to the Earth's ecosystems. Indoor air pollution and urban air quality are listed as two of the world's worst toxic pollution problems in the 2008. According to the 2014 WHO report, in 2012 the air pollution caused the deaths of around 7 million people worldwide.[1]

Pollutants: Before flue-gas desulfurization was installed, the emissions from this power plant in

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New Mexico contained excessive amounts of sulfur dioxide. An air pollutant is a substance in the air that can have adverse effects on humans and the ecosystem. The substance can be solid particles, liquid droplets, or gases. A pollutant can be of natural origin or man-made.[2] Pollutants are classified as primary or secondary. Primary pollutants are usually produced from a process, such as ash from a volcanic eruption. Other examples include carbon monoxide gas from motor vehicle exhaust, or the sulfur dioxide released from factories. Secondary pollutants are not emitted directly. Rather, they form in the air when primary pollutants react or interact.[3] Ground level ozone is a prominent example of a secondary pollutant. Some pollutants may be both primary and secondary: they are both emitted directly and formed from other primary pollutants.[4]

Major primary pollutants produced by human activity include:

- Sulphur oxides (SO_x) - particularly sulfur dioxide, a chemical compound with the formula SO_2. SO_2 is produced by volcanoes and in various industrial processes. Coal and petroleum often contain sulfur compounds, and their combustion generates sulfur dioxide. Further oxidation of SO_2, usually in the presence of a catalyst such as NO_2, forms H_2SO_4, and thus acid rain. This is one of the causes for concern over the environmental impact of the use of these fuels as power sources.
- Nitrogen oxides (NO_x) - Nitrogen oxides, particularly nitrogen dioxide, are expelled from high temperature combustion and are also produced during thunderstorms by electric discharge. They can be seen as a brown haze dome above or a plume downwind of cities. Nitrogen dioxide is a chemical compound with the formula NO_2. It is one of several nitrogen oxides. One of the most prominent air pollutants, this reddish-brown toxic gas has a characteristic sharp, biting odor.
- Carbon monoxide (CO)- CO is a colourless, odourless, toxic yet non-irritating gas. It is a product by incomplete combustion of fuel such as natural gas, coal or wood. Vehicular exhaust is a major source of carbon monoxide.
- Volatile organic compounds - VOCs are a well-known outdoor air pollutant. They are categorized as either methane (CH_4) or non-methane (NMVOCs). Methane is an extremely efficient greenhouse gas which contributes to enhanced global warming. Other hydrocarbon VOCs are also significant greenhouse gases because of their role in creating ozone and prolonging the life of methane in the atmosphere. This effect varies depending on local air quality. The aromatic NMVOCs benzene, toluene and xylene are suspected carcinogens and may lead to leukemia with prolonged exposure. 1,3-butadiene is another dangerous compound often associated with industrial use.
- Particulates, alternatively referred to as particulate matter (PM), atmospheric particulate matter, or fine particles, are tiny particles of solid or liquid suspended in a gas. In contrast, aerosol refers to combined particles and gas. Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation and sea spray. Human activities, such as the burning of fossil fuels in vehicles, power plants and various industrial processes also generate significant amounts of aerosols.[5] Averaged worldwide, anthropogenic aerosols—those made by human activities—currently account for approximately 10 percent of our atmosphere. Increased levels of fine particles in the air are linked to health hazards such as heart disease, altered lung function and lung cancer.[6]
- Persistent free radicals connected to airborne fine particles are linked to cardiopulmonary disease.
- Toxic metals, such as lead and mercury, especially their compounds.
- Chlorofluorocarbons (CFCs) - harmful to the ozone layer; emitted from products currently banned from use.

These are gases which are released from air conditioners, refrigerators, aerosol sprays, etc. CFC's on being released into the air rises to stratosphere. Here they come in contact with other gases and damage the ozone layer. This allows harmful ultraviolet rays to reach the earth's surface. This can lead to skin cancer, disease to eye and can even cause damage to plants.

- Ammonia (NH_3) - emitted from agricultural processes. Ammonia is a compound with the formula NH_3. It is normally encountered as a gas with a characteristic pungent odor. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to foodstuffs and fertilizers. Ammonia, either directly or indirectly, is also a building block for the synthesis of many pharmaceuticals. Although in wide use, ammonia is both caustic and hazardous. In the atmosphere, ammonia reacts with oxides of nitrogen and sulphur to form secondary particles.
- Odors — such as from garbage, sewage and industrial processes.
- Radioactive pollutants - produced by nuclear explosions, nuclear events, war explosives and natural processes such as the radioactive decay of radon.

Effects of Acid Rain

- Acid Rain increases the acidity in soil and acidification of soil changes its chemistry and biological factors. If soil gets acidified, plants

absorb dangerous acid content and it will be dangerous for human beings and animals if they consume the plant.

- Acid Rain seriously affects the aquatic organisms. Increase in PH of surrounding water may affect the physiology of aquatic organism. It may lead to the direct death of these aquatic organisms or they will die due to some diseases. Acid rain also indirectly affects these aquatic organisms by interfering with reproduction.
- Acidification of water in freshwater system may lead to the massive killing of fishes and other aquatic organisms.
- Acid Rain seriously impacts the forests. If acid rain falls on trees, it can affect their growth and make them serious diseases. It also destroys the tree leaves. Also it leads to the serious insect attack.
- Acid rain may corrode vehicles, buildings, and other man made materials.

Secondary pollutants include:

- Particulates created from gaseous primary pollutants and compounds in photochemical smog. Smog is a kind of air pollution. Classic smog results from large amounts of coal burning in an area caused by a mixture of smoke and sulfur dioxide. Modern smog does not usually come from coal but from vehicular and industrial emissions that are acted on in the atmosphere by ultraviolet light from the sun to form secondary pollutants that also combine with the primary emissions to form photochemical smog.
- Ground level ozone (O_3) formed from NO_x and VOCs. Ozone (O_3) is a key constituent of the troposphere. It is also an important constituent of certain regions of the stratosphere commonly known as the Ozone layer. Photochemical and chemical reactions involving it drive many of the chemical processes that occur in the atmosphere by day and by night. At abnormally high concentrations brought about by human activities (largely the combustion of fossil fuel), it is a pollutant and a constituent of smog.[7]

Effects of Ozone Depletion

- Ozone Depletion may result in serious changes in environmental conditions.
- Ozone layer Depletion lets in more UV radiation to earth surface may warms up troposphere and increases surface temperature. Thus it increases the global warming.
- Ozone layer Depletion leads to many biological impacts. UV radiations damage the response of the skin and it seriously affects the functioning of the skin. Moreover it may lead to the skin cancer.
- Ozone layer Depletion affects seriously on plants and trees. It may affect the growth of plants and trees.
- Ozone layer Depletion seriously affects the eco system. It may affect the life cycle of plants and food chain. This will make a serious impact on all human beings and animals.

Secondary pollutants include: Particulates created from gaseous primary pollutants and compounds in photochemical smog. Smog is a kind of air pollution. Classic smog results from large amounts of coal burning in an area caused by a mixture of smoke and sulfur dioxide. Modern smog does not usually come from coal but from vehicular and industrial emissions that are acted on in the atmosphere by ultraviolet light from the sun to form secondary pollutants that also combine with the primary emissions to form photochemical smog.

- Peroxyacetyl nitrate (PAN) - similarly formed from NO_x and VOCs.

Minor air pollutants include:

- A large number of minor hazardous air pollutants.
- A variety of persistent organic pollutants, which can attach to particulates

Persistent organic pollutants (POPs) are organic compounds that are resistant to environmental degradation through chemical, biological and photolytic processes. Because of this, they have been observed to persist in the environment, to be capable of long-range transport, bio-accumulate in human and animal tissue, bio-magnify in food chains and to have potential significant impacts on human health and the environment.[8]

Sources: There are various locations, activities or factors which are responsible for releasing pollutants into the atmosphere. These sources can be classified into two major categories.

Anthropogenic (man-made) sources: These are mostly related to the burning of multiple types of fuel.

- **Stationary Sources** include smoke stacks of power plants, manufacturing facilities (factories) and waste incinerators, as well as furnaces and other types of fuel-burning heating devices. In developing and poor countries, traditional biomass burning is the major source of air pollutants; traditional biomass includes wood, crop waste and dung.
- **Mobile Sources** include motor vehicles, marine vessels and aircraft.

Controlled or prescribed burning is a technique sometimes used in forest management, farming, or

greenhouse gas abatement. Fire is a natural part of both forest and grassland ecology and controlled fire can be a tool for foresters. Controlled burning stimulates the germination of some desirable forest trees, thus renewing the forest.

- **Fumes** from paint, hair spray, varnish, aerosol sprays and other solvents.
- **Waste deposition** in landfills, which generate methane. Methane is highly flammable and may form explosive mixtures with air. Methane is also an asphyxiant and may displace oxygen in an enclosed space. Asphyxia or suffocation may result if the oxygen concentration is reduced to below 19.5% by displacement.
- **Military resources**, such as nuclear weapons, toxic gases, germ warfare and rocketry.
- **Natural sources:**

1. Dust from natural sources, usually large areas of land with few or no vegetation.
2. Methane, emitted by the digestion of food by animals, for example cattle.
3. Radon gas from radioactive decay within the Earth's crust. Radon is a colorless, odorless, naturally occurring, radioactive noble gas that is formed from the decay of radium. It is considered to be a health hazard. Radon gas from natural sources can accumulate in buildings, especially in confined areas such as the basement and it is the second most frequent cause of lung cancer.
4. Smoke and carbon monoxide from wildfires.
5. Vegetation, in some regions, emits environmentally significant amounts of VOCs on warmer days. These VOCs react with primary anthropogenic pollutants—specifically, NO_x, SO_2 and anthropogenic organic carbon compounds—to produce a seasonal haze of secondary pollutants.
6. Volcanic activity, which produces sulfur, chlorine and ash particulates.[9]

Emission factors: Air pollutant emission factors are representative values that people attempt to relate the quantity of a pollutant released to the ambient air with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., kilograms of particulate emitted per tonne 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. There are 12 compounds in the list of POPs. Dioxins and furans are two of them and are intentionally created by combustion of organics, like open burning of plastics. The POPs are also endocrine disruptors and can mutate the human genes.[10]

Air pollution exposure: Air pollution risk is a function of the hazard of the pollutant and the exposure to that pollutant. Air pollution exposure can be expressed for an individual, for certain groups (e.g. neighborhoods or children living in a county), or for entire populations. For example, one may want to calculate the exposure to a hazardous air pollutant for a geographic area, which includes the various microenvironments and age groups. This can be calculated as an inhalation exposure. This would account for daily exposure in various settings (e.g. different indoor micro-environments and outdoor locations). The exposure needs to include different age and other demographic groups, especially infants, children, pregnant women and other sensitive subpopulations. The exposure to an air pollutant must integrate the concentrations of the air pollutant with respect to the time spent in each setting and the respective inhalation rates for each subgroup for each specific time that the subgroup is in the setting and engaged in particular activities (playing, cooking, reading, working, etc.). For example, a small child's inhalation rate will be less than that of an adult. A child engaged in vigorous exercise will have a higher respiration rate than the same child in a sedentary activity. The daily exposure, then, needs to reflect the time spent in each micro-environmental setting and the type of activities in these settings. The air pollutant concentration in each microactivity/microenvironmental setting is summed to indicate the exposure.[11]

Indoor air quality (IAQ)

1. A lack of ventilation indoors concentrates air pollution where people often spend the majority of their time. Radon (Rn) gas, a carcinogen, is exuded from the Earth in certain locations and trapped inside houses. Building materials including carpeting and plywood emit formaldehyde (HCHO) gas. Paint and solvents give off volatile organic compounds (VOCs) as they dry. Lead paint can degenerate into dust and be inhaled. Intentional air pollution is introduced with the use of air fresheners, incense and other scented items. Controlled wood fires in stoves and fireplaces can add significant amounts of smoke particulates into the air, inside and out. Indoor pollution fatalities may be caused by using pesticides and other chemical sprays indoors without proper ventilation.[12] Carbon monoxide (CO) poisoning and fatalities are often caused by faulty vents and chimneys, or by the burning of charcoal indoors. Chronic carbon monoxide poisoning can result even from poorly adjusted pilot lights. Traps are built into all domestic plumbing to keep sewer gas

and hydrogen sulfide, out of interiors. Clothing emits tetrachloroethylene, or other dry cleaning fluids, for days after dry cleaning.

2. Though its use has now been banned in many countries, the extensive use of asbestos in industrial and domestic environments in the past has left a potentially very dangerous material in many localities. Asbestosis is a chronic inflammatory medical condition affecting the tissue of the lungs. It occurs after long-term, heavy exposure to asbestos from asbestos-containing materials in structures. Sufferers have severe dyspnea (shortness of breath) and are at an increased risk regarding several different types of lung cancer. As clear explanations are not always stressed in non-technical literature, care should be taken to distinguish between several forms of relevant diseases. According to the World Health Organisation (WHO), these may defined as; asbestosis, *lung cancer*, and *Peritoneal Mesothelioma* (generally a very rare form of cancer, when more widespread it is almost always associated with prolonged exposure to asbestos).

3. Biological sources of air pollution are also found indoors, as gases and airborne particulates. Pets produce dander, people produce dust from minute skin flakes and decomposed hair, dust mites in bedding, carpeting and furniture produce enzymes and micrometre-sized fecal droppings, inhabitants emit methane, mold forms in walls and generates mycotoxins and spores, air conditioning systems can incubate Legionnaires' disease and mold and houseplants, soil and surrounding gardens can produce pollen, dust and mold. Indoors, the lack of air circulation allows these airborne pollutants to accumulate more than they would otherwise occur in nature.[13]

Health effects: Air pollution is a significant risk factor for a number of health conditions including respiratory infections, heart disease, COPD, stroke and lung cancer. The health effects caused by air pollution may include difficulty in breathing, wheezing, coughing, asthma and worsening of existing respiratory and cardiac conditions. These effects can result in increased medication use, increased doctor or emergency room visits, more hospital admissions and premature death. The human health effects of poor air quality are far reaching, but principally affect the body's respiratory system and the cardiovascular system. Individual reactions to air pollutants depend on the type of pollutant a person is exposed to, the degree of exposure, the individual's health status and genetics. The most common sources of air pollution include particulates, ozone, nitrogen dioxide and sulfur dioxide. Children aged less than five years that live in developing countries are the most vulnerable population in terms of total deaths attributable to indoor and outdoor air pollution.[14]

Mortality: It is estimated that some 7 million premature deaths may be attributed to air pollution. India has the highest death rate due to air pollution. India also has more deaths from asthma than any other nation according to the World Health Organisation. In December 2013 air pollution was estimated to kill 500,000 people. Diesel exhaust (DE) is a major contributor to combustion derived particulate matter air pollution. In several human experimental studies, using a well validated exposure chamber setup, DE has been linked to acute vascular dysfunction and increased thrombus formation. This serves as a plausible mechanistic link between the previously described association between particulates air pollution and increased cardiovascular morbidity and mortality.

Cardiovascular disease: A 2007 review of evidence found ambient air pollution exposure is a risk factor correlating with increased total mortality from cardiovascular events (range: 12-14% per a 10microg/m^3 increase). Air pollution is also emerging as a risk factor for stroke, particularly in developing countries where pollutant levels are highest. A 2007 study found that in women air pollution is associated not with hemorrhagic but with ischemic stroke. Air pollution was also found to be associated with increased incidence and mortality from coronary stroke in a cohort study in 2011. Associations are believed to be causal and effects may be mediated by vasoconstriction, low-grade inflammation or autonomic nervous system imbalance or other mechanisms.

Cystic fibrosis: A study from around the years of 1999 to 2000, by the University of Washington, showed that patients near and around particulates air pollution had an increased risk of pulmonary exacerbations and decrease in lung function. Patients were examined before the study for amounts of specific pollutants like *Pseudomonas aeruginosa* or *Burkholderia cenocepacia* as well as their socioeconomic standing. Participants involved in the study were located in the United States in close proximity to an Environmental Protection Agency. 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 function, everyday pollutants such as smoke, emissions from automobiles, tobacco smoke and improper use of indoor heating devices could further compromise lung function.[15]

Lung disease: Chronic obstructive pulmonary disease (COPD) includes diseases such as chronic bronchitis and emphysema. Researchers have demonstrated increased risk of developing asthma and COPD from increased exposure to traffic-related air pollution. Additionally, air pollution has been associated with increased hospitalizations and mortality from asthma and COPD. It is believed that much like cystic fibrosis, by living in a more urban environment serious health hazards become more apparent. Studies have shown that in urban areas patients suffer mucus hypersecretion, lower levels of lung function, and more self diagnosis of chronic bronchitis and emphysema.

Cancer: A review of evidence regarding whether ambient air pollution exposure is a risk factor for cancer in 2007 found solid data to conclude that long-term exposure to PM2.5 (fine particulates) increases the overall risk of non-accidental mortality by 6% per a 10μg/m^3 increase. Exposure to PM2.5 was also associated with an increased risk of mortality from lung cancer (range: 15-21% per a 10μg/m^3 increase) and total cardiovascular mortality (range: 12-14% per a 10μg/m^3 increase). The review further noted that living close to busy traffic appears to be associated with elevated risks of these three outcomes increase in lung cancer deaths, cardiovascular deaths and overall non-accidental deaths. The reviewers also found suggestive evidence that exposure to PM2.5 is positively associated with mortality from coronary heart diseases and exposure to SO_2 increases mortality from lung cancer, but the data was insufficient to provide solid conclusions.[16]

Children: Around the world, children living in cities with high exposure to air pollutants are at increased risk of developing asthma, pneumonia and other lower respiratory infections. Air pollution is also a significant contribution to environmental toxins in pregnancy. The World Health Organization reports that the greatest concentrations of particulates are found in countries with low economic world power and high poverty and population growth rates. Examples of these countries include Egypt, Sudan, Mongolia and Indonesia. These dangerous pollutants are known as the criteria pollutants, and include ozone, particulates, sulfur dioxide, nitrogen dioxide, carbon monoxide, and lead. Protective measures to ensure children's health are being taken in cities such as New Delhi, India where buses now use compressed natural gas to help eliminate the "pea-soup" smog.

Early exposure to air pollution: The worst short-term civilian pollution crisis in India was the 1984 Bhopal Disaster. Leaked industrial vapours from the Union Carbide factory, belonging to Union Carbide, Inc., U.S.A. (later bought over by Dow Chemical Company), killed more than 25,000 people outright and injured anywhere from 150,000 to 600,000. The United Kingdom suffered its worst air pollution event when the December 4 Great Smog of 1952 formed over London. In six days more than 4,000 died and more recent estimates put the figure at nearer 12,000. An accidental leak of anthrax spores from a biological warfare laboratory in the former USSR in 1979 near Sverdlovsk is believed to have caused at least 64 deaths.

Reduction efforts: There are various air pollution control 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 regulations), expanding regulation to new sources (such as cruise and transport ships, farm equipment, and small gas-powered equipment such as lawn trimmers, chainsaws, and snowmobiles), increased fuel efficiency (such as through the use of hybrid vehicles), conversion to cleaner fuels (such as bioethanol, biodiesel, or conversion to electric vehicles). Titanium dioxide has been researched for its ability to reduce air pollution. Ultra violet light will release free electrons from the material creating free radicals, breaking up VOCs and NOx gases. One form is superhydrophilic. Air pollution is usually concentrated in densely populated metropolitan areas, especially in developing countries where environmental regulations are relatively lax or nonexistent.[17]

Air pollution in India: Traffic congestion on good road infrastructure is a daily reality of India's urban centers. Slow speeds and idling vehicles produce, per trip, 4 to 8 times more pollutants and consume more carbon footprint fuels, than free flowing traffic. Air pollution in India is a serious issue with the major sources being fuelwood and biomass burning, fuel adulteration, vehicle emission and traffic congestion. In autumn and winter months, large scale crop residue burning in agriculture fields - a low cost alternative to mechanical tilling - is a major source of smoke, smog and particulate pollution. India has low per capita emissions of greenhouse gases but the country as a whole is the third largest after China and the United States. The Air (Prevention and Control of Pollution) Act was

passed in 1981 to regulate air pollution and there have been some measurable improvements. However, the 2013 Environmental Performance Index ranked India 155 out of 178 countries.[18]

Fuel wood and biomass burning: Cooking fuel in rural India is prepared from a wet mix of dried grass, fuelwood pieces, hay, leaves and mostly cow/livestock dung. This mix is patted down into disc-shaped cakes, dried and then used as fuel in stoves. When it burns, it produces smoke and numerous indoor air pollutants at concentrations 5 times higher than coal. A rural stove using biomass cakes, fuelwood and trash as cooking fuel. Surveys suggest over 100 million households in India use such stoves (*chullahs*) every day, 2-3 times a day. Clean burning fuels and electricity are unavailable in rural parts and small towns of India because of poor rural highways and limited energy generation infrastructure. Fuel wood and biomass burning is the primary reason for near-permanent haze and smoke observed above rural and urban India and in satellite pictures of the country. Fuel wood and biomass cakes are used for cooking and general heating needs. These are burnt in cook stoves known as *chullah* or *chulha* in some parts of India. These cook stoves are present in over 100 million Indian households and are used two to three times a day, daily. As of 2009, majority of Indians still use traditional fuels such as dried cow dung, agricultural wastes and firewood as cooking fuel. This form of fuel is inefficient source of energy, its burning releases high levels of smoke, PM10 particulate matter, NO_x, SO_x, PAHs, polyaromatics, formaldehyde, carbon monoxide and other air pollutants.[19] Some reports, including one by the World Health Organization, claim 3-4 lakhs people die of indoor air pollution and carbon monoxide poisoning in India because of biomass burning and use of *chullahs*. The air pollution is also the main cause of the Asian brown cloud which is delaying the start of the monsoon. Burning of biomass and firewood will not stop, unless electricity or clean burning fuel and combustion technologies become reliably available and widely adopted in rural and urban India. India is the world's largest consumer of fuel wood, agricultural waste and biomass for energy purposes. From the most recent available nationwide study, India used 148.7 million tonnes coal replacement worth of fuel wood and biomass annually for domestic energy use. India's national average annual per capita consumption of fuel wood, agri wate and biomass cakes was 206 kilogram coal equivalent. In 2010 terms, with India's population increased to about 1.2 billion, the country burns over 200 million tonnes of coal replacement worth of fuel wood and biomass every year to meet its energy need for cooking and other domestic use. The study found that the households consumed around 95 million tonnes of fuel wood, one-third of which was logs and the rest was twigs. Twigs were mostly consumed in the villages and logs were more popular in cities of India. The overall contribution of fuel wood, including sawdust and wood waste, was about 46% of the total, the rest being agri waste and biomass dung cakes. Traditional fuel (fuelwood, crop residue and dung cake) dominates domestic energy use in rural India and accounts for about 90% of the total. In urban areas, this traditional fuel constitutes about 24% of the total. Fuel wood, agri waste and biomass cake burning releases over 165 million tonnes of combustion products into India's indoor and outdoor air every year. To place this volume of emission in context, the Environmental Protection Agency (EPA) of the United States estimates that fire wood smoke contributes over 420,000 tonnes of fine particles throughout the United States – mostly during the winter months. United States consumes about one-tenth of fuel wood consumed by India and mostly for fireplace and home heating purposes. EPA estimates that residential wood combustion in the USA accounts for 44% of total organic matter emissions and 62% of the PAH, which are probable human carcinogens and are of great concern to EPA. The fuel wood sourced residential wood smoke makes up over 50% of the wintertime particle pollution problem in California. In 2010, the state of California had about the same number of vehicles as all of India. India burns tenfold more fuel wood every year than the United States, the fuel wood quality in India is different than the dry firewood of the United States and the Indian stoves in use are less efficient thereby producing more smoke and air pollutants per kilogram equivalent. India has less land area and less emission air space than the United States. In summary, the impact on indoor and outdoor air pollution by fuel wood and biomass cake burning is far worse in India. A United Nations study finds firewood and biomass stoves can be made more efficient in India. Animal dung, now used in inefficient stoves, could be used to produce biogas, a cleaner fuel with higher utilization efficiency. In addition, an excellent fertilizer can be produced from the slurry from biogas plants. Switching to gaseous fuels would bring the greatest gains in terms of both thermal efficiency and reduction in air pollution, but would require more investment. A combination of technologies may be the best way forward. Between 2001 and 2010, India has made progress in adding electrical power generation capacity, bringing electricity to rural areas and reforming market to improve availability and distribution of liquefied cleaner burning fuels in urban and rural area. Over the same period, scientific data collection and analysis show improvement in India's air quality, with some

regions witnessing 30-65% reduction in NO_x, SO_x and suspended particulate matter. Even at these lower levels, the emissions are higher than those recommended by the World Health Organization. Scientific studies conclude biomass combustion in India is the country's dominant source of carbonaceous aerosols, emitting 0.25 teragram per year of black carbon into air, 0.94 teragram per year of organic matter, and 2.04 teragram per year of small particulates with diameter less than 2.5µm. Biomass burning, as domestic fuel in India, accounts for about 3 times as much black carbon air pollution as all other sources combined, including vehicles and industrial sources.[20]

Fuel adulteration: Some Indian taxis and auto-rickshaws run on adulterated fuel blends. Adulteration of gasoline and diesel with lower-priced fuels is common in South Asia, including India. Some adulterants increase emissions of harmful pollutants from vehicles, worsening urban air pollution. Financial incentives arising from differential taxes are generally the primary cause of fuel adulteration. In India and other developing countries, gasoline carries a much higher tax than diesel, which in turn is taxed more than kerosene meant as a cooking fuel, while some solvents and lubricants carry little or no tax. As fuel prices rise, the public transport driver cuts costs by blending the cheaper hydrocarbon into highly taxed hydrocarbon. The blending may be as much as 20-30%. For a low wage driver, the adulteration can yield short term savings that are significant over the month. The consequences to long term air pollution, quality of life and effect on health are simply ignored. Also ignored are the reduced life of vehicle engine and higher maintenance costs, particularly if the taxi, auto-rickshaw or truck is being rented for a daily fee. Adulterated fuel increases tailpipe emissions of hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x) and particulate matter (PM). Air toxin emissions — which fall into the category of unregulated emissions — of primary concern is benzene and polyaromatic hydrocarbons (PAHs), both well known carcinogens. Kerosene is more difficult to burn than gasoline; its addition results in higher levels of HC, CO and PM emissions even from catalyst-equipped cars. The higher sulfur level of kerosene is another issue. The permissible level of fuel sulfur in India, in 2002, was 0.25% by weight as against 0.10% for gasoline. The higher levels of sulfur can deactivate the catalyst. Once the catalyst becomes deactivated, the amount of pollution from the vehicle dramatically increases. Fuel adulteration is essentially an unintended consequence of tax policies and the attempt to control fuel prices, in the name of fairness. Air pollution is the ultimate result. This problem is not unique to India, but prevalent in many developing countries including those outside of south Asia. This problem is largely absent in economies that do not regulate the ability of fuel producers to innovate or price based on market demand.[21]

Traffic congestion: Traffic congestion is severe in India's cities and towns. Traffic congestion is caused for several reasons, some of which are: increase in number of vehicles per kilometer of available road, a lack of intra-city divided-lane highways and intra-city expressways networks, lack of inter-city expressways, traffic accidents and chaos from poor enforcement of traffic laws. Traffic congestion reduces average traffic speed. At low speeds, scientific studies reveal, vehicles burn fuel inefficiently and pollute more per trip. For example, a study in the United States found that for the same trip, cars consumed more fuel and polluted more if the traffic was congested, than when traffic flowed freely. At average trip speeds between 20-40km/hour, the cars pollutant emission was twice as much as when the average speed was 55-75km/hour. At average trip speeds between 5-20km/hour, the cars pollutant emissions were 4-8 times as much as when the average speed was 55-70km/hour. Fuel efficiencies similarly were much worse with traffic congestion. Traffic gridlock in Delhi and other India cities is extreme. The average trip speed on many Indian city roads is less than 20km/hour; a 10 kilometer trip can take 30 minutes, or more. At such speeds, vehicles in India emit air pollutants 4-8 times more than they would with less traffic congestion; Indian vehicles also consume a lot more carbon footprint fuel per trip, than they would if the traffic congestion was less. Emissions of particles and heavy metals increase over time because the growth of the fleet and mileage outpaces the efforts to curb emissions. In cities like Bangalore, around 50% of children suffer from asthma.[22]

Greenhouse gas emissions: India was the third largest emitter carbon dioxide in 2009 at 1.65Gt/year, after China (6.9Gt/year) and the United States (5.2Gt/year). With 17% of world population, India contributed some 5% of human-sourced carbon dioxide emission; compared to China's 24% share. On per capita basis, India emitted about 1.4 tons of carbon dioxide per person, in comparison to the United States' 17 tons/person, and a world average of 5.3 tons/person. About 65% of India's carbon dioxide emissions in 2009 was from heating, domestic uses and power sector. About 9% of India's emissions were from transportation (cars, trains, two wheelers, airplanes, others).

India's coal-fired, oil-fired and natural gas-fired thermal power plants are inefficient and offer significant potential for CO_2 emission reduction through better technology. Compared to the average emissions from coal-fired, oil-fired and natural gas-fired thermal power plants in European Union (EU-27) countries, India's thermal power plants emit 50-120% more CO_2/kWh produced. This is in significant part to inefficient thermal power plants installed in India prior to its economic liberalization in the 1990s. Between 1990 and 2009, India's carbon dioxide emissions per GDP purchasing power parity basis have decreased by over 10%, a trend similar to China. Meanwhile, between 1990 and 2009, Russia's carbon dioxide emissions per GDP purchasing power parity basis have increased by 40%. India has one of the better records in the world, of an economy that is growing efficiently on CO_2 emissions basis. In other words, over the last 20 years, India has reduced CO_2 emissions with each unit of GDP increase. Per Copenhagen Accord, India aims to further reduce emissions intensity of its growing GDP by 20-25% before 2020, with technology transfer and international cooperation. Nevertheless, it is expected, that like China, India's absolute carbon dioxide emissions will rise in years ahead, even as International Energy Agency's Annex I countries expect their absolute CO_2 emissions to drop. A significant source of greenhouse gas emissions from India is from black carbon, NO_x, methane and other air pollutants. These pollutants are emitted in large quantities in India every day from incomplete and inefficient combustion of biomass (fuel wood, crop waste and cattle dung). A majority of Indian population lacks access to clean burning fuels, and uses biomass combustion as cooking fuel. India's poorly managed solid wastes, inadequate sewage treatment plants, water pollution and agriculture are other sources of greenhouse gas emissions.[23]

Impacts of Greenhouse Gas Effect:

- Increase in greenhouse gases lead to climate change over small time spans.
- Increase in greenhouse effect lead to the melting of ice caps and glaciers result in rise in sea level. Thus most of the coastal areas will submerge under sea water.
- Change in global temperature would affect the ecosystem.
- Increase in temperature lead to several health problems.

Recent trends in air quality: With the last 15 years of economic development and regulatory reforms, India has made progress in improving its air quality. The table presents the average emissions sampled at many locations, over time, and data analyzed by scientific methods, by multiple agencies, including The World Bank. For context and comparison, the table also includes average values for Sweden in 2008, observed and analyzed by same methods. Over 1995-2008, average nationwide levels of major air pollutants have dropped by between 25-45 percent in India. India's Central Pollution Control Board now routinely monitors four air pollutants namely sulphur dioxide (SO_2), oxides of nitrogen (NO_x), suspended particulate matter (SPM) and respirable particulate matter (PM10). These are target air pollutants for regular monitoring at 308 operating stations in 115 cities/towns in 25 states and 4 Union Territories of India. The monitoring of meteorological parameters such as wind speed and direction, relative humidity and temperature has also been integrated with the monitoring of air quality.[24]

The monitoring of these 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 yield 104 observations in a year.

For 2010, the key findings of India's central pollution control board are:

- Most Indian cities continue to violate India's and world air quality PM10 targets. Respirable particulate matter pollution remains a key challenge for India. Despite the general non-attainment, some cities showed far more improvement than others. A decreasing trend has been observed in PM10 levels in cities like Solapur and Ahmedabad over the last few years. This improvement may be due to local measures taken to reduce sulphur in diesel and stringent enforcement by Gujarat government.
- A decreasing trend has been observed in sulphur dioxide levels in residential areas of many cities such as Delhi, Mumbai, Lucknow, Bhopal during last few years. The decreasing trend in sulphur dioxide levels may be due to recently introduced clean fuel standards, and the increasing use of LPG as domestic fuel instead of coal or fuelwood, and the use of LPG instead of diesel in certain vehicles.
- A decreasing trend has been observed in nitrogen dioxide levels in residential areas of some cities such as Bhopal and Solapur during last few years. The decreasing trend in sulphur dioxide levels may be due to recently introduced vehicle emission standards, and the increasing use of LPG as domestic fuel instead of coal or fuelwood.[25]
- Most Indian cities greatly exceed acceptable levels of suspended particulate matter. This may be because of refuse and biomass burning, vehicles, power plant emissions, industrial sources.

- The Indian air quality monitoring stations reported lower levels of PM10 and suspended particulate matter during monsoon months possibly due to wet deposition and air scrubbing by rainfall. Higher levels of particulates were observed during winter months possibly due to lower mixing heights and more calm conditions. In other words, India's air quality worsens in winter months, and improves with the onset of monsoon season.
- The average annual SOx and NOx emissions level and periodic violations in industrial areas of India were significantly and surprisingly lower than the emission and violations in residential areas of India
- Of the four major Indian cities, air pollution was consistently worst in Delhi, every year over 5 year period (2004–2008). Kolkata was a close second, followed by Mumbai. Chennai air pollution was least of the four.[26]

Conclusion

Air pollution can affect our health in many ways. Numerous scientific studies have linked air pollution to a variety of health problems including: (1) aggravation of respiratory and cardiovascular disease; (2) decreased lung function; (3) increased frequency and severity of respiratory symptoms such as difficulty breathing and coughing; (4) increased susceptibility to respiratory infections; (5) effects on the nervous system, including the brain, such as IQ loss and impacts on learning, memory, and behavior; (6) cancer; and (7) premature death. Some sensitive individuals appear to be at greater risk for air pollution-related health effects, for example, those with pre-existing heart and lung diseases (e.g., heart failure/ischemic heart disease, asthma, emphysema, and chronic bronchitis), diabetics, older adults, and children. In 2008, approximately 127 million people lived in counties that exceeded national air quality standards. Air pollution also damages our environment. Ozone can damage vegetation, adversely impacting the growth of plants and trees. These impacts can reduce the ability of plants to uptake CO_2 from the atmosphere and indirectly affect entire ecosystems. Visibility is reduced by particles in the air that scatter and absorb light. Typical visual range is about 60 to 90 miles, or about one-half of the visual range under natural conditions. Pollution in the form of acids and acid-forming compounds (such as sulfur dioxide [SO_2 and oxides of nitrogen [NO_x]) can deposit from the atmosphere to the Earth's surface. Typical visual range in the eastern U.S. is 15 to 30 miles, approximately one-third of what it would be without man-made air pollution. This acid deposition can be either dry or wet. Wet deposition is more commonly known as acid rain. Acid rain can occur anywhere and, in some areas, rain can be 100 times more acidic than natural precipitation. Acid deposition can be a very serious regional problem, particularly in areas downwind from high SO_2 and NO_x emitting sources (e.g., coal burning power plants, smelters, and factories). Acid deposition can have many harmful ecological effects in both land and water systems. While acid deposition can damage tree foliage directly, it more commonly stresses trees by changing the chemical and physical characteristics of the soil. In lakes, acid deposition can kill fish and other aquatic life.
Air pollution can also impact the Earth's climate. Different types of pollutants affect the climate in different ways, depending on their specific properties and the amount of time they stay in the atmosphere. Any pollutant that affects the Earth's energy balance is known as a "climate forcer." Some climate forcers absorb energy and lead to climate warming, while others reflect the sun's rays and prevent that energy from reaching the Earth's surface, leading to climate cooling. Climate forcers can either be gases or aerosols (solid or liquid droplets suspended in the air) or include many traditional air pollutants, such as ozone and different types of particle pollution.

Prevention and Control method of Air Pollution: Air pollution is becoming a serious problem for our planet. We can't completely prevent the air pollution, but we can control air pollution by following some control methods. Filters must be use in chimneys of industries. Use of non combustive energy sources such as solar energy, wind energy, tidal energy, etc. Industries must be surrounded with trees; these trees will block the spreading of smoke after combustion of fuels in industries. Some of the vascular plants and non-vascular plants respond to air pollutants. Using these plants we can monitor highly dangerous air pollutants. Most of all, we should educate people who don't aware about the control of air pollution.
In this industrial age, air pollution cannot be eliminated completely, but steps can be taken to reduce it. The government has developed and continues to develop, guidelines for air quality and ordinances to restrict emissions in an effort to control air pollution. On an individual level, you can reduce your contribution to the pollution problem by carpooling or using public transportation. Additionally, buying energy-efficient light bulbs and appliances or otherwise reducing your electricity use will reduce the pollutants released in the production of electricity, which creates the majority India's industrial air pollution.

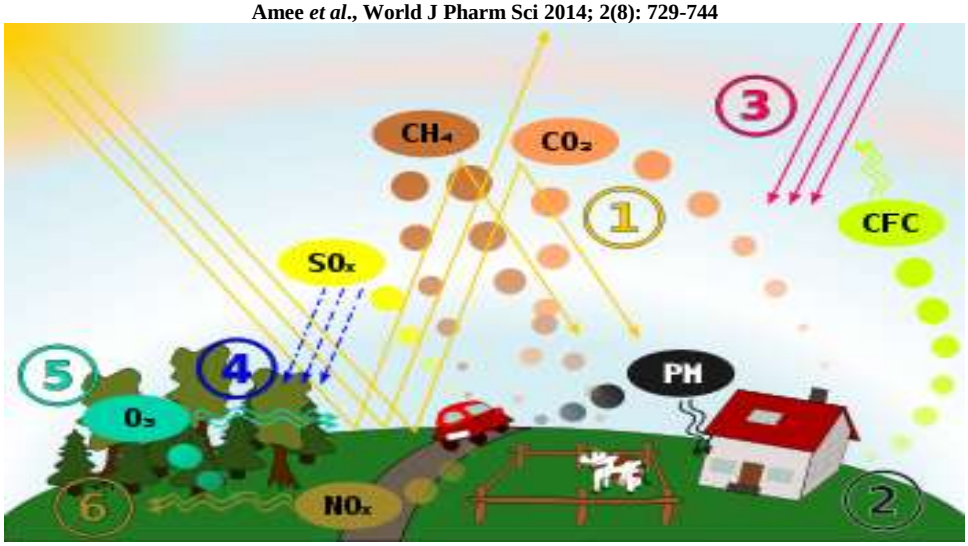


Figure-1: Schematic drawing, causes and effects of air pollution: (1) greenhouse effect (2) particulate contamination (3) increased UV radiation (4) acid rain (5) increased ground level ozone concentration (6) increased levels of nitrogen oxides.

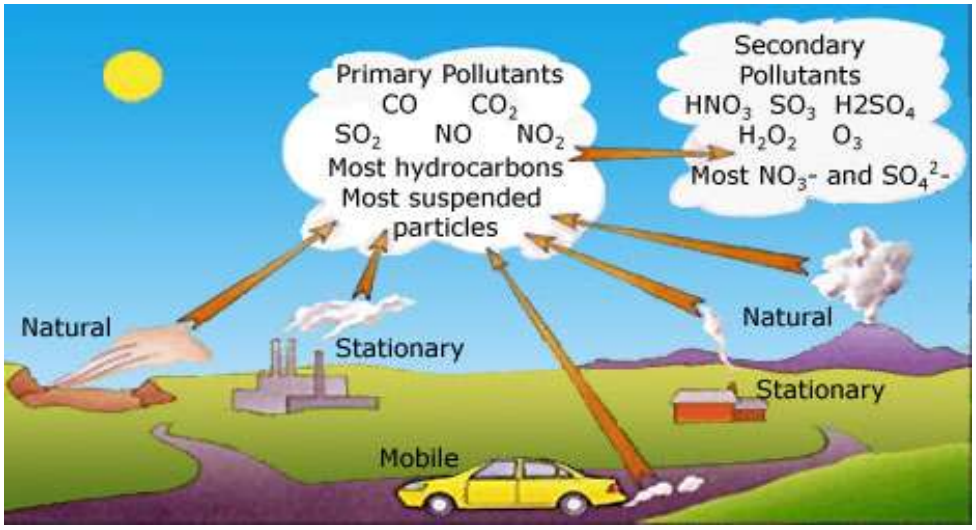


Figure-2: Primary & Secondary Pollution

Figure-3: Industrial Air Pollution

Figure-4: Air Pollutant Emission

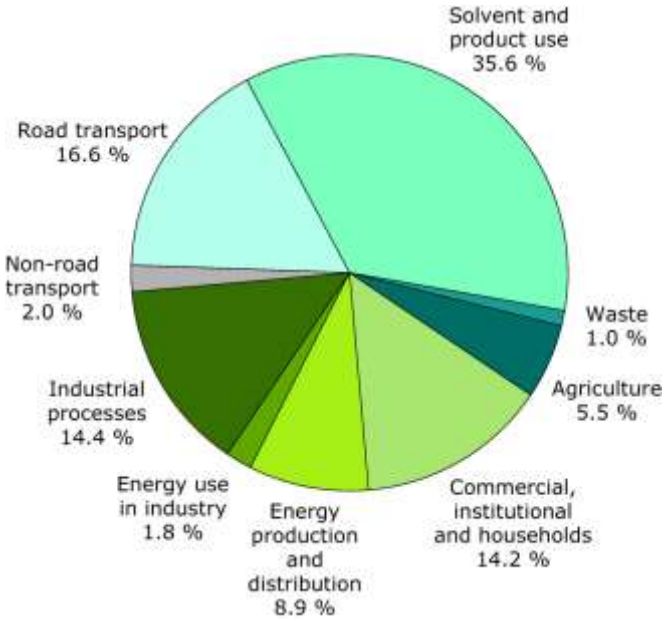


Figure-5: Distribution of Pollutants

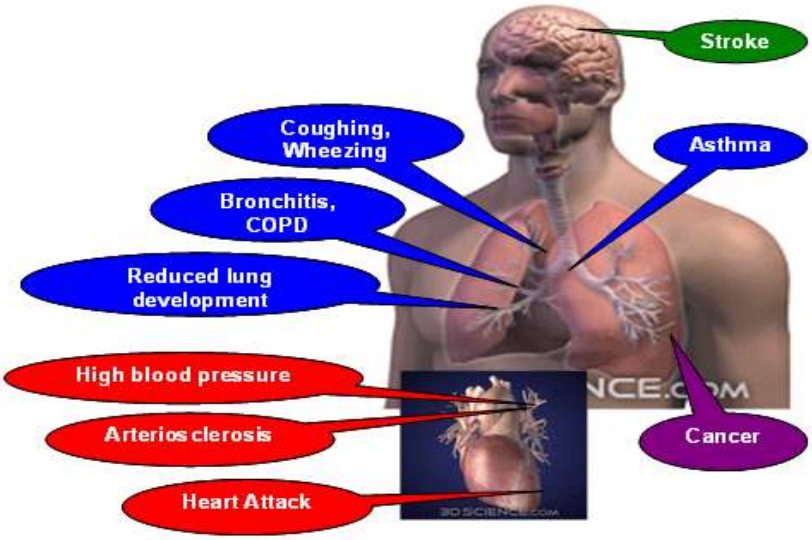


Figure-6: Health Hazards of Air Pollution

Figure-7: Smog (Smoke+Fog)

Figure-8: Domestic Air Pollution

Figure-9: Air Pollution by Automobiles

Figure-10: Traffic Air Pollution

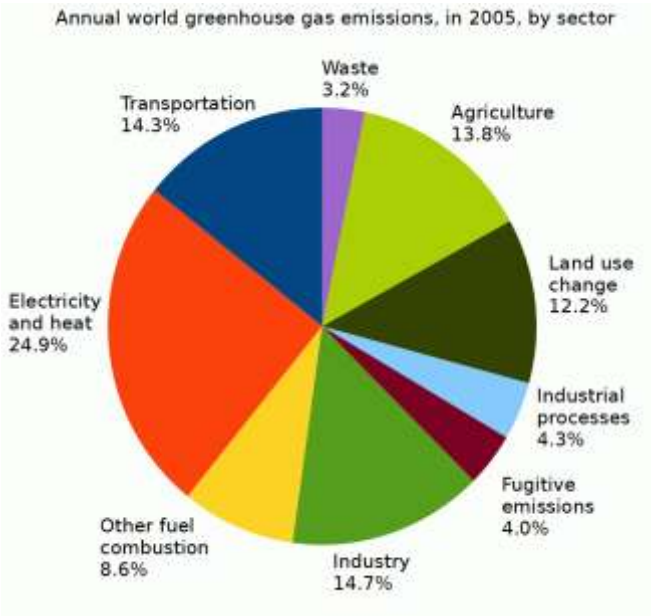
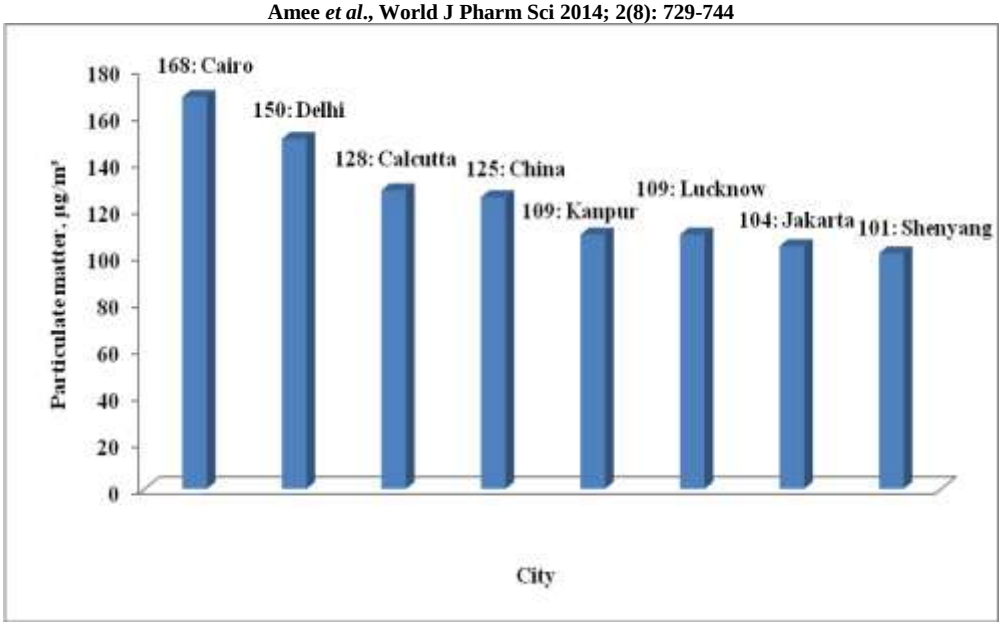


Figure-11: Greenhouse Gas Emission

Figure-12: Air Containing Dense Carbon Particles



Histogram-1: Most polluted world cities by PM

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