Air Pollution: An Overview

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The atmosphere is so essential to sustain life on earth that we take it for granted that it can survive to maintain life in spite of the many ways in which we disturb its equilibrium. We think about the quality of water we drink and most people boil water to kill any microorganisms in it before drinking. However, did you ever think about how pure is the air you breathe? People in cities and along main highways are especially vulnerable to breathing polluted air. We are all familiar with the sneezing bouts caused by inhaling air containing dust particles. In addition, people living in congested areas breathe air polluted not only with dust and soot but also with toxic gases generated by automobiles and factories. In this paper we present, some of the major air pollutants which we encounter in our daily lives.

Air pollution is the introduction of chemicals, particulate matter, or biological materials to air that cause harm or discomfort to humans or other living organisms, or damages the natural vegetation and structures. An air pollutant can be defined as a substance present in a sufficient concentration in air to produce a harmful effect on humans and other animals, vegetation or other materials. These air pollutants contribute to changing the composition of the atmosphere. **Table 1** gives the major air pollutants normally encountered in our daily lives.

Most of these pollutants are produced by human activities such as transport, power generation, industrial processes, forest and agricultural fires and incineration of solid wastes.

There are two types of air pollutants. A primary air pollutant is a substance that has been added directly to the air from a given source. It can even be carbon dioxide which is already present in air which rises above a certain level or else it could be something like the oxides of nitrogen or sulphur which are added from the exhaust fumes of motor vehicles. A Secondary air pollutant is one formed in the atmosphere through a chemical reaction involving normal or added components of air.

Oxides of carbon

Carbon monoxide is perhaps the most abundant air pollutant in a

Table 1 Major classes of air pollutants and examples

Class of pollutant	Examples
Oxides of carbon	carbon dioxide, carbon monoxide
Oxides of sulphur	sulphur dioxide, sulphur trioxide
Oxides of nitrogen	nitric oxide, nitrogen dioxide
Hydrocarbons	methane, butane, benzene
Photochemical oxidants	ozone, peroxyacylnitrates (PAN)
Particulates	soot, dust, asbestos, salt spray
Other Inorganic compounds	hydrogen sulphide, sulphuric acid

city such as Colombo. This is produced along with oxides of nitrogen and sulphur during the combustion of petrol or diesel in all types of motor vehicles. During the combustion of hydrocarbons such as petrol or diesel, if the combustion is complete and if adequate oxygen is present then the product should be carbon dioxide. However, in practice, these conditions are not achieved. Instead partial combustion takes place producing carbon monoxide and carbon (soot). A simple example to illustrate this is the gas cooker you have at home. Normally we can see two zones in such a flame: an inner blue zone and an outer pale blue or almost colourless outer zone. The blue colour is due to carbon monoxide and the outer colourless flame is where full combustion takes place giving carbon dioxide. Sometimes, if the nozzle holes are blocked, we see a yellow flame and this is due to the presence of carbon.

Carbon dioxide is essential for plants to make carbohydrates through the process of photosynthesis. However, the carbon dioxide concentration in the atmosphere has been steadily increasing and has now reached 0.386 ppm (or 0.0386%) and this is a serious issue because of its contribution to global warming which in turn produces adverse climatic changes. Increased burning of fossil fuel (coal, natural gas, oil, petrol) and destruction of forests are responsible for this effect.

The other oxide of carbon, viz. carbon monoxide is extremely toxic. When inhaled it reacts with the oxygen carrying component in our blood producing carboxy haemoglobin which reduces the amount of oxygen carried to the brain and other parts of the body. This results in dizziness, headaches, chest pains and a general deterioration of health. Headaches and nausea that people get when travelling in air conditioned buses is mainly due to carbon monoxide generated in the closed environment of the bus. People also get headaches if exposed to polluted air in a busy section of the city over a long time. This is particularly harmful to people with heart problems.

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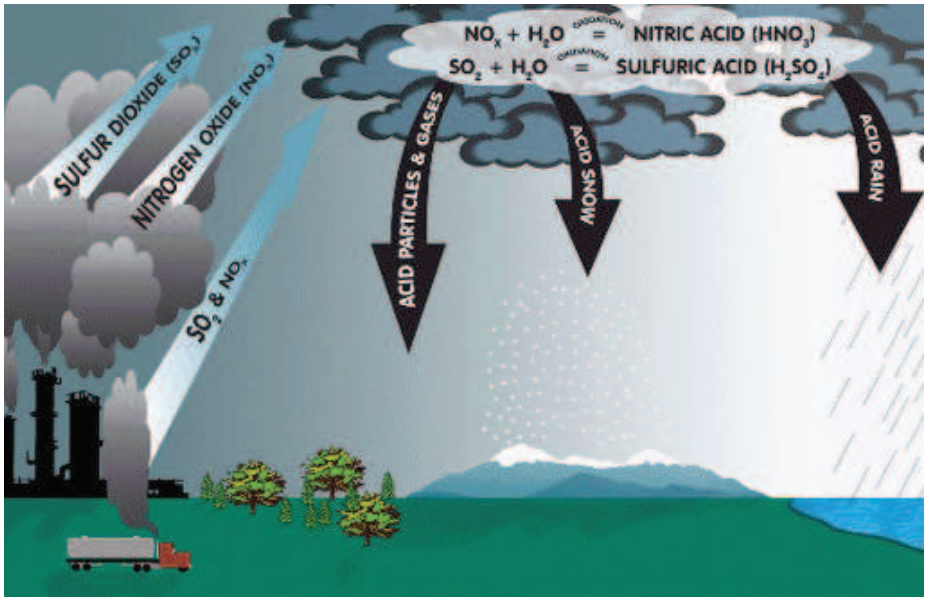
Oxides of nitrogen

Nitric oxide is formed when oxygen reacts with nitrogen in air at the high temperatures inside an automobile engine. This is called thermal nitric oxide as opposed to fuel nitric oxide which is formed during the combustion of organic nitrogen compounds in petrol or diesel. Nitric oxide reacts with more oxygen from the atmosphere forming reddish brown nitrogen dioxide which has a characteristic sharp, biting odour. It is extremely irritating particularly to eyes and lungs.



Cities such as Los Angeles in the USA are sometimes referred to as brown cities due to the presence of this oxide of nitrogen. The nitrogen dioxide produced eventually reacts with water and forms nitric acid which comes down as acid rain.

Sulphur oxides

Some cities in the West such as London, New York and Chicago use coal or oil for domestic heating and electricity generation. These power plants produce particulates such as dust and soot and also sulphur dioxide, a dangerous pollutant. It is also produced in the combustion of petrol and diesel in motor vehicles. Thus, it is a problem even in a country like Sri Lanka where the number of automobiles has been increasing year after year. Furthermore, with increasing industrialisation, the newly constructed factories contribute significantly to increased sulphur dioxide levels in the atmosphere. It is also produced during incineration of solid wastes, forest fires and during the eruption of volcanoes where large quantities sulphur dioxide are emitted to the atmosphere.

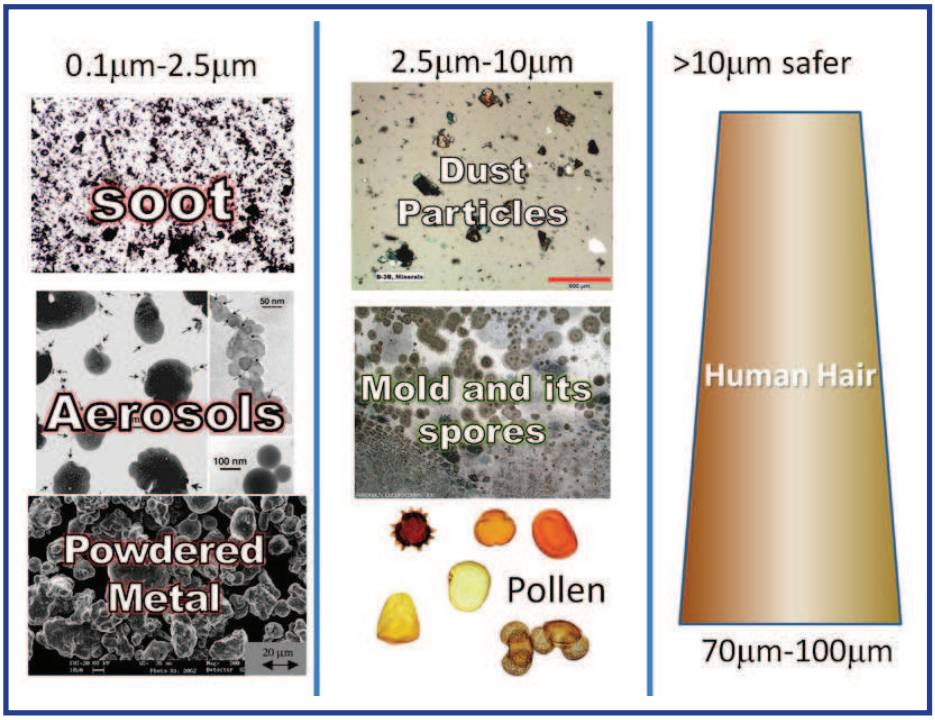
Coal, oil and other petroleum products contain varying amounts of sulphur in the form of organic sulphur compounds which get oxidised during the combustion process. In addition, coal also has iron sulphide as an impurity and the sulphur percentage of some of the cheaper coals can be as high as 4%. Both organic sulphur compounds and inorganic sulphur compounds in coal generate sulphur dioxide upon combustion. Generally in a coal powered electricity generation plant, scrubbers are installed to remove sulphur dioxide from leaving to the atmosphere. A scrubber is a type of filter mechanism lined with lime which reacts with sulphur dioxide. Another way to remove sulphur is by employing fluidised bed reactors where coal is mixed with limestone and then fired. Here, limestone decomposes giving calcium oxide which then reacts with sulphur dioxide.

Sulphur dioxide is also produced as a byproduct in various metallurgical processes where the metal sulphides are roasted to the corresponding oxide. Sulphur dioxide can damage plants, dissolve marble and concrete and even eat away iron and steel. The effects it has on the delicate lung tissues are all too obvious. Even at extremely small concentrations, sulphur dioxide poses a potential health hazard. Sulphur dioxide also reacts with oxygen in the air under the influence of sunlight producing sulphur trioxide which could then react with rain water producing sulphuric acid contributing to acid rain.

Hydrocarbons and other volatile organic compounds

The primary source of hydrocarbons present in the atmosphere is the release of unburnt fuel from automobiles. Some minor components escaping to the atmosphere without combustion such as 3,4-benzopyrene are well known carcinogens. There are other volatile compounds which are divided into the separate categories of methane (CH_4)

and non-methane volatile compounds (NMVOCs). Methane is produced during the decomposition of organic matter under anaerobic conditions such as those found under the water logged conditions in a paddy field. It is an efficient greenhouse gas which contributes to enhanced global warming. In the category of NMVOCs, are the aromatic compounds benzene, toluene and xylene which escape to the atmosphere as unburnt fuel, are suspected carcinogens and may lead to leukemia and other cancers through prolonged exposure. 1,3-butadiene is another dangerous compound which is given out in industrial processes.



Other types of volatile organic compounds present in the atmosphere include pesticides used in agriculture. In addition, chlorofluorocarbons used as aerosols and refrigerants also contribute significantly to Greenhouse effect.

Fine particles

These refer to all those solid and liquid particles commonly referred to as aerosols, and includes dust, soot, ash, asbestos, lead compounds, sulphuric acid droplets, ammonium sulphate, as well as aerosols (formed by the reaction of atmospheric ammonia with sulphuric acid), oils etc. In addition to creating visibility problems for motorists and airplanes, these are some of the most toxic of all air pollutants. Most of these are produced due to activities of man such as land clearing, forest burning, and due to combustion of fossil fuels in vehicles and industries.

Particles are classified according to their sizes and the widely used unit is the micron (1 micron = 10^{-6} metres). Particles > 10 microns are filtered by the nose and hence do not reach the lungs while those smaller penetrate into the lung. Fine particles are those with diameters < 2.5 microns and coarse particles are those with sizes > 2.5 microns. They are commonly referred to as the PM 10 and the PM 2.5 fractions. Particles are generated into the atmosphere from the following sources;

Automobile exhaust fumes
Forest and domestic fires
Volcanoes
Indoor cooking using firewood
Soil and rock debris
Sea salt spray
Industry

The adverse health effects of particulates are well established. What is startling is that an

increase in 10 μg/$m^{-3}$of the PM 2.5 fraction causes a 1.5% increase in total daily mortality and a 2.1% increase in ischemic heart disease.

Photochemical smog

Photochemical smog is a type of air pollution produced when sunlight acts upon motor vehicle exhaust gases to form harmful substances such as ozone (O_3), aldehydes and peroxy acyl nitrates (PAN).

Nitrogen dioxide given out during fossil fuel combustion and other industrial activities dissociates as a result of the UV radiation from the sunlight giving nitric oxide and oxygen atoms. These reactive oxygen atoms combine with atmospheric oxygen to give ozone.

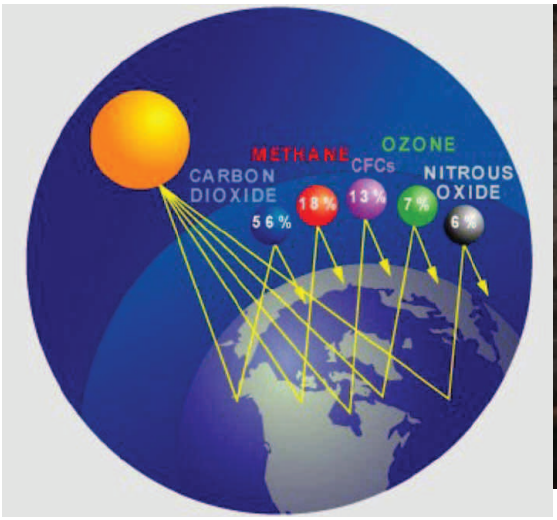
Ozone is considered as a photochemical oxidant with strong oxidising properties and affects humans as well as vegetation. Ozone is also produced during the operation of photocopiers and laser printers and hence they should be operated in well ventilated areas. It has been shown that this gas causes reduced lung function and exacerbates asthma. It also causes yellowing of leaves of some sensitive plants such as spinach and tobacco.

Ozone so formed reacts with unburnt hydrocarbons from motor vehicles and nitrogen dioxide to yield a class of compounds known as peroxyacylnitrates (PAN). These have tear like properties and are oxidising agents causing numerous health problems.

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, and being capable of long-range transport, bioaccumulate in human and animal tissue, biomagnify in food chains, and have potential significant impacts on human health and the environment.

Indoor air pollution

The commonest form of indoor air pollution is the kitchen smoke coming from indoor cooking using firewood. Most rural households carry out cooking in congested kitchens and is quite unhealthy. This is again due to particles in the smoke and in addition, there are a large number of carcinogenic polyaromatic hydrocarbons, peroxyacyl nitrates and carbon monoxide. Carbon monoxide causes headaches and the peroxyacyl nitrates



cause eye irritation. Both of these are common symptoms experienced by people during firewood cooking. Through years of exposure our mothers who spend a lot of time in indoor kitchens may develop lung cancer due to the toxic aromatic hydrocarbons. What is needed is that people should be educated to cook in an outdoor open kitchen which helps to disperse the pollutants instead of an enclosed indoor kitchen. Children too are affected since they spend more time with mothers rather than fathers who normally spend their time outside the kitchen. Diseases like pneumonia, bronchitis, asthma and other pulmonary diseases are common among these two categories.

Radon coming from granite is another source of indoor air pollution where radioactive minerals included in the granitic rocks disintegrate giving radon gas which is radioactive and inhalable. Inside the lungs this gas decays into solid radioactive elements which keep on emitting harmful radiations over a long period of time. Exposure to such radiations cause cancer and if granite is used as floor tiles, then the area should be well ventilated by keeping the windows open. The danger lies in enclosed spaces such as air conditioned rooms where the air is internally cooled and no fresh air is drawn in by the air conditioners.

Modern furniture where urea-formaldehyde resins are used for binding pieces of wood together emit fomaldehyde with time. It is a known carcinogen and hence should be avoided. This problem is severe in western countries where the rooms are either air conditioned during summer and heated in winter with the windows closed. Household pesticides always leak and give pesticides into indoor air. Cigarette smoking too is a serious indoor air pollution problem since other non-smokers are affected due to passive smoking.

Biological sources of air pollution are also found indoors, as gases and airborne particulates. Hairs from pets, dust mites in bedding, fungi producing fungal spores, house plants, soil and pollen from surrounding gardens are some examples of biological air pollutants.

Air pollution also causes major global environmental problems such as global warming and the depletion of the ozone layer. It is a major health problem in big cities of Sri Lanka and the health costs of treating respiratory diseases is escalating owing to increased vehicle numbers and urbanisation. Implementing long term solutions such as rapid mass transport systems such as electric trains, and improvement of the public transport systems is an urgent necessity.

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