

Air and Water Pollution

Prof. O.A. Illeperuma



Advances in science and technology, have resulted in a rapid increase in the global population. In Sri Lanka, the population at the time of independence was around 7 million, which had increased to 20.5 million today. The number of motor vehicles has increased by more than 700% during the past 30 years. People have been moving to cities in search of employment. Increased use of agrochemicals, polythene and plastics have created a plethora of environmental problems. The result of all this

has been the pollution of air, water and soil, affecting our lives causing a wide variety of diseases, and a reduction in the quality of life.

Air Pollution: the silent killer

An average person inhales around ten thousand litres of air daily, and while we are concerned about the water we drink, have we ever thought of the purity of the air we breathe? Air pollution is now widely believed to cause not only respiratory diseases such as asthma, bronchitis and pneumonia, but is

also responsible for a plethora of other health conditions such as heart disease, obesity, low birth weight, cancer and even baldness. It is hence appropriate to see how these diseases can be minimized for a healthy living.

Recently there has been a lot of publicity in the media about the unhealthy air pollution in Colombo. US embassy's air pollution monitoring site gives hourly data on the pollution levels in Colombo. This site reports pollution levels in terms of the air quality index where



Table 1 : Health effects of air pollutants

Pollutant	Health effects
Sulphur dioxide (SO ₂)	Wheezing and exacerbation of asthma
Nitrogen dioxide (NO ₂)	Respiratory functions and symptoms of asthma
Carbon monoxide (CO)	Headaches, nausea, heart disease
Ozone (O ₃)	Exacerbate asthma, reduced lung function
Fine particles	Aggravates asthma, respiratory problems, silicosis, asbestosis, heart diseases, cancers

The following table gives the health effects of air pollutants. More recently, there has been a growing interest in very small particles of plastics, commonly called microplastics as a serious air and water pollution hazard. Worldwide, the annual total production of plastics and polythenes is around 4000 million tons, and this is a major environmental problem. When they degrade or during

the safe level is 100 and anything above 100 is considered unhealthy. Recently it reached values around 150, which is unsafe for asthmatics, children and elderly with heart problems. Children, especially babies, are affected by air pollution to a greater extent because they inhale more air relative to their body weights. At this pollution level, it is best for these sensitive groups to stay indoors.

Air pollution in Sri Lanka is mainly generated by motor vehicles during the combustion of petrol or diesel. Petrol, for example is a mixture of hydrocarbons and during combustion produces carbon dioxide, carbon monoxide and carbon in the form of soot. Minor constituents in petrol containing nitrogen and sulphur produce sulphur dioxide and nitrogen dioxide during combustion. Other sources of air pollution are thermal power plants burning diesel and coal and various industrial processes. The fine particles emitted are the most dangerous out of all pollutants. The larger particles that enter our respiratory

system gets filtered by the nose and the upper respiratory tract, but the finer particles go right inside the lung, damaging its sensitive tissues, resulting various respiratory diseases like asthma, bronchitis and pneumonia. In addition, the carbon particles have many other compounds adsorbed on them, some of which can cause cancer. Heart diseases and stroke can also be initiated by a high degree of air pollution. World Health Organization (WHO) recently classified diesel smoke as an agent definitely cause cancer.

Ozone is another pollutant formed by the reaction of nitrogen dioxide (NO₂) generated during fossil fuel combustion in the presence of sunlight. It is also produced during the operation of laser printers and photocopiers where the intense light sources break up the oxygen (O₂) molecule, and the oxygen atoms so created react with oxygen molecules to give ozone. Its concentration outdoors reaches a maximum around noon when solar intensity is at its highest.

their use fine particles of plastics are generated. They are also present in indoor air where various plastics undergo abrasion and also from various clothing made from synthetic fibers. When children play with plastic toys invariably they undergo abrasion resulting in microplastics getting into the surroundings. When polythenes and plastics undergo decay in the soil, small particles which are about one millionth of a meter in diameter get into water and air, which can penetrate deep into the lungs. They can carry bacteria and other toxic compounds into the body. Although their long-term health effects have not been fully investigated there are claims that they cause cancer, as well as heart and brain diseases.

WHO has estimated that 8 million people die of air pollution annually and out of these 4.3 million deaths are from indoor air pollution.

Cooking using firewood in congested kitchens is the main source of indoor air pollution.

Firewood smoke is rich in carbon monoxide which causes headaches, and some tear gas like compounds cause redness in eyes and produce tears. In addition, there are deadly cancer-causing compounds in kitchen smoke and mothers who have cooked in congested kitchens for a number of years are likely to develop various types of cancers in later life. Other indoor sources of pollution are the use of mosquito coils and incense sticks inside homes. These not only generate fine particles, but also toxic compounds such as benzene and polyaromatic compounds which are known cancer causing substances. Firewood can still be used if cooking is carried out in an open kitchen with adequate ventilation.

Air pollution became a much-discussed topic after the widely publicized New Delhi smog last November, where the AQI values exceeded 400. Schools were closed and children were advised to stay indoors. During the same period, Sri Lanka recorded a maximum value of 136 which is in the unhealthy category. This is not unexpected, since even in 2018 November, the AQI value in Colombo had a high value of 164, but this became a hot topic only because of the New Delhi smog. Research on air pollution monitoring in Kandy revealed that the highest air pollution levels were observed during the November to February season. Data from the Colombo monitoring station too revealed a similar trend. This is due to a phenomenon called transboundary air pollution where pollution clouds from highly polluted countries such as India and China travel thousands of kilometers and reach Sri Lanka during the north-east monsoonal period.

What should be done to ensure that we breathe clean air? Most countries discourage people from using their cars to travel to work in big cities. Instead people are encouraged to use public transport, Improving public transport is the best way to reduce vehicular pollution in major cities. Nevertheless, individually we can take precautions to alleviate the effects by wearing face masks in crowded cities. Ordinary doctor's face masks are not very efficient. A better choice is a face mask with an activated carbon filter, which can help to filter many of the undesirable compounds in air. The carbon particles in soot can adsorb the highly poisonous substances called polyaromatic hydrocarbons, which are well-known cancer-causing substances. An activated carbon filter has the ability to adsorb such toxic chemicals. Children in big cities should be advised to wear a face mask during the time they travel to their schools and even inside the classroom.

Water pollution: How clean is our water?

Water is unique to our planet covering more than two-thirds of the earth's surface. It moderates climate, provides water for agriculture and allows organisms to survive. All life forms depend on water. We drink water, cook with it, wash in it, and travel on it. It is essential for industry, agriculture, mining, energy production and waste disposal.

Water on earth is present mainly in the oceans with over 97 percent, while fresh water in rivers and lakes constitutes only about 1 percent of the total. There is water in the atmosphere, in polar ice caps,

and also as underground water. Even in areas with plenty of fresh water, increased population and industry have been responsible for deterioration of the quality of water due to pollution. Scientists believe that by the year 2025, one-third of the world's population will face severe shortages of water for drinking purposes and for irrigation.

Water is an essential component of our body, and about 65 percent of our body weight comprises of water. The average recommended daily intake of water is 1.3 to 1.7 litres for children, 3.7 litres for men and 2.7 litres for women. Even animals and plants have a high percentage of water in their compositions, with fish constituting about 80 percent and plants constituting between 80 to 90 percent.

Water Pollution may be defined as any chemical or physical change in water that may be detrimental to living things. There are two main reasons why water pollution has become a serious problem.

These are, increase in human population, and urbanisation. The slums of Colombo have poor sanitation facilities and hence faecal pollution of water is a common problem in large cities. Since World War II, a large number of synthetic chemicals have been manufactured for various purposes, and many of these contaminate water supplies. Chemical processing of ores such as gold results in dumping large quantities of toxic chemicals like mercury and cyanide which are highly toxic.

Water pollution may cause a variety of diseases, and poses serious

Table 2 : Some pollutant types and sources polluting Kelani River

Type of pollutant	Source
Textile and Batik dye waste Chromium (Cr) Lead (Pb) Mercury (Hg) and cadmium (Cd) Domestic sewage Nitrate, phosphate Pesticides Rubber processing waste Bacteria and viruses Suspended solids	Textile factories Leather tannery Reclaiming old car batteries Old batteries in waste dumps Pradeshiya sabha, households Household waste, sewage Agriculture Rubber factories Human sewage Agriculture, improper land use

problems for human health. This is mainly because we may get exposed to polluted water in various ways, including,

- ◆ Drinking polluted water
- ◆ Bathing and swimming in polluted water
- ◆ Consuming meat from animals fed with polluted water and vegetables grown with polluted water.
- ◆ Washing vegetables in polluted water streams

Types of water pollutants

Water pollution can be broadly classified as chemical or biological types. Types of chemicals causing water pollution are:

- ◆ Crude oil and various petroleum products. These include waste engine oil from service stations and garages. These compounds are lighter than water and float on water, thereby preventing oxygen from reaching living organisms in a water body. Some of these may get dissolved in water and even in small amounts can be harmful.

- ◆ Fertiliser runoffs: These include high concentrations of nitrates and phosphates.

- ◆ Trihalomethanes – These are usually byproducts of water chlorination, and may pollute groundwater and surface water via leaking sewerage lines and discharges. Examples of such compounds are: chloroform, bromoform, dichlorobromomethane;
- ◆ Metals and their compounds – Of these higher health risk are the organo-metal compounds which may form when metals water react with organic compounds in water. Common examples include mercury, arsenic and chromium. Thus, if water is polluted with both metals and organic compounds the health risk is higher, and can also affect aquatic life.

- ◆ Pesticides– In Sri Lanka people use pesticides far in excess of the required amounts and these contaminate the streams and rivers.
- ◆ Polychlorobiphenyls (PCB)- Transformer oils contain these deadly compounds, which during

their discharge can end up in waterways.

- ◆ Industrial waste: Waste from factories such as rubber, textile, leather tanning, battery recycling, and paper manufacture. discharge into water Biological agents. Which pollute our waterways include mainly bacteria and viruses.

The effects of water pollution may appear immediately after exposure to water with a high degree of pollutant. Other chemicals in water such as very small concentrations of pesticides may cause diseases after exposure to several years. For example, Mahaweli River is contaminated with pesticides used in the vegetable crops grown in Nuwara Eliya, with some of the pesticides used and this may cause long term effects on people who consume such contaminated water downstream. Some of the green leaves grown around the marshes have been shown to be contaminated with chromium coming from the chromate used for leather tanning. In Sri Lanka,

Table 3 : Some major industries polluting our waterways

Industry	Waste product
Paper and pulp industry	Black liquor
Rubber processing industries	Acetic/formic acids, amino acids
Textile factories	Textile and batik dyes
Leather tanning	Animal tissues, chromate
Fruit processing industries	Carbohydrates, fats and oils
Breweries	Carbohydrates
Milk products	Carbohydrates, proteins

water borne diseases account for the highest percentage of hospital admissions. Diseases caused by this kind of pollution include cholera, typhoid, hepatitis and dysentery. Sri Lanka does not have major chemical industries with the potential to pollute our waterways, but there are still very serious pollution problems due to discharges from domestic waste, agriculture and industry. The Kelani river is the most polluted river in Sri Lanka where untreated sewage and effluents from several industries are discharged into the river, often without any pre-treatment. Some of these sources are given in Table 2.

Let us discuss some of the common water pollutants and identify their origins and health effects. There are many sources of pollution that release nitrates. Human sewage is perhaps the most important source of nitrate pollution. For example, if a well is situated close to a toilet pit, well water gets contaminated with relatively large concentrations of nitrate. It also comes from fertiliser run-offs which causes eutrophication of lakes and algal blooms. Nitrate is also produced due to the bacterial oxidation of ammonia and ammonium salts coming from fertilizers. Nitrate in drinking water is harmful to human health. In the human body,

nitrate gets reduced to nitrite which further reacts with secondary amines to give cancer causing nitrosoamines.

Phosphates leach out to water from the phosphate fertilizers used in agriculture, and also from detergents which are now commonly used for cleaning dishes, clothes etc. instead of traditional soap. Along with organic matter and nitrates, they cause algal blooms which in turn results in fish kills in lakes.

In Sri Lanka, municipal solid waste is usually dumped in low-lying marshes. The liquid that flows from these waste dumping sites is

Table 4 : Relationship between water quality and the amount of dissolved oxygen

Water quality	Dissolved oxygen (mg/L)
Excellent	8.0-9.0
Slightly polluted	6.7-8.0
Generally polluted .	4.5-6.0
Highly polluted	<4.

called leachate. This leachate has very high dissolved organic matter and disease-causing bacteria that pollutes our waterways. Heavy metals such as Ni, Cd and Hg from used batteries are also present in the leachate and these are highly toxic.

Water purification

Living matter that is added to our waterways get oxidised by bacteria which also include all organic matter arising from plants and animal tissues. However, the expanding human population, industrial pollution and increased use of agrochemicals makes natural purification processes insufficient for the direct consumption of water from a river or a stream. Hence water has to be purified before consumption.

Water purification at government sponsored water schemes involves aeration, to remove undesirable gases such as hydrogen sulphide, filtration to remove fine particles of clay and soil, and chlorination to kill bacteria.

Many countries have now abandoned the use of chlorine since it reacts with dissolved organic compounds in water to give a class of highly carcinogenic compounds called chloroaromatics. Instead of chlorine, ozone or irradiation with ultra-violet rays are used in most developed countries for water purification.

While it is certainly devoid of bacteria and other pathogens, there are many other harmful chemicals dissolved in municipal drinking water supplies which are not removed during purification.

These include pesticides, nitrate, heavy metals and even extremely toxic compounds such as dioxin. These are not even monitored in Sri Lanka's drinking water supplies, and some of these are accumulative poisons which may cause kidney ailments and cancer at later stages. Organic matter and water quality The accumulation of oxygen demanding wastes adversely affect aquatic life. Table 3 gives some examples of water pollution arising from organic wastes of industries. Human excreta and organic garbage fall into this category. To break down the organic waste from animal farms, breweries and food processing industries, aerobic bacteria are required.

Some major industries polluting our waterways Since oxygen is utilised for this process, oxygen gets depleted in the river which in turn makes the river unhealthy for both fish and plant life. The concentration of dissolved oxygen in a water body gives the extent to which the water body is polluted (Table 4).

Marine pollution

Oceans receive a heavy dose of what we throw away from land. Pollutants such as chemicals, nutrients, and heavy metals are carried from factories, agriculture and cities by streams and rivers into the sea. At the same time a large amount of polythenes and plastics too end up in the ocean, and in fact microplastics have been detected in fish. An estimated one million tons of oil make their way into the oceans from land-based sources.

Conclusion

The Earth summit conference held

in June 1992 in Rio de Janeiro and attended by a large number of World leaders, was the first major attempt at creating awareness on global issues related to human survival. In their proclamation, the importance of education has been aptly described.

“Education is critical for promoting sustainable development and improving the capacity of the people to address environment and development issues. Both formal and non-formal education are indispensable to changing people's attitudes, so that they have the capacity to assess and address their sustainable development concerns. It is also critical for achieving environmental and ethical awareness, values and attitudes, skills and behaviour consistent with sustainable development and for effective participation in decision making. To be effective, environment and development education and human (which may include spiritual) development, should be integrated in all disciplines, and should employ formal and non-formal methods and effective means of communication.” Agenda 21, chapter 36.3 (UNCED Rio de Janeiro, 3-14 June 1992)



Prof. O.A. Illeperuma
Emeritus Professor of Chemistry,
University of Peradeniya,
Peradeniya

