

CHAPTER 10

THE IMPACT OF POLLUTANTS ON SOILS AND AIR QUALITY

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Introduction

Developing countries rely mostly on their soil resources to sustain livelihoods of their populations. *Because of their ever-increasing populations, enormous pressure is exerted on soils and other resources, which result with their use beyond sustainable levels. Waste products are also generated and in most cases are not properly disposed and they end up reducing the quality of both soil and air resources.*

Soil and air pollution studies have received a lot of attention more especially in developing countries where pollutants have been produced over a long period of time. Pollutants were produced as by-products of processes that sustained the activities of the human race. Hazardous waste, which was produced from industries as well as agricultural enterprises, found its way to either soil, air or water resources. This behaviour continued unabated for quite some time until human health and productivity of the soil resources was seriously impaired. Soil and air quality issues have now spread to developing countries where some still use technologies that are old-fashioned and not so environmentally friendly.

This chapter *examines different soil and air pollutants and how they affect the quality of such resources. The sources of this hazardous waste are identified and possible redemption measures are also suggested.* Examples from Botswana as well as other countries on soil and air pollution are used in the chapter.

Impacts of Pollutants on Soils and Air Quality

Hazardous waste is *solid waste that causes harm because of its quantity, concentration, or physical, chemical or infectious characteristics.* Hazardous substances can be present as contaminants in soil and fill materials; as components of buildings or structures; as wastes deposited in the ground, in tanks or pipes; as substances used or produced during the reclamation works; or as contaminants in surface or groundwater.

Physical and chemical soil properties determine soil quality. **Physical properties** such as bulk density and texture influence aeration, permeability, infiltrability, and other attributes such as water-holding capacity or constructive properties can be quantified and related to quality. **Chemical properties** are

the concentrations of organic and inorganic constituents that determine characteristics such as soil fertility, biological activity, degree of pollution, salinity, corrosiveness, or shrink-swell potential and are also quantifiable and related to soil quality.

The ability of a soil to produce quality food, fibre, or feed refers to the contribution the soil makes to the capacity of a site to have profitable production of crops that are free of harmful substances. The site quality would then include a desirable combination of soil characteristics (including low concentrations of pollutants), climate and available water. Where pollutants are disposed to the ground without necessary precautions as, for example, indiscriminate dumping of waste, such activities will tend to lead to soil as well as surface and groundwater pollution. This, for example, requires that authorities have to pay special attention to the construction of sanitary landfills as opposed to ordinary dumping which result in contamination of both soils and water resources.

Types of Pollutants

There are a number of pollutants that have been identified, which affect soils, water and air quality. Some of these are discussed below.

Nutrients

This category primarily reflects the negative impacts of Nitrogen and Phosphorous when present at relatively high concentrations. *The presence of Phosphorous in surface water and nitrates in surface- and ground- water are the main indicators of environmental contamination of soil.* Agricultural production practices are responsible for a fair share of the problems associated with excessive nutrients. Significant contributions are also made from private home and horticultural uses of fertilisers, naturally-occurring sources, sewage treatment facilities, septic tanks, food processing plants, and livestock.

Pesticides

Pesticides represent a wide range of mostly organically based chemicals used to control pests such as weeds, insects, rodents, or plant pathogens. Once again agricultural production practices account for the majority of pesticide use, with private home and horticultural uses also being significant. Pesticides are normally released intentionally into the environment at low levels, although accidental spills involving large quantities or high concentrations do occur.

Hazardous Substances

Hazardous substances comprise the broadest category of all. It is a catch-all term that basically *includes materials that are acutely or chronically toxic to*

humans and other organisms when improperly administered, used, or disposed of. Many of the hazardous substances are organic compounds with properties *analogous to pesticides.* However, hazardous substances are generally not intentionally released into the environment; and soil contamination problems usually involve improper use, disposal, or accidental spills over small areas with high concentrations of the chemical in question.

Acidification

This category of pollutants, comprising **acidification**, includes several unrelated processes. **Acid precipitation** *is mainly the end result of conversion of the oxides of N and S into their respective acids in the atmosphere.* The concern is with the precipitation having a lower than normal pH and its impact on the environment. **Acid mine drainage** represents another source of acidification where water has been acidified by the weathering and oxidation of sulphide materials, primarily pyrite (FeS₂). Such water can have pH as low as 2.0 and can have significant impacts on soil or surface water systems.

Salinity and Sodicity

Salinity and sodicity are primarily characterised by *reductions in plant productivity due to water stress caused by the increased osmotic potential and changes in physical properties (dispersion with a resultant reduction in permeability) when salt or sodium concentrations in soils become too high.* Irrigation with water containing high salt concentrations or a high level of sodium relative to Calcium and Magnesium are the chief causes of these problems. Runoff from roads de-iced with sodium chloride onto roadside soils is another lesser source of salinity and sodicity.

Trace Elements

Trace elements *are elements that are normally present in relatively low concentrations in soils or plants.* They may be essential for growth and development of humans or other organisms, although many are not. Trace elements of concern as pollutants are those that cause acute or chronic health problems in humans, animals, plants, or aquatic organisms when present in above-critical threshold concentrations.

Sediments

Sediments *represent soil particles that have been eroded from the landscape and have been carried to surface waters.* Areas most susceptible to sediment-generating erosion include construction sites, recently tilled farmland, or overgrazed pastures. Sediments can physically block light transmission through water which can, in turn: (i) alter the ecology of the body of water; and/or (ii)

can be enriched in Phosphorous, which can accelerate eutrophication, and can act as sources or sinks for a variety of water pollutants. Sediments can also accumulate in surface waters, thus inhibiting navigation and recreation activities and reducing the longevity of darn structures.

Particulate, Greenhouse Gases and Smog-forming Compounds

Particulate matter *is relatively inert particles generally consisting of carbon, soil, volcanic ash etc. suspended in the atmosphere.* **Greenhouse gases** are the gases responsible for the greenhouse effect. *The greenhouse effect refers to an apparent increase in the concentration of various gases in the atmosphere - primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons - that make it more difficult for radiated heat to escape the atmosphere, hence resulting in an increase in the mean global temperature above that existing without the influence of man.* Some greenhouse gases are manmade and others are naturally occurring, although their concentrations are increasing in the atmosphere due to human activities

Air Quality

Introduction

Air is a mixture of gases in defined proportions that can be changed as a result of pollution. **Atmospheric pollution** *involves the addition (or, theoretically, subtraction) of particles, gases or energy forms such as heat, radiation or noise so that the altered atmosphere is less useful to mankind or poses some harm because of its impact on weather, climate, human health, animals, vegetation and materials* (Godish, 1991). The concept of pollution entails a sense of degradation, a loss of quality, and adverse environmental effects whether it is applied to the air, water, or land.

Historically, air pollution concerns have been associated with ambient air and with the freely moving air of the outdoor environment. As a consequence, control programmes focus on ambient air pollution. However, air pollution is not just limited to the outdoor environment. Significant pollution can occur in occupational environments, in the built environment of our homes and offices and in personal habits such as smoking.

Air Pollution

Air that is polluted is defined as *air that contains one or more chemicals in high enough concentration to harm human beings, other animals, vegetation or materials* (Miller, 1996).

There are two generic types of air pollutants, namely, primary air pollutants and secondary air pollutants. **Primary air pollutants** are *chemicals that are added directly to the atmosphere in above normal concentrations*. Examples include the emission of carbon dioxide by industrial manufacturing processes, leading to a rise above normal concentrations in the atmosphere. Another example is the emission of lead from car exhausts resulting from petrol combustion. **Secondary air pollutants** are harmful chemical substances formed in the atmosphere through chemical reactions amongst air components.

Air pollution is undesirable in the environment because it has some negative impacts like corrosion of paint; buildings, statues and it could also damage trees and crops.

Air As a Finite Resource

Clean air is essential to the existence of all living things including human beings. On average, each human being requires about 14kg of air per day to satisfy basic physiological (including respiratory) requirements. The atmosphere is made up of different layers and about 95% of the air is in the troposphere. Most air pollutants are added to the troposphere where they are mixed vertically and horizontally by air currents. The composition of air varies according to the location. In general, percentages of carbon dioxide and water vapour vary but the other percentages remain relatively constant.

Effects of Air Pollution on Living Organisms and Materials

Damage to Human Health

The human respiratory system has a number of mechanisms to protect individuals from air pollution. Mucus and cilia are the main structures responsible for the protection of organisms from pollution.

Many years of exposure to smoking and air pollutants can destroy these defence mechanisms leading to lung cancer, chronic bronchitis and emphysema. Elderly people, infants, pregnant women, and people with heart disease, asthma, or other respiratory diseases are especially vulnerable to air pollution (Miller, 1996).

Damage to Plants

Air pollutants have negative impacts on the growth and productivity of plants. **Secondary air pollutants** in particular, when they fall down with rain, are capable of removing chlorophyll from vegetation, thus leaving vegetation

yellowish in colour. Vegetation without chlorophyll will not be able to photosynthesise and this has a tendency to affect vegetation growth and productivity. Air pollutants are also responsible for removing wax, which reduces evapotranspiration from vegetation leaves. With removal of wax from their leaves, vegetation loses a lot of water that affects the normal functioning of trees.

Major Classes of Air Pollutants

Carbon oxides	Carbon monoxide, Carbon dioxide.
Sulphur oxide	Sulphur dioxide, Sulphur trioxide.
Nitrogen oxides	Nitric oxide, Nitrogen dioxide, Nitrous oxide.
Volatile organic compounds	Methane, Propane, Benzene, Chlorofluoro carbons (CFCs).
Suspended particles	Solid particles (dust, soot, asbestos, lead, nitrate and sulphate salts), liquid droplets (sulphuric acid, PCBs, dioxins, pesticides).
Photochemical oxidants	Ozone, Peroxyacyl nitrates (PANs), Hydrogen peroxide (H ₂ O ₂), Aldehydes.
Radioactive substances	Radon-222, Iodine-131, Strontium-90, Plutonium-239, emissions from fossil fuel and nuclear power plants.
Other inorganic compounds	Asbestos, hydrogen fluoride (HF), hydrogen sulphide, Ammonia, Sulphuric acid, Nitric acid.
Other organic compounds	Pesticides, Herbicides, Various alcohols and acids.

Table 10.1: Major Classes of Air Pollutants (*Source:* Miller, 1996)

Plants could also be damaged when air pollutants directly block the pores of leaves. The impact of this damage is generally noticed after a long period of time. By then, the process cannot be reversed and so much damage has been done. This problem is not so severe in developing countries as compared with the situation prevailing in the more developed countries with a long history of industrialisation. Severe damage to vegetation as a result of air pollutants has

been reported in both Europe and North America. According to Miller (1996), in 1991, the seven European countries with the highest percentages of coniferous forest damage were Great Britain (57%), Poland (45%), Czechoslovakia (41%), Denmark (30%), Portugal (30%), Russia (26%), and Germany (25%).

Damage to Aquatic Life

When it rains, a lot of air pollutants are brought back to the ground. Running water to ponds, lakes and other water bodies will tend to transport these air pollutants. The receiving water bodies will, more often than not, suddenly become inundated with a milieu of chemical waste that changes their natural set-up. The result of all this is negative impact on aquatic life. Most lakes in Europe and North America are dead as a result of pollution.

Damage to Materials

Air pollutants are responsible for damage for a number of structures. The fallout of soot on buildings, cars and clothing requires costly cleaning. Air pollutants break down exterior paint on cars and houses, and they deteriorate roofing materials. Irreplaceable marble statues, historic buildings, and stained-glass windows around the world have been pitted, gouged, and discoloured by air pollutants.

Possible Solutions to Preventing and Reducing Air and Soil Pollution

Soil and air quality can be improved if in the first instance fewer pollutants are released into the environment. This can be achieved by setting standards that have to be adhered to by individuals, companies and industries. Most of the waste products could be recycled and reused in order to reduce the volume of waste material which will eventually find its way to soil, water and air resources causing pollution.

Governments should have clear guidelines on how to dispose different types of waste. The type of waste industries are likely to produce have to be known well in advance before securing a licence of operation. Once the waste products likely to be generated are known then, a monitoring system has to be put in place in order to ensure that set standards are adhered to. All this will require countries to set ministries or departments for the environment.

Before setting up landfills thorough investigations have to be undertaken to

ensure that the structure will not pose any risk to both soil and water resources. Vehicles should constantly be monitored for the type and amount of gases they produce and this must be done on a regular basis.

Information on air and soil quality in developing countries is very scarce and therefore this is a challenge to developing countries scientists to generate information on this subject in order to advance the noble goals of sustainable development which embrace sensible use of our resources.

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