Chapter 1

Introduction

At a glance

Air quality depends on the quantities of natural and anthropogenic emissions to the atmosphere, and on the atmosphere's potential for dispersing and removing pollutants. Details about common pollutants, typical sources, and the nature of their effects on human health, the ecology, and climate change are provided in this chapter. The purpose of the ***State of Air Report 2005*** is to give an overview of the state of air quality in South Africa, providing insight into sources of emissions and associated health, welfare, and broader environmental impacts, as well as identifying significant sources, pollutants, and areas in which they have an impact. In addition, the report summarizes current air quality management practices and explores opportunities for realizing emission reductions and air quality improvements. The report focuses mostly on priority pollutants and local and urban ambient air pollution issues.

Ambient air quality is, for example, of primary concern in proximity to industrial and mining activities and busy traffic routes

The atmosphere is a shared resource. The quality of air depends on the quantities of natural and anthropogenic emissions to the atmosphere, and on the atmosphere's potential for dispersing and removing pollutants. Air pollutants vary in terms of their residence times in the atmosphere and the effects associated with them. Gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs) are long-lived and have international significance because of their respective implications for global warming and depletion of stratospheric ozone. Pollutants such as nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), and particulate matter (PM) are significant primarily in terms of local human health impacts and local and regional environmental impacts. A list of common pollutants, typical sources, and the nature of their effects on human health, the ecology, and climate change, are summarized in Table 1.1.

In assessing air quality, it is necessary to distinguish between ambient (outdoor) air quality and indoor air pollution levels. Ambient air quality is, for example, of primary concern in proximity to industrial and mining activities and busy traffic routes. In such instances, indoor pollutant concentrations are generally lower than ambient air pollution levels. Indoor air pollutant concentrations within homes that burn fuels such as coal and wood are of considerable concern, particularly in poorly ventilated dwellings. In areas where households burn such fuels, people can be exposed to high indoor pollutant concentrations, in addition to being exposed to elevated ambient pollutant concentrations when outdoors. It is generally when they are out of doors that residents of households that do not burn such fuels experience their highest exposures to common combustion-related emissions such as PM, SO_2, NO_2, and CO. Poor ambient air quality and increased exposure to it are, in such instances, associated with pollutants emitted by neighbouring activities, for example vehicle activity along roadways, residential areas where wood and coal are burned (particularly where households have no access to electricity), and industrial and mining operations.

The cooling towers of a decommissioned coal-fired power station in Johannesburg.

The purpose of this report is to give an overview of the state of air quality in South Africa, providing insight into sources of emissions and associated health, welfare, and broader environmental impacts. Identifying significant sources, pollutants, and areas on which they have an effect, represents an important first step in air quality management. The report also summarizes current air quality management practices and explores opportunities for realizing emission reductions and air quality improvements. Although the focus is mainly on criteria (common) pollutants and local and urban ambient air pollution issues, reference is made to non-criteria pollutants, regional and global challenges, and health risks posed by indoor air pollution exposures.

In characterizing the national state of air quality, reference is made to existing and available information from source inventories, ambient air quality monitoring stations, and relevant literature. For the purpose of informing this *State of Air Report 2005*, air quality monitoring data were obtained from agencies for over 120 stations across the country and all available data for the period 1994–2004 were collected. A detailed description of the entire dataset is given, the quality of the data evaluated, and summary statistics presented for these data, in the supplementary report entitled *Technical Compilation to Inform the State of Air Report* (DEAT, 2006a), which is reproduced in the Appendix. This technical support document provides a full index of air quality monitoring efforts and presents trends at all stations from which sufficient data were collected. Air quality trends for selected air pollution monitoring stations were extracted for inclusion in the current report to illustrate the state of air quality in various local environments, such as heavy industrial areas, areas where households burn fuel (wood and coal), and sites characterized by high volumes of road traffic.

Table 1.1: Key pollutants, sources and impacts

Pollutants	Main contributing sources	Impacts
Particulate matter (PM) Less than 10 microns in size (PM_{10}) Dust, sand, ash, soot, smoke, pollen, exhaust emissions	· Household fuel combustion – primarily coal-burning on the Highveld and wood-burning in coastal areas · Industrial, commercial, and institutional fuel-burning appliances · Industrial process and fugitive emissions · Vehicle tail pipe emissions (primarily diesel vehicle emissions) · Mining and quarrying, including fugitive dust and smouldering coal dumps · Biomass burning, including wild-fires and crop-burning practices · Vehicle entrainment from paved and unpaved roads · Agriculture – fugitive dust emissions during ploughing · Windblown dust · Coal-fired base-load electricity generation · Diesel-powered locomotives and shipping · Other sources including: informal waste combustion, tyre-burning, waste incineration.	*Health* Exposure to PM has been associated with hospitalization for respiratory or cardiovascular diseases and exacerbation of respiratory diseases, such as asthma. The health effects depend on particle size and chemical composition. *Ecological* Wet and dry PM deposition can cause damage to plants, metal surfaces, fabrics, and buildings. Depending on chemical composition, PM can contaminate soil and water. Other impacts include reduced visibility and the production of haze.
Sulphur dioxide (SO_2)	· Industrial, commercial, and institutional fuel-burning appliances – specifically coal and heavy fuel oil (HFO) combustion · Coal-fired base-load electricity generation – specifically on the Mpumalanga Highveld · Gas-turbine peak-load electricity generation · Refineries · Industrial processes, including pulp and paper manufacture and metallurgical operations · Coal mining, including smouldering coal dumps (especially abandoned and defunct collieries), most of which are on the Mpumalanga Highveld · Household coal and wood combustion · Vehicle engine emissions (primarily diesel-powered vehicles) · Emissions from diesel-powered locomotives and shipping emissions (in harbour cities) · Biomass burning, including wild-fires and crop-burning.	*Health* Sulphur dioxide causes upper respiratory irritation and can aggravate existing respiratory diseases, especially asthma. *Ecological* Sulphur dioxide contributes to acid deposition, which causes acidification of dams and rivers, and damages trees and crops as well as buildings and statues. Leachates and percolates can contaminate subterranean aquifers.
Nitrogen oxides (NO_X, NO, NO_2)	· Vehicle tail pipe emissions – all areas · Industrial and other fuel-burning processes, specifically gas-burning appliances · Base-load electricity generation, specifically on the Mpumalanga Highveld · Gas-turbine peak-load electricity generation · Household fuel combustion – primarily coal-burning on the Highveld and wood-burning in coastal areas · Diesel-powered locomotive engines and shipping emissions (in harbour cities) · Airports – aircraft and passenger vehicle emissions at international airports (such as those in Cape Town, Johannesburg, and eThekwini), are significant sources · Biomass burning, including wild-fires and crop-burning practices · Tyre-burning is one of several minor sources.	*Health* Exposure to nitrogen dioxide (NO_2) increases the risk of respiratory infections. *Ecological* Nitrogen oxides play an important role in the atmospheric reactions that create ozone and contribute to acid deposition. Ozone can cause acidification of dams and rivers, damage trees and crops as well as buildings and statues, and also reduce visibility.

Table 1.1: Key pollutants, sources and impacts (continued)

Pollutants	Main contributing sources	Impacts
Ground-level ozone (O_3)	· Secondary pollutant, formed through a complex photochemical reaction sequence requiring reactive hydrocarbons, nitrogen dioxide, and sunlight and controllable only through reduction of the concentrations of nitrogen dioxide and/or hydrocarbons in ambient air · Production of ground-level O_3 takes time, so air masses could have moved away from the sources of precursors before peak concentrations are reached.	*Health* Ozone at ground level is a major health concern. This gas damages lung tissue and reduces lung function. It also reduces resistance to colds and other infections. *Ecological* Ozone is beneficial in the stratosphere because it shields the Earth from the Sun's harmful ultraviolet radiation. At ground level, it is a major component of smog, reducing visibility and impacting adversely on plant function and productivity. Ozone is also implicated in the deterioration of rubber, paints, plastics, and textiles. *Climate change* Ground-level ozone is a greenhouse gas, and modelling by NASA has shown O_3 to be responsible for between one-third and half of the observed warming trend in the Arctic during winter and spring (Pollution Online, 2006).
Carbon monoxide (CO)	Carbon monoxide is produced by incomplete combustion of carbon fuels (including petrol, diesel, wood, coal, and liquid petroleum gas) in the transportation, industrial, and household sectors.	*Health* When CO enters the bloodstream, it reduces the delivery of oxygen to the body's tissues and cells, because the haemoglobin in the red blood cells has a higher affinity for CO than for oxygen.
Carbon dioxide (CO_2)	Carbon dioxide is found naturally in the atmosphere. It is also a product of complete combustion of fossil fuels.	*Health* Carbon dioxide constitutes a health risk only at concentrations high enough to displace oxygen and cause asphyxiation. *Climate change* Carbon dioxide is a greenhouse gas.
Volatile organic compounds (VOCs) including hydrocarbons	· Commonly occurring VOCs including benzene, ethylbenzene, toluene, and xylene · Transport (petrol vehicles are a key contributor, as well as diesel vehicles and airport activities) · Industrial processes, particularly chemical manufacturing facilities and refineries – including stack emissions and diffuse sources such as evaporative emissions from chemical storage · Dry cleaners, paint spray booths, and residential use of solvents and paints · Household fuel-combustion · Waste disposal sites – trace releases of toxic and odoriferous VOCs · Biomass burning, including wild fires and crop burning	*Health* Some VOCs are respiratory irritants, others cause malodour (for example, limonene, amines, butyric acid), and some are carcinogens (such as benzene and methylene chloride). *Ecological* VOCs participate in the complex chemical reactions whereby O_3 is formed at ground level.
Methane (CH_4)	Landfill sites and livestock farming are important sources of methane.	*Health* Methane constitutes a health risk only at concentrations high enough to displace oxygen and cause asphyxiation. It is a serious hazard at explosive or combustible concentrations. *Climate change* Methane is a greenhouse gas, with a global warming potential (GWP) of 23[1].

1. Each greenhouse gas (GHG) has a calculated global warming potential (GWP), which is a measure of its contribution to global warming. The GWP is a relative scale, which compares the gas in question to the same mass of carbon dioxide (assigned a GWP of 1). GWP depends on the absorption of infrared radiation, the spectral location of its absorbing wavelengths, and the atmospheric lifetime of the species.

Table 1.1: Key pollutants, sources and impacts (continued)

Pollutants	Main contributing sources	Impacts
Ammonia (NH_3)	Sources of ammonia are industries (fertilizer and explosive manufacture); the natural decomposition of animals, plants, and manure; and the use of consumer products containing ammonia.	*Health* Ammonia is produced within the human body and contributes to the acid/base balance. Exposure to high concentrations can cause irritation to the eyes, nose, and throat. *Ecological* Ammonia in soil is a source of nitrogen for plants.
Hydrogen sulphide (H_2S) and total reduced sulphur (TRS)	Sources of H_2S are natural gas, sulphur springs, refineries, paper mills, iron smelters, food processing, sewage treatment, and landfill sites.	*Health* At low concentrations, hydrogen sulphide is associated with malodour and mild respiratory ailments. As concentration increases, it can cause eye, nose, and throat irritation, headache, nausea, and vomiting. At high concentrations, pulmonary oedema may develop. Exposure to concentrations greater than 500 ppm may cause death. *Ecological* Hydrogen sulphide can be oxidized in air to form sulphuric acid and elemental sulphur. In water, it can damage plants such as rice.
Lead (Pb)	Leaded petrol additives (leaded fuel), lead smelters, and battery plants are the main sources of lead in air.	*Health* Lead affects the human central nervous system and causes a decrease in IQ. Children are a sensitive population as they absorb Pb more readily than adults and their nervous system is still developing. Lead accumulates in bone. It also affects the kidneys, blood-forming system, and reproductive system. *Ecological* Lead is a widely used metal that can contaminate air, water, and soil.
Chromium (Cr), specifically hexavalent chromium (Cr^{6+}); cadmium (Cd)	· Cr^{6+} is generally produced by industrial processes, particularly ferro-chromium plants in the case of Cr · Particulate emissions from incinerators can contain heavy metals such as chromium and cadmium.	*Health* Cr^{6+} is a confirmed human carcinogen. Cd is a probable human carcinogen. *Ecological* The reduction of Cr^{6+} to Cr^{3+} is possible in aerobic soils. Cr^{6+} can be reduced to Cr^{3+} in water, if a suitable reducing agent (such as, for example, some organic substances) is available. Cadmium is highly toxic to wildlife; can be more toxic to plants at lower soil concentrations than other heavy metals; and is more readily absorbed than other metals.

Source: Intergovernmental Panel on Climate Change, 2001