Chapter 10

Air quality

The atmosphere is the earth's largest single shared resource, which protects and supports life through the absorption of dangerous ultraviolet solar radiation, warming the surface and regulating temperature.

Chapter 10

Contents

10.1 INTRODUCTION

The atmosphere is the earth's largest single shared resource, which protects and supports life through the absorption of dangerous ultraviolet solar radiation, warming the surface and regulating temperature. However, these vital roles are under serious threat due to human-driven activities that result in the introduction of pollutants into the atmosphere (Hunter *et al*. 2002). These activities or drivers include industrialization, urban growth, population growth and changing consumption patterns. Significant sectors contributing to atmospheric degradation are transport, power generation, incineration, waste and biomass burning.

Air emissions requiring management on local and regional levels include sulphur dioxide, nitrogen oxide (NO) and nitrogen dioxide (NO_2), carbon monoxide (CO), VOCs, benzene (C_6H_6), POPS and particulate matter. Some of these primary pollutants undergo chemical transformation in the atmosphere, creating secondary pollutants such as sulphuric acid (H_2SO_4 - acid deposition) and ozone (O_3). When dispersed by winds, these pollutants persist long enough to pose problems in distant areas, in some cases posing an additional problem of trans-boundary pollution (Hunter *et al*. 2002).

Gaseous emissions such as carbon dioxide from fossil fuel combustion, methane and CFCs, while not directly hazardous to human and ecological functioning, are now recognized as perturbing to the functioning of the atmosphere on a global scale. Other global environmental challenges with local significance to South Africa include climate change, stratospheric ozone depletion due to CFC emissions, and mercury emissions from coal combustion for power generation and cement production. General environmental degradation and the depletion of natural resources are also major challenges facing the country and hence the drive towards resource management and conservation.

One of the reasons why air pollution is such a threat to human health is that we have no choice over the air we breathe (Koenig 2000). Thus in our homes, outdoors and workplaces, we often breathe air which is not as clean as we would prefer. Inhalation is a route of entry into the body for toxic chemicals, resulting in respiratory illnesses such as asthma, increased susceptibility to acute respiratory infections, cancer, heart and lung diseases. Air pollution can cause a variety of environmental effects which include acid rain that can damage forests and crops, or acidify soil and water bodies, and eutrophication, a condition in a water body where high concentrations of nutrients, such as nitrogen, stimulates blooms of algae leading to death of fish (Koenig 2000).

10.2 AIR QUALITY

In South Africa, outdoor and indoor air pollution continues to be perceived as a serious problem, with emissions for sulphur dioxide, particulate matter, nitrogen dioxide, nitrogen oxides, ozone, benzene and VOCs, and the corresponding concentrations a cause of concern. Air quality in various areas of the country is affected by pollutants emitted by numerous sources. These sources include power generation activities, industrial processes, waste disposal, transportation (private and public vehicles), biomass burning, domestic fuel burning, landfill sites, waste water treatment and agriculture.

10.2.1 Indoor air quality

Indoor sources are the primary cause of indoor air quality problems in homes. Poor ventilation can increase indoor pollutant levels due to weak dilution of emissions from indoor sources. There are numerous sources of indoor air pollution, including combustion of domestic fuels such as coal, wood, paraffin, tobacco smoke, asbestos products, pesticides used in the home, and household cleaning products.

Public exposure to air pollution has been largely associated with outdoor pollution. However, the largest exposures to health-damaging pollution probably occur in the developing world among the poorest and most vulnerable populations, largely women and young children, who are most exposed to indoor pollution sources (Smith 2002). The fact that domestic fuel burning occurs under unfavourable combustion conditions, often without venting to the outside, largely impacts on indoor air quality.

Indoor combustion for cooking and heating, using coal, wood, paraffin or traditional sources of fuel (dung and agricultural residues) may produce high levels of particulate matter (condensed volatile organic vapours) and carbon monoxide. Exposure to indoor air pollution is dependent on the type of fuel used, type of equipment used, location of the stove, and ventilation of the space (Smith 2002). Resultant indoor pollution levels are extremely high, average daily PM_{10} concentrations in households can be up to ~1,000 µg/m³ (WHO 2000), exceeding the World Health Organization's (WHO) and other international guidelines (WHO 2000). This is because incomplete combustion of the fuels results in the release of high concentrations of some air pollutants associated with combustion into the living environment.

10.2.2 Ambient air quality

Ambient air quality is defined as the physical and chemical measure of pollutant concentrations in the ambient atmosphere to which the general population will be exposed. In most developing countries, ambient air quality is reported to have deteriorated seriously, especially in urban areas, exposing populations to pollutant levels above the recommended limits (UNEP 2002).

Outdoor air pollution is perceived as a serious problem due to elevated concentrations of some pollutants which result in adverse health and environmental effects. However, the realization of the health effects associated with air pollution has led to various responses at international, national and local levels aimed at improving air quality.

10.3 SOURCES OF AIR POLLUTION

Air pollution emanates from various sources, which include natural and anthropogenic sources. Natural sources of air pollution include volcanoes, which produce sulphur, chlorine and particulates. Wildfires result in the production of smoke, carbon dioxide and carbon monoxide. Other natural sources of air pollution include domestic animals such as cattle, which release methane, and pine trees, which release VOCs. Most forms of air pollution are as a result of human activities and include fossil fuel burning (coal, oil and natural gas in industrial processes), electricity generation, vehicle emissions, aircraft emissions, domestic fuel burning, and the use of household materials that contain persistent organic pollutants, biomass burning and waste incineration.

10.3.1 Vehicle emissions

Vehicle emissions contribute to the deterioration in air quality, especially in urban areas. There is an increase in the number of privately owned vehicles in South Africa. The increase in the number of vehicles has, as expected, resulted in an increase in fuel consumption (Figure 10.1). In urban areas, vehicle emissions may be responsible for 90 to 95 per cent of carbon monoxide and 60 to 70 per cent of nitrogen oxides within the atmosphere (Schwela 2004). Emissions from vehicles contribute to photochemical smog, especially in areas that experience high traffic density such as central business districts (CBDs) (Schwela 2004) (Box 10.1). Vehicle emissions in Cape Town have been identified as one of the sources of brown haze (Piketh *et al*. 2004).

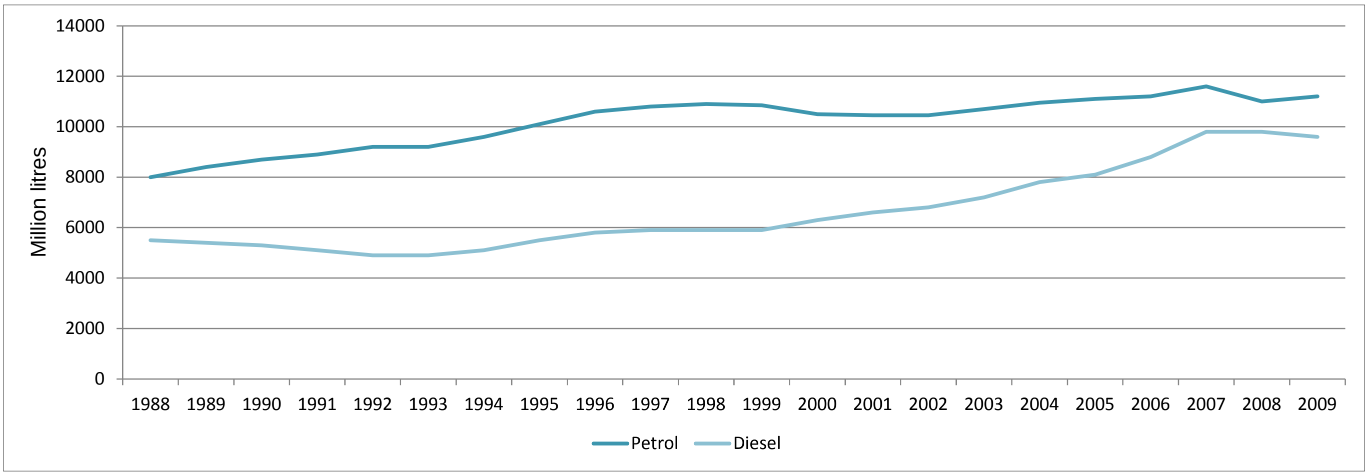


Figure 10. 1: Consumption of petrol and diesel in South Africa from 1988 to 2009
Source: SAPIA (2012)

10.3.2 Electricity generation and consumption

The generation of electricity in South Africa is largely dependent on coal. The generation of electricity through coal-fired power stations results in the emission of pollutants such as particulate matter, sulphur dioxide, nitrogen oxides and mercury. The air quality impacts of the pollutants that are produced by power generating activities are largely felt in the province of Mpumalanga where most of the coal reserves lie. The detailed impacts of electricity generation on the environment can be found in Chapter 12: Energy of this report.

Box 10. 1: Carbon dioxide vehicle emissions tax

A carbon tax is an environmental tax levied on the carbon content of fuels and is a form of carbon pricing. Fuel combustion results in the release of CO_2, a greenhouse gas contributing to the threat of human-induced climate change. Greenhouse gas emissions are a result of fossil fuel combustion and are closely related to the carbon content of the respective fuels they originate from. It is for this reason that a tax on these emissions can be levied by taxing the carbon content of fossil fuels at any point in the product cycle of the fuel.

In September 2010, South Africa implemented a CO_2 emissions tax on new passenger vehicles as part of a sustainable development initiative and climate change mitigation measure. This CO_2 tax currently applies to new passenger vehicles at the time of sale but will in future include commercial vehicles once CO_2 standards have been set for these vehicles. Passenger vehicles which emit over 120 g/km are subject to a tax of R75 per g/km over this figure. The main objective of this CO_2 tax is to influence the composition of South Africa's vehicle fleet to become more energy efficient and environmentally friendly while generating revenue.

There are however concerns that this CO_2 tax will increase the price of new vehicles and reduce sales, thereby negatively affecting the automobile industry. It has also been argued that the tax is discriminatory as it targets new vehicles and not the existing vehicles in the country. However, the new CO_2 tax is expected to add around two per cent to the cost of a new vehicle, and some doubt has been expressed as to whether this will have a significant effect on motivating new vehicle buyers to purchase environmentally friendly vehicles. Another negative comment expressed by many is that the current standard of South African fuel makes it almost impossible to either import or manufacture a passenger vehicle in South Africa that can achieve the 120 g/km threshold.

A number of countries have implemented carbon taxes or energy taxes that are related to carbon content. For example, environmental taxes with implications for greenhouse gas emissions have been levied in OECD countries on energy products and vehicles rather than CO_2 emissions directly.

10.3.3 Domestic fuel burning

A growing concern is the level of pollution from domestic fuel burning and the associated health effects. Low-income households and informal settlements are dependent on domestic fuels, such as coal, paraffin and wood, for cooking and heating.

Domestic fuel burning results in pollutants such as sulphur dioxide, carbon monoxide, VOCs and particulates. The release of sulphur dioxide, or hydrogen sulphide and carbon dioxide is dependent on combustion and fuel characteristics. Complicating issues further, is the fact that most of the household activities are undertaken using simple, small-scale cook stoves. Many of these stoves are not vented (do not have flue or hoods for the exit of pollutants from the living environment). In addition, poor combustion conditions result in high emission rates, which in turn significantly affect neighbourhood air quality.

10.3.4 Industrial emissions

Industry is a major consumer of energy and depends mainly on fossil fuels, especially coal. The industrial/mining sector is also a major consumer of electricity nationally. The largest industrial consumer of electricity is the mining sector, followed by the iron and steel, and non-ferrous metals industries.

Air pollution is a major concern in areas of heavy industrial development such as the Vaal Triangle Airshed Priority Area, South Durban Industrial Basin (SDIB) and the Highveld Priority Area (HPA).

Poor past land use planning in South Africa has resulted in the positioning of heavy industrial developments in proximity to heavily populated residential areas (Leaner *et al*. 2009). The negative environmental effects of air pollution resulting from industrial operations are felt directly during the active phase. However, in some cases, these negative environmental effects may be experienced long after industrial operations have ceased. This is evident in Gauteng where mine residue areas (Box 10.2) resulting from intensive mining activities which were undertaken in the Witwatersrand, have become a serious source of wind-blown dust. Compounding the problem is the close proximity of human settlements right up to the foot of the mine tailings storage facilities.

Box 10. 2: Mine residue areas in Gauteng

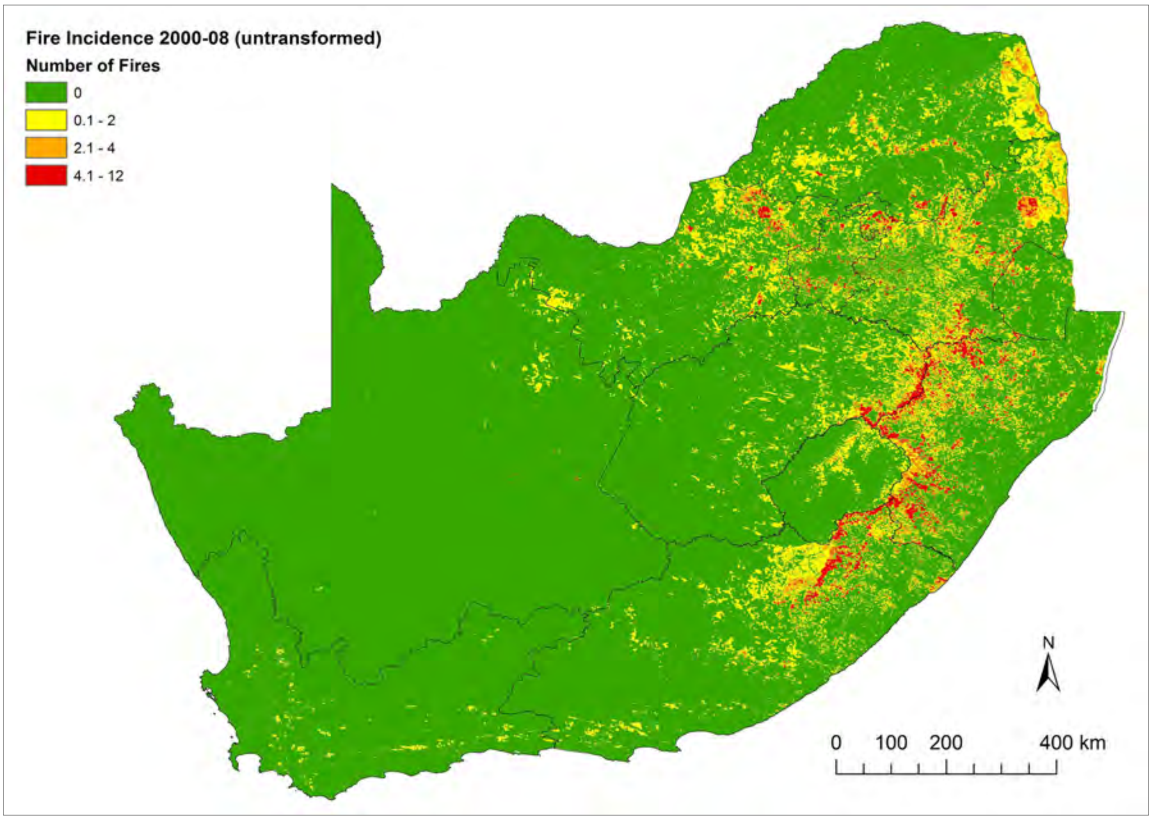
Mine residue areas in Gauteng include tailings disposal facilities, waste rock dumps, open cast excavations and quarries. Many of these mine residue areas are sources of dust pollution, especially during secondary reclamation of the tailings that entails removal of protective layers of vegetation for the duration of the reclamation project. On the Far West Rand (Randfontein and Carltonville), enhanced concentrations of uranium (relative to average crustal rock) have led to concerns about mobilization of radioactive substances. Of major concern is that some residential areas are located in proximity to or downwind of these tailings dumps, either through intentional planning (Davidsonville) or incidental expansion of older townships (Meadowlands).

Gauteng currently has 380 identified mine residue areas of which the majority are gold-mining residues (GDARD 2009). These gold tailings contain compounds such as residues of cyanide (used during gold extraction) and heavy metals such as arsenic which is enriched by a factor of approximately 50 in the gold-bearing ore relative to average crustal rock. In 2010 the Mine Health and Safety Council commissioned a major study to determine the health implications of atmospheric emissions from gold mine tailings storage facilities. Results are anticipated in 2013.

10.3.5 Biomass burning

Biomass burning is a significant source of gases and particulate matter emissions to the atmosphere. Pollutants associated with biomass burning include greenhouse gases (carbon dioxide, methane and nitrous oxide), carbon monoxide, and VOCs especially in the tropical and subtropical regions. The emission of carbon monoxide, methane and VOC affects the oxidation capacity of the atmosphere by reacting with hydroxyl (OH) radicals. Emissions of nitric oxide and VOCs lead to the formation of ozone and other photochemical oxidants (Koppman *et al*. 2005). Almost 90 per cent of all biomass burning emissions are thought to be anthropogenic (Koppman *et al*. 2005).

Veld fires are a persistent problem in South Africa as they pose a risk to life, and cause damage to property and the environment. According to the National Veldfire Risk Assessment (Forsyth *et al*. 2010), there is a marked trend in fire incidence from the eastern to western parts of the country and, to a lesser extent from northern to southern parts (Map 10.1) (Forsyth *et al*. 2010).



Map 10. 1: Map of fire incidences in South Africa for January 2000 to December 2008
Source: Forsyth et al. *(2010)*

Aside from air quality impacts veld fires cause economic, social and environmental losses including industrial losses of infrastructure and the related financial implications, destruction of power lines and other infrastructure such as farm and country resorts. The social impacts thereof include loss of homes and resources for rural livelihoods, stock losses and loss of grazing. The environmentally damaging effects of veld fires include the loss of biodiversity, damage to vegetation and the release of pollutants to the atmosphere (Forsyth *et al*. 2010).

10.3.6 Landfill site gas emissions

Land fill sites are a major source of methane, and a contributory factor to carbon dioxide. These gases are primarily of concern as they are greenhouse gases. A range of other gases may be emitted, including odorous gases such as hydrogen sulphide and mercaptans, toxins such as phenols and chlorobenzene and carcinogens such as benzene and methylene chloride (Abushammala *et al*. 2009). The gases generated in landfills result from the process of waste decomposition and are related to the waste composition and landfill technologies used (Abushammala *et al*. 2009).

10.3.7 Tyre burning emissions

Air emissions from tyre burning include uncontrolled and controlled emissions. Uncontrolled sources are open tyre fires, which produce many products of incomplete combustion and release them directly into the atmosphere. Controlled combustion sources include incineration in boilers and kilns specifically designed for efficient combustion of solid fuel (Reisman 1997). Emissions from controlled combustion sources are much lower and more often than not, these sources also have appropriate air pollution control equipment for the control of particulate emissions (Reisman 1997). Open tyre burning emissions include significant quantities of fine black carbon (classified for control purposes as PM_{10} and $PM_{2.5}$).

Emissions from open tyre-burning can cause significant acute (short-term) and chronic (long-term) health effects such as respiratory effects, cancer and nervous system depression (US-EPA 1997). They can also lead to the pollution of soil, surface water, and ground water and an integrated approach must be applied to manage these impacts.

The indiscriminate burning of tyres to recover the scrap metal is a major concern. For example in Cape Town, it has been reported that at Cape Town International Airport, the black smoke limits or impairs vision resulting in pilots using their instruments to assist with the landing of aircraft (www.capetown.gov.za 2012).

There has been regulatory development with regard to the issue of used tyres in South Africa. In pursuance of the National Environmental Management: Waste Act (No 59 of 2008 – NEM:WA) and within the framework of the waste management hierarchy, there is increasing focus on producers and users of tyres to ensure safe reuse, materials and energy recovery and safe disposal of tyres. This will have an impact by availing more air space in landfill sites and reduce toxic emission and harmful exposure as a result of the indiscriminate burning of used tyres.

10.3.8 Airport emissions

There are various sources of emissions associated with airport activities. These include road traffic at and around airports, aircraft exhaust fumes, emissions from ground service equipment and auxiliary power units and airport buildings.

Aircraft often travel for great distances at varying altitude, generating emissions that can potentially impact local, regional and global air quality (ICAO 2011). Emissions associated with aircraft activities include carbon dioxide, particulate matter, nitrogen oxides, carbon monoxide, sulphur dioxide and VOCs (ICAO 2011). Aircraft emissions are a function of the fuel specifications, number of aircraft operations which include landing and take-off cycles, aircraft fleet mix, and length of time aircrafts spend in each of the modes of operation: take-off, climb out, approach and idle (ICAO 2011). South Africa has a number of domestic and international airports. Although comprehensive emissions inventories were undertaken for the international airports in Cape Town (Cape Town International Airport) and in Johannesburg (O.R. Tambo International Airport) (Burger & Watson 2003) and the results reported in the 2005 State of Air Report, more research in this field is still required.

10.3.9 Agricultural emissions

Agricultural activities can be considered a significant contributor to particulate emissions through tilling, harvesting and other activities associated with field preparation. Gaseous and particulate emissions are also released to the atmosphere through agricultural activities such as fertilizer and chemical treatment, land resource management practices such as burning of residue crops and vegetation (UN-EPA 2012).

The sugarcane industry burns 90 per cent of its crop at harvest, while ten per cent is harvested green. In 2008, KwaZulu-Natal identified sugarcane burning as a significant source of air pollution (KZN DAEA&RD 2011). It has been established that during sugarcane burning, incomplete combustion occurs releasing pollutants such as carbon monoxide and particulates. Measures being taken to reduce emissions from sugarcane burning include sugarcane burning policies, green harvesting and sustainable sugarcane farm management system (KZN DAEA&RD 2011).

10.4 COMMON AIR POLLUTANTS IN SOUTH AFRICA

The most common air pollutants in the country are shown in Table 10.1. The priority pollutants are a good indicator of air quality in general.

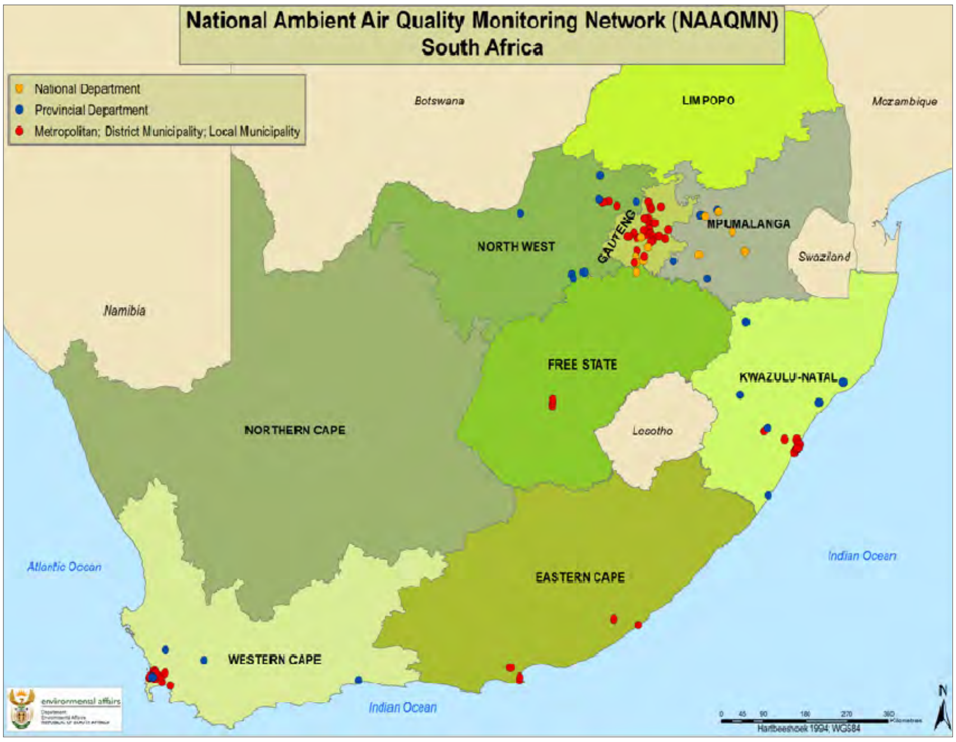
Table 10. 1: Pollutants of concern in South Africa

Current criteria pollutants	Possible future pollutants	
	National pollutants	**Local pollutants**
Sulphur dioxide Nitrogen dioxide Ozone Carbon monoxide Lead (Pb) Particulate Matter (PM_{10}) Benzene	Mercury Particulate matter ($PM_{2.5}$) Dioxins Furans POPs Other VOCs Pollutants controlled by international conventions ratified by South Africa	Chrome Fluoride (particulate and gas) Manganese (Mn)

Source: DEA (2007)

10.5 AMBIENT AIR QUALITY MONITORING IN SOUTH AFRICA

In South Africa, a substantial amount of ambient air quality monitoring is conducted by a wide range of monitoring agencies, using a range of monitoring methodologies and approaches (DEA 2011a). Monitoring campaigns around the country have also been driven by the implementation of the NEM:AQA. Currently, the National Ambient Air Quality Monitoring Network (NAAQMN) has 94 government air quality monitoring stations operated by all three spheres of government (Map 10.2).



Map 10. 2: Overview of the government-owned air quality monitoring networks
Source: DEA (2011a)

The DEA currently operates five stations in the HPA. The SAWS owns six stations located in the Vaal Triangle Airshed Priority Area (VTAPA). Four provincial departments currently operate 21 stations, with the Western Cape Department of Environmental Affairs and Development Planning (DEA&DP) operating four stations, KwaZulu-Natal Department of Agriculture, Environmental Affairs and Rural Development (DAEA&RD) operating six stations, North West Department of Agriculture, Conservation, Environment and Rural Development (DACERD) operating seven stations, and Mpumalanga Department of Economic Development, Environment and Tourism (DEDET) operating four stations. The DEA has recently commissioned three continuous air quality monitoring stations in the Waterberg District in Limpopo. The remaining stations are owned by municipalities.

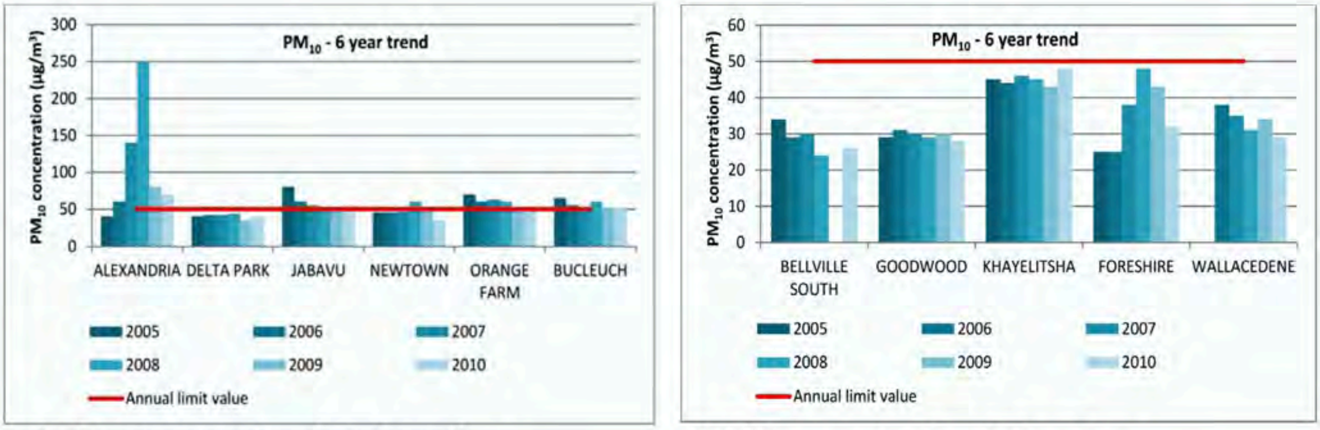
The most commonly monitored pollutants are sulphur dioxide, nitrogen dioxide, nitrogen oxides, ozone, and particulate matter (ambient PM_{10} and $PM_{2.5}$). The other pollutants measured include lead, carbon monoxide, total suspended particles (TSPs), VOCs, benzene, toluene, ethylbenzene, xylene components (BTEX), hydrogen sulphide, and total reduced sulphur (TRS).

10.5.1 Monitored pollutant concentrations

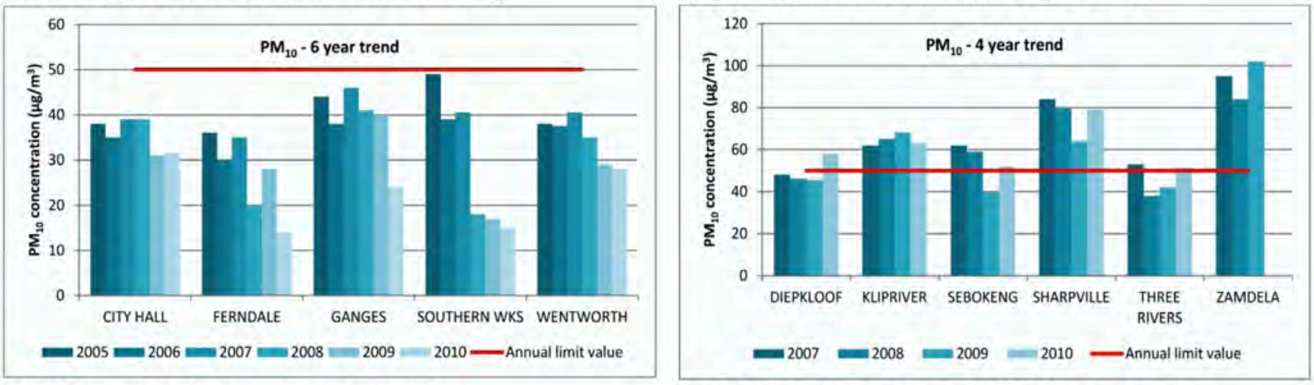
10.5.1.1 Particulates

Elevated Particulate Matter concentrations still occur in various parts of the country, exceeding the South African annual PM_{10} ambient air quality standard especially in residential areas. Elevated PM_{10} concentrations in excess of air quality limits are also recorded by some industrial monitoring sites. Most of the exceedances of the PM_{10} annual standard occur in the priority areas, so re-affirming the decisions to declare such areas a priority zones (Figure 10.2 and 10.3).

National government has set a target that by 2020, air quality in all low-income settlements should be in full compliance with ambient air quality standards. Particulate matter is therefore a national concern due to exceedances of the National Ambient Air Quality Standards (NAAQS), which are designed for the protection of the environment and human health.



a) **PM_{10} concentrations in Johannesburg** **(b) PM_{10} concentrations in Cape Town**



(c) PM_{10} concentrations in eThekwini **(d) PM_{10} concentrations in the Vaal Triangle**

Figure 10. 2: Measured annual average PM_{10} mass concentrations at: a) Johannesburg; b) Cape Town; c) eThekwini; and, d) Vaal Triangle monitoring stations for 2005 to 2010

Stations are labelled on x-axis. Red lines indicate the national standard for annual PM_{10} mass concentration.

Source: DEA (2011b)

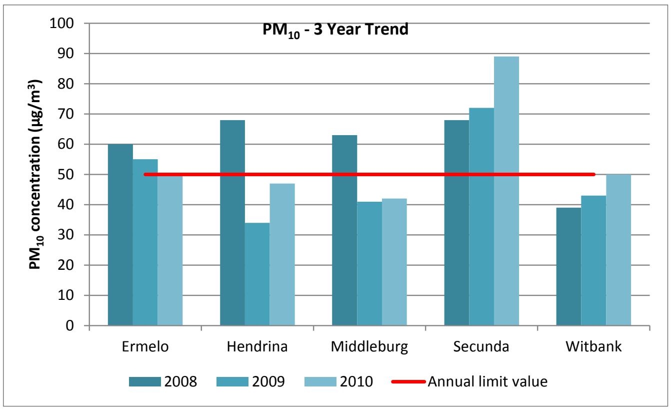


Figure 10. 3: PM$_{10}$ concentrations at the Highveld Priority Area
Source: DEA (2011b)

10.5.1.2 Sulphur dioxide

In the domestic fuel burning areas such as Diepkloof, Sebokeng, Sharpville, the annual air quality standard for sulphur dioxide is rarely exceeded except in Alexandra in Johannesburg. Although concentrations at some industrial sites at the HPA exceed the sulphur dioxide annual air quality standard, significant improvements in the reduction of sulphur dioxide emissions have been reported at Cape Town (Killarney), Richards Bay (RBCCA 2008 and 2011) and eThekwini Metropolitan Municipality.

Petrochemical, metallurgy, power generation, pulp and paper, and ceramic processes are some of the industrial processes that contribute to sulphur dioxide emissions. Figure 10.4, Figure 10.5 and Figure 10.6 show sulphur dioxide trends in monitoring stations around the country.

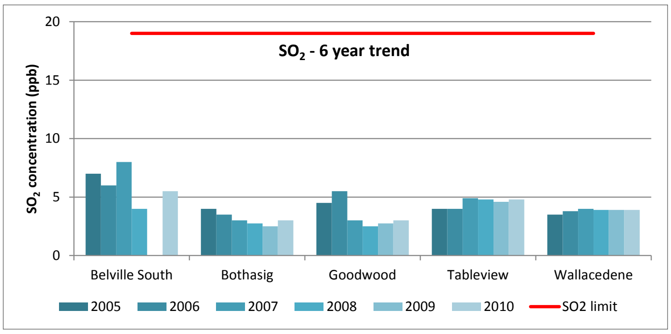


Figure 10. 4: Sulphur dioxide concentrations in Cape Town
Source: DEA (2011b)

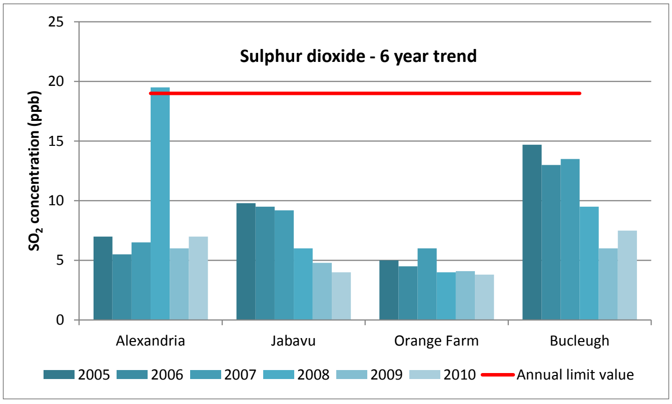
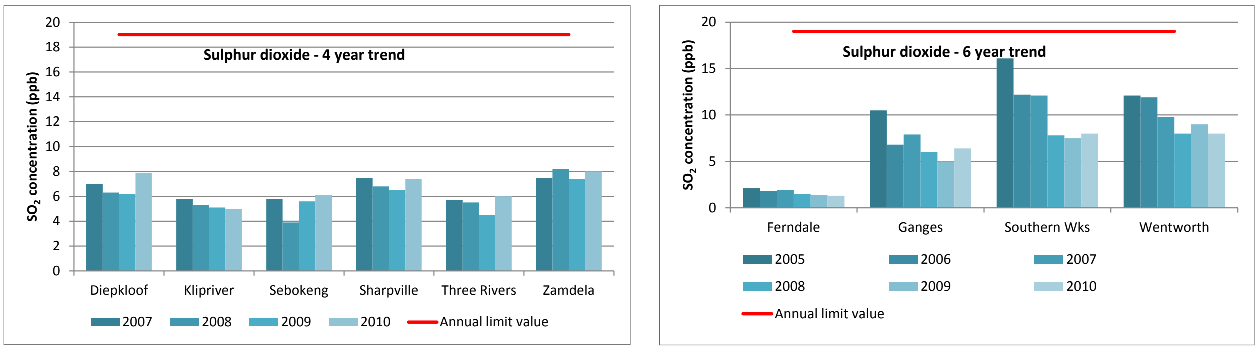
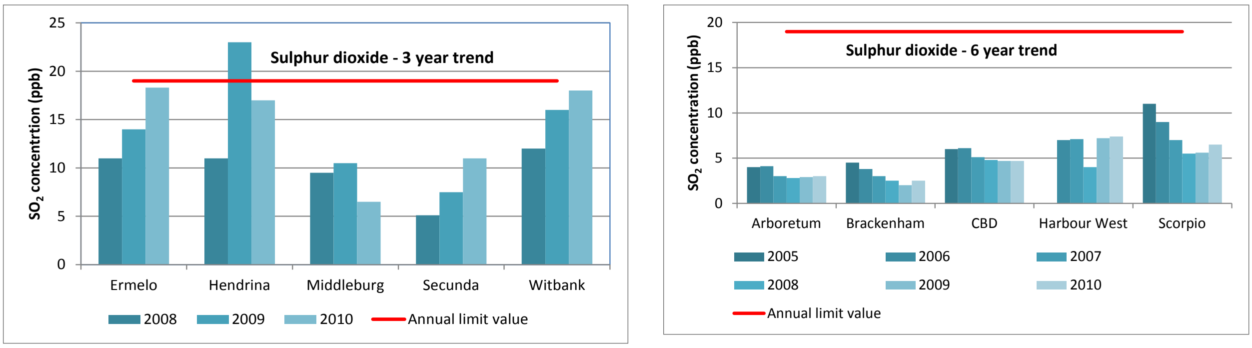


Figure 10. 5: Sulphur dioxide concentrations in Johannesburg
Source: DEA (2011b)



(a) So$_2$ concentrations in the Vaal Triangle

(b) So$_2$ concentrations in eThekwini



(c) So$_2$ concentrations in the Highveld Priority Area

(d) Richards Bay annual average So$_2$ concentrations

Figure 10. 6: Measured annual average sulphur dioxide (SO$_2$) concentrations in: a) Vaal Triangle; b) eThekwini; c) Highveld; and, d) Richards Bay monitoring stations for various periods
Stations are labelled on x-axis. Red lines indicate the national standard for annual sulphur dioxide.
Source: DEA (2011b)

10.5.1.3 Nitrogen dioxide and ozone

Air quality limits for nitrogen dioxide and ozone are exceeded at road traffic-related sites, some domestic fuel burning areas and industrial areas. The increasing number of vehicles in the country is expected to have an impact on future traffic-related nitrogen dioxide.

10.5.1.4 Carbon monoxide

Carbon monoxide is an indicator for traffic emissions and fuel combustion activities. Generally carbon monoxide levels are low and are not an area of focus in ambient air quality management. However, exposure to carbon monoxide is a concern in the context of indoor air quality and is exacerbated by incomplete combustion and poor ventilation.

10.5.1.5 Availability of data

Despite the availability of continuous monitored data from the stations which make up the NAAQMN, there is limited air quality monitoring capability in South Africa. In some areas, no air quality monitoring activities occur.

10.5.2 Ambient air quality and associated impacts

10.5.2.1 Health risks

Air pollution can causes adverse health impacts (Matooane *et al*. 2004). Pollution from the burning of domestic fuel (coal, wood and paraffin) has been described as the single largest contributor to the negative health impacts of air pollution (FRIDGE 2004) (Box 10.3).

Box 10. 3: South Durban Health Study

The South Durban Health Study aimed to assess the influences of industrial and vehicular emissions on respiratory health (epidemiological), to survey the range of ambient exposures and to determine the health risk these pose for the community. The study included South Durban (Bluff (Dirkie Uys), Merebank (Nizam), Wentworth/Austerville (Assegai), Lamontville (Entuthekwini)) and North Durban (KwaMashu (Ngazana), Newlands East (Ferndale) and Newlands West (Briardale)) (Naidoo *et al*. 2007).

The research estimated lifetime cancer risks from inhalation of pollutants. Individual lifetime risk is defined as the increased lifetime risk of cancer for an individual exposed to the maximum predicted long-term concentration (Naidoo *et al*. 2007). The largest risks were posed by VOC's (benzene) and semi-volatile compounds (dioxins, furans and naphthalene).

The study indicated that for children attending primary school in South Durban, compared to the northern suburbs, had an increased risk for persistent asthma and for marked airway hyperactivity (eThekwini Municipality 2006). Higher outdoor concentrations of nitrogen dioxide, nitrogen oxides, PM_{10}, and sulphur dioxide were strongly and significantly associated with poorer lung function notably among children with persistent asthma and children with certain genes on days following exposure. For adults, living in communities in the south, as compared to the north, was significantly associated with hay fever, and somewhat associated with chronic bronchitis, wheezing with shortness of breath, and hypertension.

10.5.2.2 Fauna and flora risks

Air pollution impacts on plants and animals, although limited research on these impacts has been undertaken in South Africa. The most common pollutants that have adverse effects on plants include sulphur dioxide, fluoride, chlorine, ozone and ethylene. The effects of pollution on plants include 'burning' at leaf tips or margins, stunted growth, premature leaf growth, delayed maturity, early drop of blossoms and reduced yield or quality (Alabama Cooperative and Extension System 2009). However, a complicating issue is the fact that injuries or damages to plants from air pollution can be confused with the symptoms caused by bacteria, fungi, viruses, nematodes, insects, nutritional deficiencies and toxicities and environmental factors such as temperature, wind and water (Enviropaedia 2011). Other pollutants such as sulphur dioxide, nitrogen dioxide and carbon dioxide can dissolve in water to form acid rain. Depending on the pH level, effects of acid rain can range from plant damage to plant death, depending on concentration and period of exposure to toxins. Entire ecosystems are also in danger because of changes in soil chemistry (Enviropaedia 2011).

Damage to plants caused by air pollution is most common close to large urban areas and industrial areas such as power generation plants, smelters, incinerators, landfill sites, pulp and paper mills, fossil fuel burning (Weissflog *et al*. 2004).

Animals are exposed to air pollutants through inhalation of gases or small particles, ingestion of particles suspended in food or water and absorption of gases through the skin. Pollutants such as ozone, sulphur dioxide and nitrogen dioxide primarily affect the respiratory system. Heavy metals (e.g. lead, arsenic, and cadmium) are emitted from various operations such as smelters and may affect the circulatory, respiratory, gastrointestinal, and central nervous systems of animals. The most affected organs are the kidney, liver, and brain. Entire populations can be affected as metal contamination can cause changes in birth, growth, and death rates (Air Pollution 2011). Acid rain has effects on animals and these include a decline in, and loss of, fish populations and amphibians. Although birds and mammals are not directly affected by water acidification, they are indirectly affected by change in the quantity and quality of their food resources (Air Pollution 2011).

10.5.3 Regional and global issues

10.5.3.1 Persistent organic pollutants

POPs are organic compounds of human origin that resist degradation and accumulate in the fatty tissue of living organisms, including humans, and are found at higher concentrations at higher levels in the food chain (WHO 2003). These pollutants can be transported over long distances in the atmosphere resulting in widespread global distribution to regions where these substances have not been used. The toxicity of POPs and the threat they pose to human health, other living organisms and the environment, has resulted in a global response to these chemicals in recent years (Ritter *et al*. 1995). Twelve POPs have been recognized internationally as the cause of adverse effects on humans and the environment (Box 10.4). These were placed in three categories:

- **Pesticides** such as dichlorodiphenyltrichloroethane (DDT) and chlordane;
- **Industrials chemical** such as polychlorinated biphenyls (PCBs) used in transformer oils; and,
- **Chemical by-products** such as dioxins and furans which are produced from combustion processes such as waste incineration and industrial processes (WHO 2003).

Concentrations of POPs have not been measured on a regular basis in urban African communities. Combustion processes can generate many POPs, (e.g., polychlorinated dibenzodioxins (PCDDs)), polychlorinated dibenzofurans (PCDFs) and PCBs, and atmospheric transport is often the primary route for transporting these contaminants into the environment (Batterman *et al*. 2007). For airborne PCDFs, recent inventories show that the largest single category contributor of emissions is uncontrolled combustion processes, e.g., biomass burning (forest, grassland, crop residue), waste burning, and accidental domestic/industrial fires (Batterman *et al*. 2007).

Box 10. 4: Africa Stockpile Programme - Achievements in South Africa

In response to the problems of pesticides in Africa, the African Stockpiles Programme (ASP) was initiated for the clean-up and safe disposal of over 50,000 tonnes of obsolete pesticide waste stockpiled across Africa (Africa Stockpiles Programme 2009).

In South Africa, a decision was made to implement a pilot collection and inventory exercise in Limpopo as the province has a strong agricultural sector. As part of this exercise, a strategy was developed in co-operation with farmers' cooperatives and pesticide distributors for the delivery of obsolete pesticides from farms to the network of existing pesticide distribution centres in the province. A total of 24 centres were established and adequate safety and containment for stocks upon delivery was provided. Information was provided to farmers on how to safely package and transport the stocks. In addition, a comprehensive communication and awareness campaign was initiated (FAO 2011). The collection phase of this project took place for a period of 60-days and at the end of this period, stocks were in the main storage location. A total number of between 60 to 80 tonnes of pesticides have been collected from various farms and provincial sectors in Limpopo. Current project activities in the province include the completion of an inventory of these stocks and thereafter the repackaging of the pesticides for safe interim storage before suitable disposal (FAO 2011). The collection phase of the project has been considered a success and an indication of multi-stakeholder cooperation among national and provincial government departments, pesticide industry, NGO groups and farmers.

There is currently no comprehensive monitoring program of POPs in South Africa. However, in line with the requirements of the Stockholm Convention for establishing baseline trends at global background sites, two programmes for monitoring POPs in the environment were set up for the African region. These programmes are the Global Passive Sampling Programme and Monitoring Network in the African Continent (MONET Africa). South Africa was a participant in both programmes and three sampling sites were selected in the country, namely; the Molopo Nature Reserve, Barberspan and Vanderbijlpark (DEA 2011c). Molopo Nature Reserve and Barberspan showed very little air pollution (not detectable - ND). The levels of DDT were quantifiable at all sites (DEA 2011c).

An extensive ambient air monitoring programme for POPs was undertaken in Durban focusing on the South Durban Industrial Basin (SDIB), an area with one of the highest industrial concentrations in Africa (eThekwini Municipality 2006). Industrial activities include petroleum refineries, a paper mill, an international airport, landfill sites, incinerators, processing and manufacturing industries, harbour and rail facilities and other industries. Several low-income residential areas are located close to these industrial activities (eThekwini Municipality 2006).

The results of the monitoring campaign indicated that the average levels of PCDFs at the sites were fairly uniform, and the Wentworth site tended to have the highest concentrations of the five most important congeners. All of the PCDDs and PCDFs were found predominantly in the particulate phase. In contrast, PCBs were found predominantly in the vapour phase, with the highest levels being found at the central Wentworth site (eThekwini Municipality 2006).

Humans can be exposed to POPs through diet, occupation, accidents and the environment, including the indoor environment. Exposure to POPs, either acute or chronic, can be associated with a wide range of adverse health effects, including illness and death. Human acute exposure to dioxins and furans can occur, through occupational risks (e.g. herbicide production, industrial accidents or chemical fires), and through burning of garbage in dump areas.

10.5.3.2 Transboundary transportation of pollutants

Pollutants emitted from natural or anthropogenic sources into the atmosphere may be transported over short or long distances, with global dispersion resulting in ultra-long range transport. When air pollutants cross geographical boundaries or migrate across several geographic zones, the pollution is hence referred to as 'transboundary' (Freiman & Piketh 2002).

Since the atmosphere is a shared resource, concerns have arisen from the effects of this transboundary pollution which is capable of affecting systems at a regional scale.

Research shows transboundary transport occurs either because the pollutants have very low deposition velocities (for example pollutants associated with haze and fine particulate matter), or an extended period of time is required for the pollutant to develop from the precursor compounds (smog, acid rain) or are chemically inert (mercury) (UNEP 2007). There are two major challenges with transboundary pollutants; first the international cooperation required to address them and second the provision of appropriate data upon which mitigation decisions can be made (UNEP 2007).

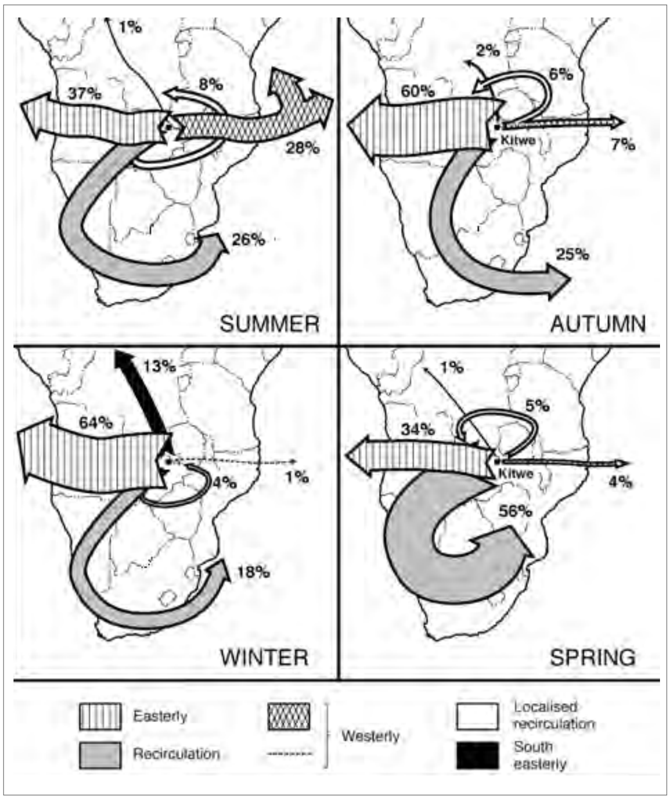
In South Africa, the Mpumalanga Highveld, with a large concentration of industrial infrastructure, is a major air pollution source region of high-elevation emissions that are transported to neighbouring countries (Swaziland, Lesotho, Mozambique, Zimbabwe and Botswana). The Highveld region accounts for the major fraction of South Africa's emission inventory of industrial particulates, sulphur dioxide and nitrogen oxides (Freiman & Piketh 2002). Due to the presence of mercury in coal, the Mpumalanga Highveld is a significant source of this pollutant due to the majority of coal-fired electricity generation plants being located in this region (Leaner *et al*. 2009).

Industrial emissions from the Zambian copper belt have been detected in South Africa (Meter *et al*. 1999). Large scale circulation over southern African results in industrial aerosols and trace gases emitted from the Highveld returning to the region after several days (D'Abreton & Tyson 1996; Piketh *et al*. 1998).

The Zambian Copperbelt is an important source of sulphur dioxide. Currently it is estimated that the emissions from these industrial emissions are up to 2.24 Mt per annum (Meter 1999; Meter *et al*. 1999; Piketh & Walton 2004). Research indicates that of the total 1.1 Mt of sulphur emitted into the regional atmosphere annually (excluding Zambia), 66 per cent originates in South Africa and about 90 per cent of this is from the Mpumalanga Highveld (Sivertsen *et al*. 1995; Wells *et al*. 1996).

The role of biomass burning emissions in contributing to the air pollution loads cannot be underestimated and biomass burning is an important source in long-range transport of air pollution in South Africa. Biomass burning is a seasonal source with highest intensities during the dry season, or between June and October. During this period in southern Africa, a large number of fires are detected north of 20 degrees south (Piketh & Walton 2004). A high frequency of burning events is also detected in northern and central Angola, the Democratic Republic of the Congo and north-western Zambia (Piketh & Walton 2004). These pollutants reach South Africa with high concentrations, a phenomenon labelled the 'River of Smoke'.

The biomass burning season in Africa starts near the equator around June and moves southward where it reaches maximum intensity in southern Africa around September (Map 10.3) (NWDAC&E 2009). Associated with biomass burning is the long-range transportation of both aerosols and trace gases across the subcontinent.



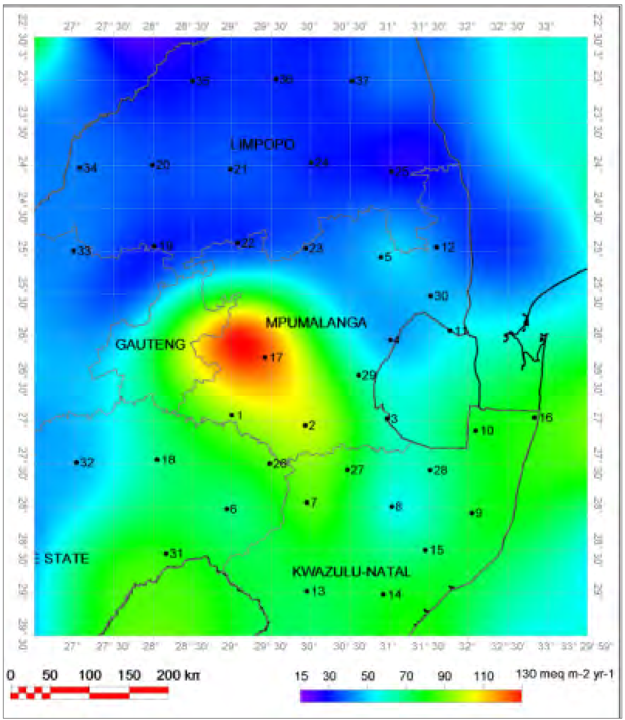
Map 10. 3: Seasonal atmospheric transport from Zambia over the southern Africa subcontinent
Source: NWDAC&E (2008)

10.5.3.3 Acid deposition

Acidic deposition occurs when emissions from the combustion of fossil fuels and other industrial processes undergo chemical reactions in the atmosphere to form acidic compounds and are deposited as wet deposition and dry deposition. The main chemical precursors leading to acidic conditions are atmospheric concentrations of sulphur dioxide and nitrogen oxides (Ecological Society of America 2000).

In South Africa, the industrial Highveld plateau is considered as a significant source of pollutants associated with acid deposition and accounts for approximately 90 per cent of South Africa's scheduled emissions of industrial dust, sulphur dioxide and nitrogen oxides (Wells *et al*. 1996, as cited in Josipovic *et al*. 2009).

A major study on acid deposition over South Africa indicated that concentration distributions for acidic gases sulphur dioxide and nitrogen dioxide show prevailing high concentrations over the industrial Highveld (Josipovic *et al*. 2009) (Map 10.4). The main findings indicated that the levels of acid deposition measured in the study do not exceed, and are not likely to exceed, critical levels and thus the challenge of acid rain over South Africa is not as serious an issue as previously thought.



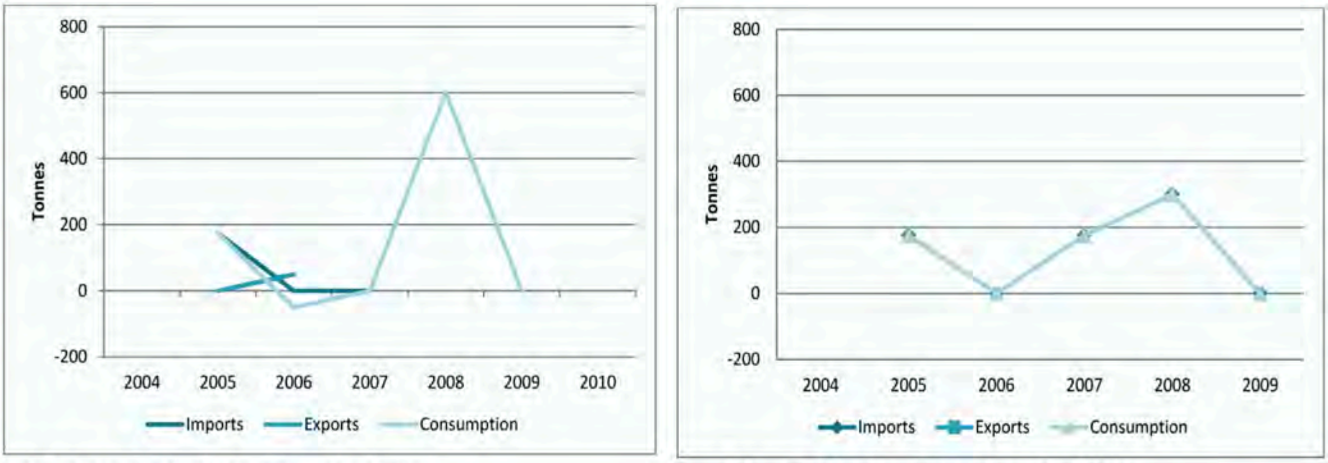
Map 10. 4: Total (dry plus wet) acidic deposition rates (meq/m² per year)
Source: Josipovic et al. *(2009)*

Acid rain affects plants and animals and produces complex changes in normal soil chemistry. It also causes staining and chemical corrosion of buildings and monuments resulting in high economic costs.

10.5.3.4 Stratospheric ozone depletion

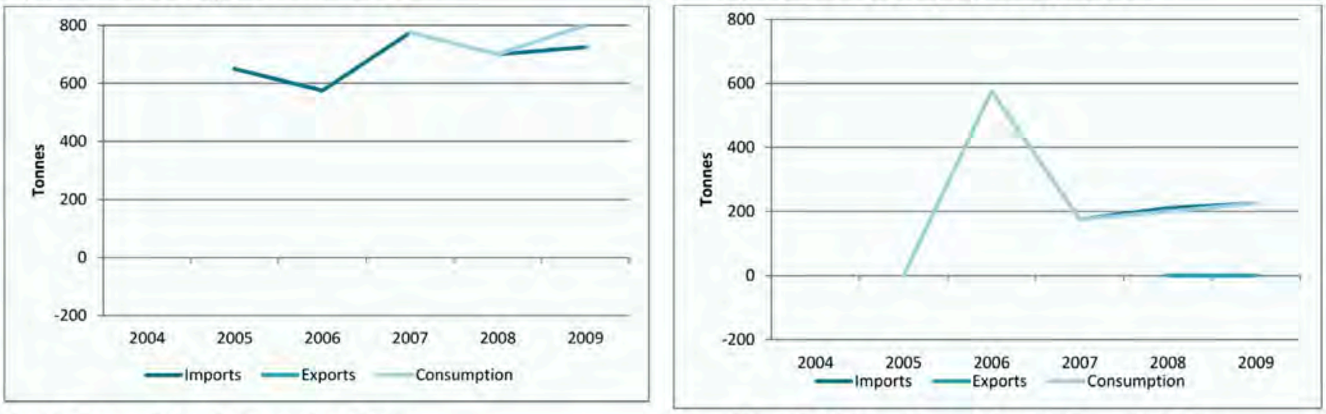
The ozone layer is an atmospheric layer of naturally occurring ozone gas that is located approximately 15 to 30 km above the earth and serves as a shield from the harmful ultraviolet B (UVB) radiation emitted by the sun (Kirk-Davidoff *et al*. 1999; Shindell *et al*. 1998). There is widespread concern that the ozone layer is deteriorating due to the release of anthropogenic CFC gases. Such deterioration allows large amounts of UVB rays to reach earth, which can cause among others, adverse health impacts, skin cancer and cataracts in humans and harm to plants and animals (Kirk-Davidoff *et al*. 1999; Shindell *et al*. 1998).

Hydrochlorofluorocarbons (HCFCs) dominate consumption at approximately 25,759 tonnes (81.4 per cent) of total ozone depleting substances (ODS) consumed during the period 2004 to 2009 in South Africa (Figure 10.7) (DEA 2009).



a) Me Br activity in South Africa

b) BCM activity in South Africa



c) HFCs activity in South Africa

d) HFC blends activity in South Africa

Figure 10. 7: Ozone depleting substances consumption trends in South Africa for the period June 2004 to June 2009
Source: DEA (2009)

CFC chemicals found mainly in refrigerants, industrial solvents and aerosol spray cans, and heavily used by industrialized nations for the past 50 years, are the primary culprits in the breakdown of the ozone layer. This is because in the upper atmosphere, CFCs are exposed to solar ultraviolet rays, which causes them to break down into substances that include chlorine. The chlorine reacts with the oxygen atoms in ozone and destroys the ozone molecule. According to the United States Environmental Protection Agency (US-EPA), one atom of chlorine can destroy more than a hundred thousand ozone molecules. The ozone layer above the Antarctic has been particularly impacted by pollution since the mid-1980s (National Geographic 2011). This region's low temperatures speed up the conversion of CFCs to chlorine. In summer, when the sun shines for long periods of the day, chlorine reacts with ultraviolet rays, destroying ozone on a massive scale by up to 65 per cent (National Geographic 2011).

Several of the anthropogenic greenhouse gases (for example CFCs and N_2O) are also ozone depleting gases. Interactions between climate change and stratospheric ozone may delay recovery of the ozone layer by 15 to 20 years (Kelfkens 2002). The depletion of stratospheric ozone and global warming due to the build-up of greenhouse gases interact to alter ultraviolet related effects on health (Kelfkens 2002).

10.5.3.4.1 Effects of stratospheric ozone depletion

There is a range of certain or possible health impacts of stratospheric ozone depletion. Many epidemiological studies have implicated solar ultraviolet radiation as a cause of skin cancer (melanoma and other types). Assessments by the UNEP (1998) projected significant increases in skin cancer incidence due to stratospheric ozone depletion (UNEP 1998). The assessment anticipated that for at least the first half of the twenty first century (and subject to changes in individual behaviours) additional solar ultraviolet radiation exposure will augment the severity of sunburn and incidence of skin cancer. High intensity ultraviolet radiation also damages the eye's outer tissues causing 'snow blindness', the ocular equivalent of sunburn (UNEP 1998).

Research shows that high ambient solar ultraviolet radiation, particularly UVB exposure, occurs in countries such as South Africa, Australia and New Zealand (Norval *et al*. 2011). South Africa has very high levels of solar radiation, over twice that of Europe and 1.5 times higher than in the United States (Eumas *et al*. 2006).

10.5.3.4.2 Responses to stratospheric ozone depletion

International responses include the Montreal Protocol of 1987, followed by the London (1990), Copenhagen (1992), Vienna (1995), another Montreal (1997), and Beijing (1999) amendments. South Africa acceded both to the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer in 1990, and to the London Amendment to the Montreal Protocol in 1992. South Africa has developed an Ozone Layer Protection Strategy as a response measure necessary to mitigate ozone layer depletion. The DEA has started the process of developing a national strategy for phasing out ozone-depleting substances and is formulating a full phase-out plan for methyl (DEA 2009).

Currently, there are six stations for monitoring UVB radiation in the country. The stations are located in Pretoria, Cape Town, Durban, Cape Point, De Aar and Port Elizabeth. The main purpose of the UVB network is to create and enhance public awareness and provide real time information of the hazard of exposure to biologically active UVB radiation reported using the 'sunburning' or erythemally-weighted radiation (UVEry) (McKenzie *et al*. 2004).

The monthly maximum UVB levels occur in January and the minimum levels in June. A comparison of the stations indicates that UVB levels in De Aar are the highest while Port Elizabeth is the lowest. UVB levels in Pretoria are second highest, followed by Durban and Cape Point (Figure 10.8). The use of the UV Index indicates that maximum UVB levels for all stations except Port Elizabeth, lie within the extreme exposure category.

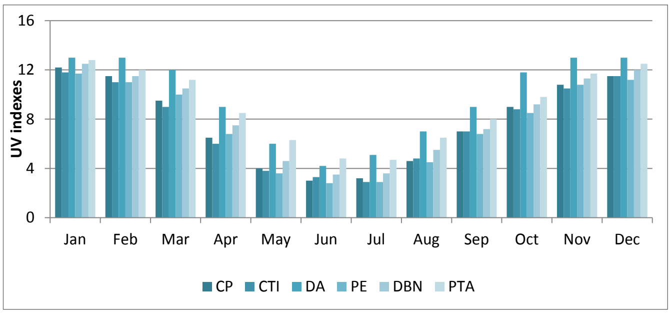


Figure 10. 8: Average maximum monthly UV indices
Source: Ncongwane and Coetzee (2010)

10.5.4 Other pressing air quality issues

South Africa faces various air pollution challenges which include persistent issues such as domestic fuel burning and industrial emissions. In addition to these problems, the country faces other pressing air quality issues. These emerging issues include waste disposal emissions, tyre burning emissions, emissions from filling stations, small boilers, asphalt plants and emerging priority pollutants such as dioxins and furans, formaldehyde and poly aromatic hydrocarbons.

10.5.4.1 Mercury emissions

Mercury is a transboundary pollutant which has both natural and anthropogenic sources. Important human activities that result in mercury release include coal combustion, waste incineration, cement production and ferrous metals production. However, despite the identification of the important sources of mercury in South Africa and other southern African countries, information on specific mercury sources and concentrations in the region is poorly understood (Leaner *et al*. 2009). For example, South Africa is a major producer of a variety of metals such as gold, platinum, lead and zinc. Although the production of these minerals and materials is known to contribute to mercury pollution, detailed mercury emissions inventories for these sources are not available (Leaner *et al*. 2009). Attempts have, however, been made by various stakeholders in South Africa to quantify emissions from various sources.

Coal-fired power plants were identified as the largest potential source of mercury emissions, especially given the fact that the country is a major producer (especially in the Highveld) and consumer of coal (Leaner *et al*. 2009) (Figure 10.9).

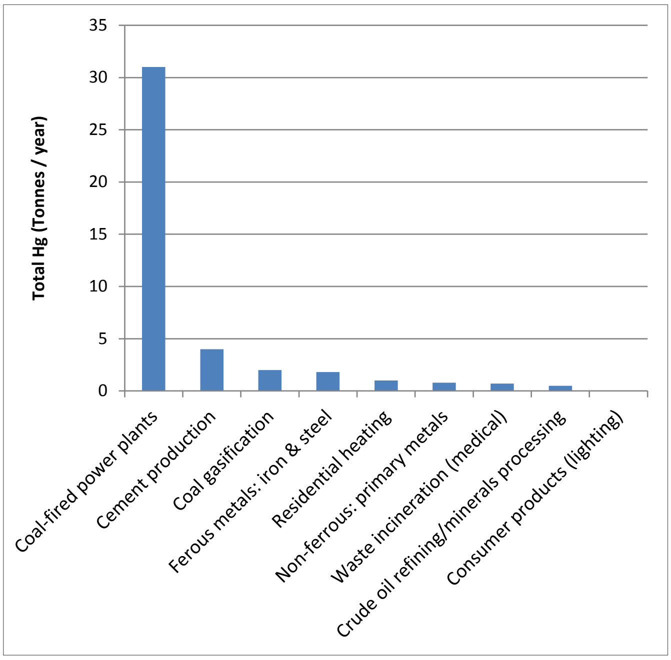


Figure 10. 9: Average atmospheric mercury emissions (1 metric tonne = 1 Mg) estimated for different source categories in South Africa during 2004

Source: Leaner et al. *(2009)*

Cement production, coal gasification, non-ferrous metals production and fuel production, crude oil refining, coal combustion in residential heating and medical waste incineration are some of the significant mercury source categories identified in South Africa. The total atmospheric emissions from all potential sources in South Africa in 2004 were estimated to be about 40 Mg (Leaner *et al*. 2009).

Mercury can cause a number of negative effects on humans and animals such as kidney damage, stomach disruption, intestinal damage, reproductive failure, deoxyribonucleic acid (DNA) alteration, disruption of the nervous system, damage to brain functions, damage to DNA and chromosomal damage. Allergic reactions include skin rashes, tiredness and headaches. Negative reproductive effects, birth defects and miscarriages are also some of the main effects of mercury in humans (Oosthuizen *et al*. 2010). The extent of mercury exposure in communities in South Africa is largely unknown (Oosthuizen *et al*. 2010).

International responses to mercury, as it is a transboundary pollutant, include the mercury guidelines under the Basel Convention, international trade in mercury under the Rotterdam Convention, and methylmercury under the Stockholm Persistent Organic Pollutants Convention. However, 2013 will be of particular public importance as this will be the year of the launch of the UNEP Global Legally Binding Treaty on Mercury. The DEA is a participant in the development of this global, legally binding, instrument on mercury and has already identified mercury as a national pollutant of concern. In addition, the DEA is working on partnership with UNEP to populate and gain a better understanding of the country's mercury emissions. UNEP has also provided funding to undertake mercury emission measurements at two Eskom power stations and is in discussions regarding a possible demonstration project that will seek to reduce mercury emissions from coal-fired power generation (Leaner *et al*. 2009).

10.5.4.2 Black carbon

Black carbon is an air pollutant formed through the incomplete combustion of fossil fuels, biofuels and biomass and is a component of $PM_{2.5}$. This pollutant is associated with significant adverse health effects such as lung cancer, respiratory and cardiovascular conditions (UNECE 2011).

In South Africa (and in general), anthropogenic sources of black carbon include domestic fuel burning, road transport, especially diesel-fuelled transportation, and biomass burning. These sources have also been identified to be the most important with regards to black carbon mitigation potential. For example, domestic fuel burning mitigation measures include the use of modern combustion stoves and substitution of biomass fuels with 'cleaner fuels' such as electricity in residential areas. Vehicle emissions can be reduced through elimination of high-emitting vehicles (UNECE 2011).

Black carbon is also known as a 'short-lived climate forcer'. This effectively means that it is a warming agent with a relatively short lifetime in the atmosphere, ranging between days and weeks and contributes to global warming through the absorption of sunlight as it penetrates from space. This leads to direct heating of the atmosphere (UNEP 2011).

The reduction of black carbon and other 'short lived climate forcers' such as tropospheric ozone and methane will provide significant benefits through improved air quality and mitigation of climate change (UNEP 2011).

10.5.4.3 Fishmeal production

Fishmeal production in South Africa has over the years been transformed into a multi-million rand industry. Fish unsuitable for human consumption, together with cannery waste (heads, tails and guts) are converted into valuable fishmeal at various factories along the west and south-east coasts of South Africa (De Koning 2005). The process of making fishmeal from fish processing plants generates various pollutants, especially the odour released from the decomposing, cooking and drying of fish and by- products. Fishmeal driers are the largest source of odour pollution within food processing plants (De Koning 2005).

In response, the DEA initiated a human health risk assessment which included measurements of gases in four fish processing plants. The assessment included those compounds known to be emitted by the fish industry that are also known to be toxic at certain concentration levels, namely hydrogen sulphide, trimethlyamine and formaldehyde.

10.6 RESPONSES TO AIR QUALITY PROBLEMS

Various air quality management instruments have been developed over the years and include environmental legislation, emissions inventories, dispersion modelling and concentration inventories. South Africa has responded to its air pollution challenges in various ways which include legislative reform, revision of ambient air quality limits, proactive planning by local authorities and sector specific controls as indicated below:

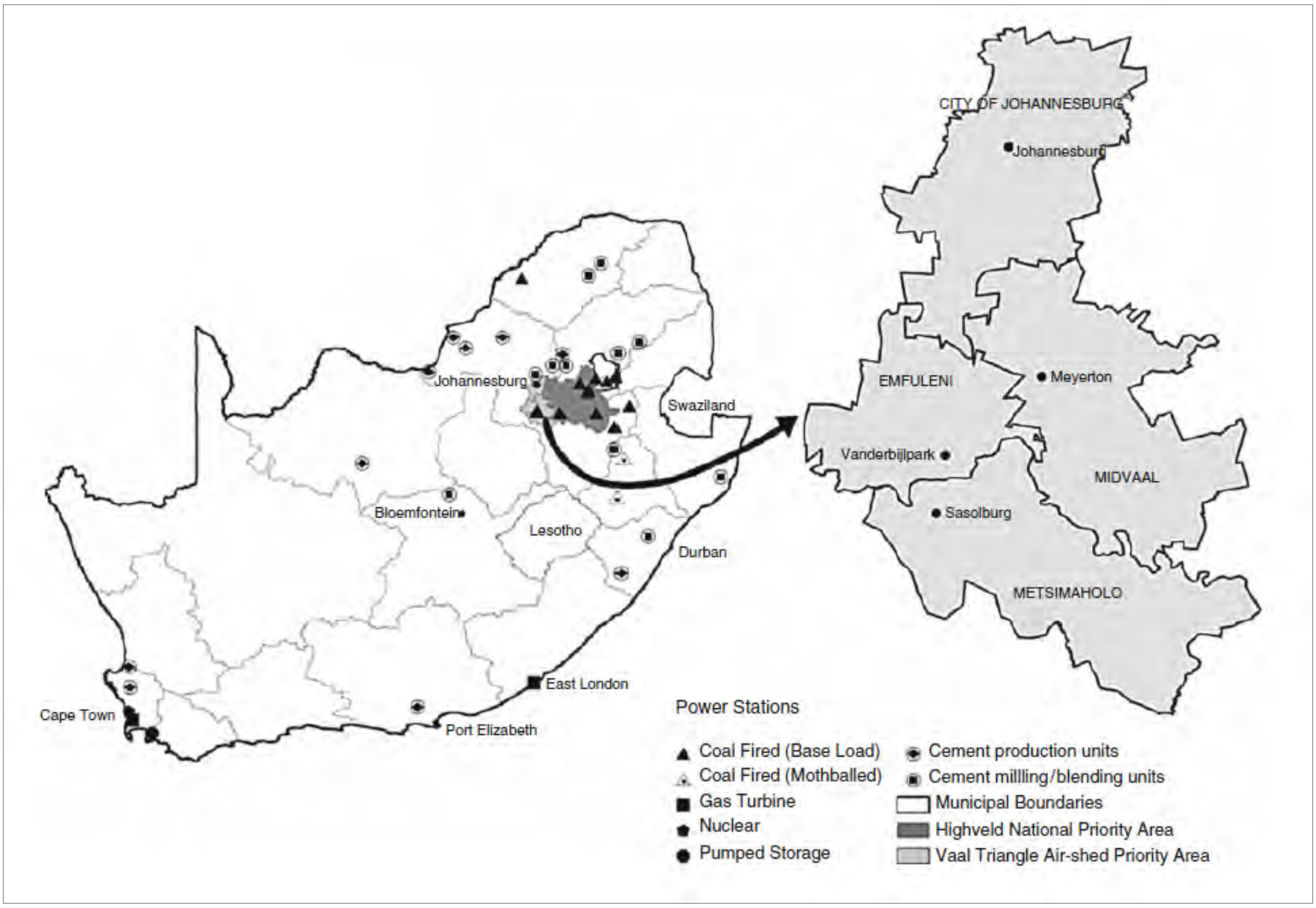
- The promulgation of the NEM:AQA. Key elements of this are the establishment of a clear institutional and planning framework for air quality management;
- The development of a South African Air Quality Information System (SAAQIS) to ensure the availability of credible and readily available air quality data. This data is in turn used to ensure that appropriate measures to improve air quality are taken;
- The development and maintenance of an effective governance framework for air quality management, National Framework for Air Quality Management in South Africa, as provided for in the NEM:AQA, so as to ensure that current and future impacts of atmospheric emissions are avoided, minimized, mitigated or managed;
- Declaration of priority areas, as provided for in the NEM:AQA and ensuring that there are significant improvements in air quality in the declared priority areas and compliance with the ambient standards (Box 10.5);
- Development of national, provincial, municipal and priority area AQMPs in fulfilment of the requirements of the NEM:AQA in areas with poor or potentially poor air quality (Table 10.2);
- Improvement of indoor and ambient air quality in dense, low-income urban settlements through ambient monitoring, *Basa njengo Magogo* (BnM) (Box 10.6), housing guidelines, energy carrier options and the Strategy for Addressing Air Pollution in Dense, Low-income Settlements, especially given the fact that it is proposed that by 2020 air quality in all low-income settlements should be in compliance with National Ambient Air Quality Standards (NAAQS);

Box 10. 5: Declaration of priority areas in South Africa

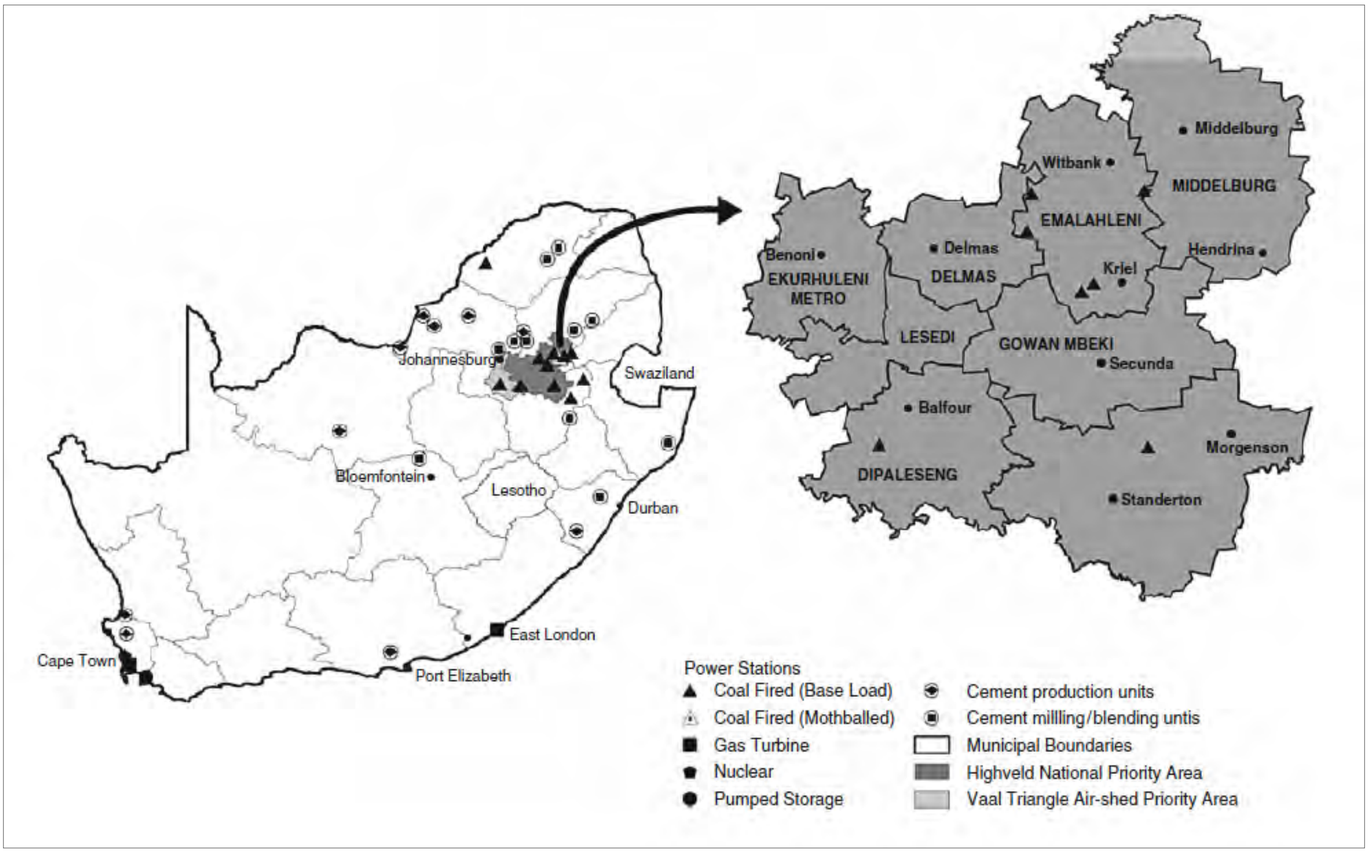
Several pollution ‘hotspots’ or priority areas exist in South Africa and in line with the requirements of the NEM:AQA, two areas have been declared as priority areas: the VTAPA (first priority area to be declared – Map 10.5) and the HPA (second priority area to be declared – Map 10.6), with intentions to declare the expanded Waterberg as the third national priority area.

Priority areas are generally areas where ambient air quality standards are being, or may be, exceeded. The declaration of these priority areas is as a result of the high pollution levels associated with heavy industrial activities and the associated health and negative environmental effects. Several activities such as heavy industries, transportation, landfill and waste incineration and domestic fuel burning are characteristic of the VTAPA (Leaner *et al*. 2009). A range of activities such as industrial, mining and agricultural activities which include coal-fired power stations, timber and related industries, metal smelters, petrochemical plants, heavy and small industrial operations exist in the HPA. Following the declaration of these priority areas, Air Quality Management Plans (AQMPs) have been developed with the goal of improving air quality. In addition, the DEA has been investigating means of optimizing the implementation of the Vaal Triangle AQMP and this has resulted in the initiation of a medium term review of the plan’s implementation status.

The DEA operates several ambient air quality monitoring stations in the two National Priority Areas of South Africa. These monitor priority pollutants such as particulate matter (PM_{10} and $PM_{2.5}$), SO_2, NO_2, O_3, CO, Pb, benzene, toluene, ethyl benzene and xylene (BTEX) other pollutants.



Map 10. 5: Location of the Vaal Triangle Priority Area in South Africa
Source: Leaner et al. *(2009)*



Map 10. 6: Location of the Highveld Priority Area in South Africa
Source: Leaner et al. *(2009)*

Table 10. 2: National and Provincial Air Quality Management Plans

National and Provincial Air Quality Management Plans in place	
Department/ Municipality	**Current status**
National	
Department of Environmental Affairs	The 2007 National Framework serves as the DEA's AQMP.
Provincial	
Gauteng	AQMP completed and under implementation.
Free State	AQMP development complete and under implementation.
North West	AQMP was completed, gazetted and officially launched in 2009. The province is currently developing an emissions inventory.
Western Cape	Completed and planning to start implementation.
Mpumalanga	Priority area AQMP developed. About 80% of the hotspot areas are included in this AQMP.
Limpopo	Currently planning to develop an AQMP. Development will feed from information from district AQMPs.
KwaZulu-Natal	The province has finalized the emissions inventory project, with plans to develop an AQMP.
Eastern Cape	The province has the intention to develop an AQMP despite financial challenges.
Northern Cape	'In-house' development of AQMP despite financial and capacity problems.

Source: DEA (2010)

Box 10. 6: The *Basa njengo Magogo* campaign

A compelling response on the part of government to the problems of poor people using coal for cooking and heating purposes, resulting in high levels of indoor air pollution, is the launching of various programmes aimed at reducing indoor air pollution levels. One such programme is a campaign to promote the *Basa njengo Magogo* (BnM) fire-lighting method (Figure 10.10). This particular method is based on the principle of putting the coal first in the brazier, followed by newspaper, and then wood on top. The paper and wood is lit and when it is burning well, two handfuls of coal are added on top. The idea is that the fire burns from the top-down, improving the combustion of the coal through increased oxygen flow created by an updraft through the fire. Smoke emitted from a BnM fire is reduced by up to 50 per cent, due to increased efficiency of the combustion of the coal (le Roux *et al*. 2009). This method has proved to be the least-cost option with the biggest potential of reducing smoke caused by the burning of coal. Particulate emissions using the BnM method are on average 87 per cent less than those of conventional bottom-up fires, and the former method uses approximately one kilogramme less coal to reach cooking temperature than the traditional bottom-up method (le Roux *et al*. 2009). At a cost of approximately R1/kg of coal this translates into a cost saving of approximately R30 per month in winter which is significant for low-income households. Significant reductions in CO and particulates from the BnM method mean that the health risks of such air pollutants are reduced; however, the method does not reduce CO_2 levels significantly (le Roux *et al*. 2009).

This method has been introduced in more than ten coal-burning urban areas in Gauteng, supported by the Central Energy Fund and DEAT's 'Clean Fires Campaign' (DEAT 2008). As can be seen from the photograph below, the cleaner-burning brazier, whose fire has been made with the BnM method, is on the left while the smoky brazier, whose fire has been made the conventional way, is on the right hand side.

Figure 10. 10: An illustration of the *Basa njengo Magogo* method

Source: Palmer Development Group

- Atmospheric Emissions Licence (AEL) - the NEM:AQA provides for the control of air pollution through an AEL which must be held by anyone undertaking any listed activity. The AEL should be issued by the relevant metropolitan or district municipality, except when the provincial department has been requested to do so or when the metro or municipality itself is the applicant;
- Vehicle emissions control in the country include the introduction of Euro-vehicle emissions regulations for petrol-driven vehicles, the on-going National Vehicle Emissions Strategy and a reduction in the maximum sulphur content of diesel and benzene content of petrol;
- Due to the dependence of coal and other fossil fuels for energy, an Integrated Energy Plan has been developed by the Department of Energy (DoE) for South Africa with a national final energy demand reduction of 12 per cent by 2015. The targets for the various sectors for 2015 are industry and mining sector 15 per cent, power generation (15 per cent), commercial and public building sectors (15 per cent), residential sector (ten per cent) and the transport sector (nine per cent);
- The recognition of source-based (command-and-control) measures in addition to alternative measures, included market post-compliance programmes and education and awareness of the major polluters;
- Programmes aimed at creating sufficient capacity in the public sector to effectively implement air quality planning, management and enforcement;
- Addressing climate change through the development of a National Climate Change Response Strategy and Implementation Plan and a National Greenhouse Emissions Inventory; and,
- A National Air Quality Indicator (NAQI) has been proposed for South Africa (DEA 2010b). The purposes of the NAQI are to:
    - Monitor national progress in implementing NEM:AQA policy targets including national compliance to air quality standards by 2020;
    - Assess the condition and reflect national air quality trends;
    - Inform the objectives of the NEM:AQA (enhancement, protection, governance);
    - Measure indicators that are informed by goals;
    - Act as a support tool for policy makers;
    - Raise public awareness and support;
    - Assist in the determination of interventions; and,
    - In response, human health based standards and objectives for a number of air pollutants have been developed or adapted for South Africa. The DEA has promulgated NAAQS for criteria pollutants PM_{10} particulate mass, sulphur dioxide, nitrogen dioxide, lead, ozone and carbon monoxide.

10.7 CONCLUSION

South Africa faces many environmental challenges, pollution and associated problems which are endemic to developing countries. The direct and indirect effects of air pollution have an impact across the country and a growing concern is the rising level of air pollution, mainly from industrial emissions, domestic use of wood, coal and paraffin, vehicle exhaust emissions, biomass burning and energy production. This concern is further exacerbated by the fact that it is proposed that compliance to the NAAQS is to be achieved by the year 2020. Adding to the environmental challenges in South Africa is the problem of transboundary air pollution which further exacerbates the air pollution and environmental challenges due to its complexity and associated effects.

Air pollution and health impacts studies in South Africa reflect that air pollution exposure results in numerous health problems in the general population with the effects more pronounced among the elderly and young. The vulnerability to air pollution is also more evident in people of low-income status. This vulnerability has also been increased by poor land use planning which has resulted in the location of heavy industrial developments in proximity to high density residential areas. The importance of density in such areas is related to impact amplification due to the low level release of the air pollutants associated with domestic fuel burning. Lack of access to electricity in rural areas, and unaffordability of electricity among poor urban dwellers, has also resulted in the continued reliance on biomass and coal energy for cooking and space heating. Exposure to this indoor air pollution and the associated health effects are some of the reasons why the elevated PM_{10} levels, which exceed the NAAQS in most residential household fuel burning areas, are of major concern. The health effects associated with exposure to indoor air pollution also have economic implications due to huge expenditures in the health sector.

Although sulphur dioxide concentrations in some residential and industrial areas exceed the thresholds, the exceedances are less frequent and dependant on the type of fuels and type of industry. In general, a reduction in industrial sulphur dioxide emissions has been noted in areas such eThekwini and Cape Town metros.

Exceedances of nitrogen dioxide and ozone thresholds due to vehicles are recorded in some metros in the country and this is an issue of concern, especially given the increasing vehicle numbers in the country and the ageing national fleet. The rapid growth in vehicle numbers has also been associated with an increase in fuel consumption and a significant increase in emissions from the transport sector. Other cross cutting issues related to air pollution from the transport sector include health implications, smog (especially in urban areas), greenhouse gases and climate change.

Other sources of air pollution in the country include airports, waste treatment facilities such as waste water treatment works and landfill sites as they are also associated with greenhouse gas emissions, fuel stations, mine residues, tyre burning, fishmeal production and small combustion facilities such as boilers. Emerging pollutants of concern include $PM_{2.5}$, VOCs, PAHs, benzene and mercury.

Due to global air pollution problems, POPs and stratospheric ozone depletion caused mainly by transboundary pollutants, air quality management in South Africa is of an international standard. The country is a party to various global treaties such as the UNFCCC, the Kyoto Protocol, Montreal Protocol and the Stockholm Convention in a bid to reduce the impacts of air pollution on the atmosphere, a shared global resource.

It is apparent that air quality management is a significant issue in the country which requires efforts from various stakeholders for the achievement of sustainable development, compliance to national standards, international best practice and above all, an environment that is not harmful to health and wellbeing.

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10.9 ANNEXURE 10. A: Ambient air pollutant concentrations

Table A: Ambient air pollutant concentrations recorded at sites within residential household fuel burning areas

Location	Year	Pollutant	% Data availability		Exceedances per year (hourly limit)		Exceedances per year (daily limit)	
			2009	2010	2009	2010	2009	2010
Johannesburg, Orange Farm - primarily domestic fuel burning	2009 and 2010	PM_{10}	95.0	75.6	NS	NS	7.0	9.0
		$PM_{2.5}$	NMD	NMD				
		NO_2	NMD	NMD				
		SO_2	92.6	56.4	92.6	56.4	0.0	0.0
		O_3	NMD	NMD				
Johannesburg, Alexandra - primarily domestic fuel burning	2009 and 2010	PM_{10}	58.0	43.6	NS	NS	52.0	28.0
		$PM_{2.5}$	NMD	NMD				
		NO_2	70.4	42.7	0.0	3.0		
		SO_2	63.3	36.4			0.0	0.0
		O_3	8.5	11.0	0[b]	0[b]		
Johannesburg, Jabavu - primarily domestic fuel burning	2009 and 2010	PM_{10}	92.3	99.2	NS	NS	24.0	24.0
		$PM_{2.5}$	NMD	NMD				
		NO_2	NMD	NMD				
		SO_2	82.2	70.7			0.0	0.0
		O_3	NMD	NMD				
Johannesburg, Ivory Park primarily domestic fuel burning	2009 and 2010	PM_{10}	25.2	47.7	NS	NS	60.0	80.0
		$PM_{2.5}$	NMD	NMD				
		NO_2	NMD	NMD				
		SO_2	82.2	70.7			0.0	0.0
		O_3	NMD	NMD				

Location	Year	Pollutant	% Data availability		Exceedances per year (hourly limit)		Exceedances per year (daily limit)	
			2009	2010	2009	2010	2009	2010
Johannesburg, Diepsloot - primarily domestic fuel burning	2009 and 2010	PM_{10}	19.18	52.0	NS	NS	30.0	77.0
		$PM_{2.5}$	NMD	NMD				
		NO_2	NMD	NMD				
		SO_2	62.5	58.4			0	0
		O_3	NMD	NMD				
Johannesburg, Delta Park - primarily domestic fuel burning	2009 and 2010	PM_{10}	97.8	67.1	NS	NS	0	1
		$PM_{2.5}$	NMD	NMD				
		NO_2	60	1.1	0.0	0.0	0.0	0.0
		SO_2						
		O_3	94.0	69.6	0[b]	0[B]	NS	NS
Vaal Triangle, Diepkloof - primarily domestic fuel burning	2009 and 2010	PM_{10}	99.2	78.6	NS	NS	1.0	15.0
		$PM_{2.5}$	93.7	42.0	NS	NS	39.0[a]	54.0[a]
		NO_2	93.4	14.3	0.0	0.0	NA	NA
		SO_2	95.9	61.9	ND	ND	0.0	0.0
		O_3	91.0	59.5	0.0	0.0	NA	NA
Vaal Triangle, Sharpeville - primarily domestic fuel burning	2009 and 2010	PM_{10}	85.2	94.3	NS	NS	34.0	60.0
		$PM_{2.5}$	94.3	72.3	NPS	NPS	45.0[a]	47.0[a]
		NO_2	97.3	39.2	0.0	0.0	NA	NA
		SO_2	93.42	63.29	ND	ND	0.0	0.0
		O_3	87.7	77.5	5.0	0.0	NA	NA
Vaal Triangle, Three Rivers - primarily domestic fuel burning	2009 and 2010	PM_{10}	74.5	80.3	NS	NS	0.0	7.0
		$PM_{2.5}$	75.9	85.5	NPS	NPS	0.0[a]	9.0[a]
		NO_2	2.7	37.5	0	0		
		SO_2	75.1	87.1	ND	ND	0.0	0.0
		O_3	77.0	78.4	5.0	0.0	NA	NA
Vaal Triangle, Zamdela - primarily domestic fuel burning	2009 and 2010	PM_{10}	76.7	0.0	NS	NS	97.0	0.0
		$PM_{2.5}$	98.4	99.7	NPS	NPS	10.0[a]	19.0[a]
		NO_2	36.7	27.4	0.0	0.0	NA	NA
		SO_2	97.5	93.1	0.0	0.0	0.0	0.0
		O_3	98.4	54.8	0.0	0.0	NA	NA
Vaal Triangle, Sebokeng - primarily domestic fuel burning	2009 and 2010	PM_{10}	84.9	92.9	NS	NS	1.0	8.0
		$PM_{2.5}$	52.88	93.15	NPS	NPS	33.0[a]	77.0[a]
		NO_2	84.7	92.6	0.0	0.0	NA	NA
		SO_2	83.6	92.1	NA	NA	0.0	0.0
		O_3	84.9	85.2	0.0	8.0	NA	NA
Vaal Triangle, Klieprivier - primarily domestic fuel burning	2009 and 2010	PM_{10}	86.9	91.8	NS	NS	32.0	11.0
		$PM_{2.5}$	96.2	54.0	NPS	NPS	83.0[a]	41.0[a]
		NO_2	79.2	83.3	0.0	0.0	NA	NA
		SO_2	86.0	69.9	ND	ND	0.0	0.0
		O_3	92.9	95.3	0.0	0.0	NA	NA

Location	Year	Pollutant	% Data availability		Exceedances per year (hourly limit)		Exceedances per year (daily limit)	
			2009	2010	2009	2010	2009	2010
Cape Town, Khayelitsha - primarily domestic fuel burning	2009 and 2010	PM_{10}	ND					
		$PM_{2.5}$	ND					
		NO_2	ND					
		SO_2	ND					
		O_3	ND					
Tshwane, Mamelodi - primarily domestic fuel burning	2009 and 2010	PM_{10}	50.1	35.3	NA	NA	48.0	13.0
		$PM_{2.5}$	ND	ND				
		NO_2	46.5	49.6	1.0	0.0	NA	NA
		SO_2	49.3	47.3			0.0	0.0
		O_3	49.4	80	0	0	NA	NA
Tshwane , Olivenhoutbosch - primarily domestic fuel burning	2009 and 2010	PM_{10}	39.5	58.1	NA	NA	41.0	59.0
		$PM_{2.5}$	ND	ND				
		NO_2	41.4	49.5	0.0	0.0	NA	NA
		SO_2	31.5	47.7	ND	ND	0.0	0.0
		O_3	41.3	61.3	0.0	0.0	NA	NA
Cape Town, Khayelitsha	2008	PM_{10}	2008		Exceedances per year (hourly limit)		Exceedances per year (daily limit)	
			96.0		NA		100.0	
Cape Town, Wallacedene	2008	PM_{10}	97.0		NA		42.0	
		O_3	97.0		4.0		NA	

Proposed daily standard for $PM_{2.5}$

(a) 8 hourly running average for ozone (O_3)

NS - No standard for pollutant; NMD - No measured data; ND - no data; NA - Not applicable

Table B: Ambient air pollutant concentrations recorded at sites impacted by industrial source types

Location	Year	Pollutant	% Data availability		Exceedances per year (10 minute average)		Exceedances per year (hourly limit)		Exceedances per year (daily limit)	
			2009	2010	2009	2010	2009	2010	2009	2010
eThekwini, Wentworth	2009 and 2010	PM_{10}	ND	ND	NA	NA			5.0	0.0
		NO_2	96.2	96.2			4.0	3.0		
		SO_2	95.9	95.9	10.0	4.0			0.0	0.0
eThekwini, Settlers School	2009 and 2010	PM_{10}	ND	ND						
		SO_2	94.7	94.7	6.0	22.0			0.0	4.0
eThekwini, Southern Works	2009 and 2010	$PM_{2.5}$	61.0	61.0	NA	NA	NA	NA	44.0	39.0
		NO_2	96.9	96.9	NA	NA	2.0	3.0	NA	NA
		SO_2	91.2	91.2	0.0	16.0			0.0	0.0
eThekwini, Alverstone	2009 and 2010	O_3	70.3	70.3			0.0	1.0	8.0[c]	38.0[c]
Tshwane, Rosslyn	2009 and 2010	PM_{10}	NMD							
		$PM_{2.5}$	NMD							
		NO_2	36.0	34.0	NA	NA	0.0	0.0	NA	NA
		SO_2	30.7	67.8	ND	ND	0.0	0.0	0.0	0.0
		O_3	4.5	32.9	NA	NA	0.0[b]	0.0[b]	NA	NA
Tshwane, Pretoria West	2009 and 2010	PM_{10}	16.7	0.0					43.0	29.0
		$PM_{2.5}$	16.7	0.0	NA	NA				
		NO_2	16.7	0.0	NA	NA	1.0	0.0	NA	NA
		SO_2	16.7	0.0	ND	ND	18.0	0.0	1.0	0.0
		O_3	16.7	0.0	NA	NA	18.0[b]	0.0[b]	NA	NA
Tshwane, Booysens	2009 and 2010	PM_{10}	41.5	28.0	NA	NA	NA	NA	4.0	4.0
		$PM_{2.5}$	NDM	NDM						
		NO_2	35.7	35.6	NA	NA	0.0	0.0	NA	NA
		SO_2	23.1	28.2	ND	ND			0.0	0.0
		O_3	41.2	32.4	NA	NA	0.0[b]	0.0[b]	NA	NA
Richards Bay, Arboretum Ext	2011	PM_{10}	ND							
		$PM_{2.5}$	ND							
		NO_2	ND							
		SO_2	98.0	97.9	0.0	0.0	0.0	0.0	0.0	0.0
		O_3	ND							
Richards Bay, Brackenham	2009 and 2010	PM_{10}	ND							
		$PM_{2.5}$	ND							
		NO_2	ND							
		SO_2	97.0	97.8	0.0	0.0	0.0	0.0	0.0	0.0
		O_3	ND							
Richards Bay, Habour West	2009 and 2010	PM_{10}	ND							
		$PM_{2.5}$	ND							
		NO_2	ND							
		SO_2	100.0	100.0	17.0	3.0	5.0	2.0	1.0	1.0
		O_3	ND							

Location	Year	Pollutant	% Data availability		Exceedances per year (10 minute average)		Exceedances per year (hourly limit)		Exceedances per year (daily limit)	
			2009	2010	2009	2010	2009	2010	2009	2010
Richards Bay, Scorpio	2009 and 2010	PM_{10}	ND							
		$PM_{2.5}$	ND							
		NO_2	ND							
		SO_2	99.0	97.3	2.0	3.0	0.0	0.0	0.0	1.0
		O_3	ND							
Highveld, Ermelo	2009/2010	PM_{10}	99.2	95.6	NA	NA	NA	NA	20.0	8.0
		$PM_{2.5}$	99.2	95.6	NA	NA	NA	NA	23.0	18.0
		NO_2	86.0	75.6	NA	NA	0.0	1.0	NA	NA
		SO_2	8.5	89.3	ND	ND	ND	ND	0.0	0.0
		O_3	99.2	92.0	NA	NA	0.0^b	0.0^b	NA	NA
Highveld, Hendrina	2009 and 2010	PM_{10}	70.4	80.2	NA	NA	NA	NA	0.0	12.0
		$PM_{2.5}$	70.4	80.2	NA	NA	NA	NA	0.0^a	4.0^a
		NO_2	55.6	73.7	NA	NA	0.0	0.0		
		SO_2	63.3	77.8	ND	ND	NA	NA	0.0	0.0
		O_3	65.2	81.4			0.0	110.0		
Eskom, Mpumalanga	2009 and 2010	PM_{10}	ND							
		$PM_{2.5}$	ND							
		NO_2	ND							
		SO_2	ND							
		O_3	ND							
Cape Town, Belville South	2008	SO_2	2008		Exceedances per year (10 minute limit)		Exceedances per year (hourly limit)		Exceedances per year (daily limit)	
			40		1		NA		NA	

(a) Proposed standard for $PM_{2.5}$
(b) 8 hourly running average for ozone (O_3)
(c) Based on 8 hour average for ozone
NS - No standard for pollutant; NMD - No measured data; ND - no data; NA - Not applicable

Table C: Ambient air pollutant concentrations recorded at road traffic related monitoring sites

Location	Year	Pollutant	% Data availability		Exceedances per year (hourly limit)		Exceedances per year (daily limit)	
			2009	2010	2009	2010	2009	2010
eThekwini, City Hall	2009 and 2010	PM_{10}	94.0	94.0	NA	NA	5.0	1.0
		NO_2	95.9	95.9	1.0	2.0	NA	NA
eThekwini, Warwick	2009 and 2010	NO_2	86.2	86.2	18.0	23.0	NA	NA
Johannesburg, Buccleuch Interchange	2009 and 2010	PM_{10}	93.7	48.0	NA	NA	17.0	0.0
		$PM_{2.5}$	91.0	47.7	NA	NA	51.0[b]	14.0[b]
		NO_2	93.2	45.5	0.0	0.0		
		SO_2	63.0	44.7	NA	NA	0.0	0.0
		O_3	89.0	27.4	0.0[a]	25.0[a]	NA	NA
Cape Town City Hall	2009 and 2010	PM_{10}	ND					
		$PM_{2.5}$	ND					
		NO_2	ND					
		SO_2	ND					
		O_3	ND					

(a) 8 hourly running average for ozone (O_3)

(b) (b)proposed standard for $PM_{2.5}$

NS - No standard; NMD - No measured data; ND - no data; NA - Not applicable

Table D: Ambient air pollutant concentrations recorded at sites impacted by multiple source types

Location	Year	Pollutant	% Data availability		Exceedances per year (hourly limit)		Exceedances per year (daily limit)	
			2009	2010	2009	2010	2009	2010
Witbank	2009 and 2010	PM_{10}	99.5	97.3	NA	NA	21.0	20.0
		$PM_{2.5}$	99.5	97.3			29.0[a]	20.0[a]
		NO_2	90.4	99.2	0.0	0.0	NA	NA
		SO_2	95.9	93.4	ND	ND	0.0[b]	0.0[b]
		O_3	99.5	99.2	0.0	0.0		
Richards Bay, CBD	2009 and 2010	PM_{10}	ND					
		$PM_{2.5}$	ND					
		NO_2	ND					
		SO_2	97.0	0.0	0.0	0.0	0.0	0.0
		O_3	ND					
Cape Town, Somerset West	2008	PM_{10}	% Data Availability		Exceedances per year (hourly limit)		Exceedances per year (daily limit)	
			91.0		NA		1.0	

Proposed $PM_{2.5}$ daily standard

(a) 8 hourly running average for ozone (O_3)

(b) NS - No standard; NMD - No measured data; ND - no data; NA - Not applicable