Review of Urban Air Quality in Sub-Saharan Africa Region - Air Quality profile of SSA countries

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Section 1. Executive Summary

1.1 Introduction

In Africa, urban outdoor air pollution is responsible for an estimated 49,000 premature deaths annually with indoor use of solid fuels being responsible for eight times this value, the main burden being borne by Sub Saharan African countries (WHO, 2002). Air pollution, outdoor and indoor, affects the health and life chances of millions of people in Sub Saharan Africa every day. There is a link between air pollution and poverty since poor people are exposed to higher concentrations of air pollutants and tend to suffer disproportionately from the effects of deteriorating air quality (AQ). Children in cities exposed to high concentrations of air pollutants will more often develop respiratory ailments which prevent them from developing and learning well. As a consequence they will suffer in adult life from low levels of qualifications and skills. The implication of poorly educated children is not only a reduction of quality of their lives but also an obstacle for the economic development of a country as a whole.

With 3.3 to 3.7 percent annually, African urban population growth rates have been and will continue to be the highest in the world. As indicated in Figure 1.1 African city-based population percentages (normalised to that of the year 2000) are growing faster than their counterparts in all other regions of the world and are estimated to continue to do so in the next two decades and very likely beyond.

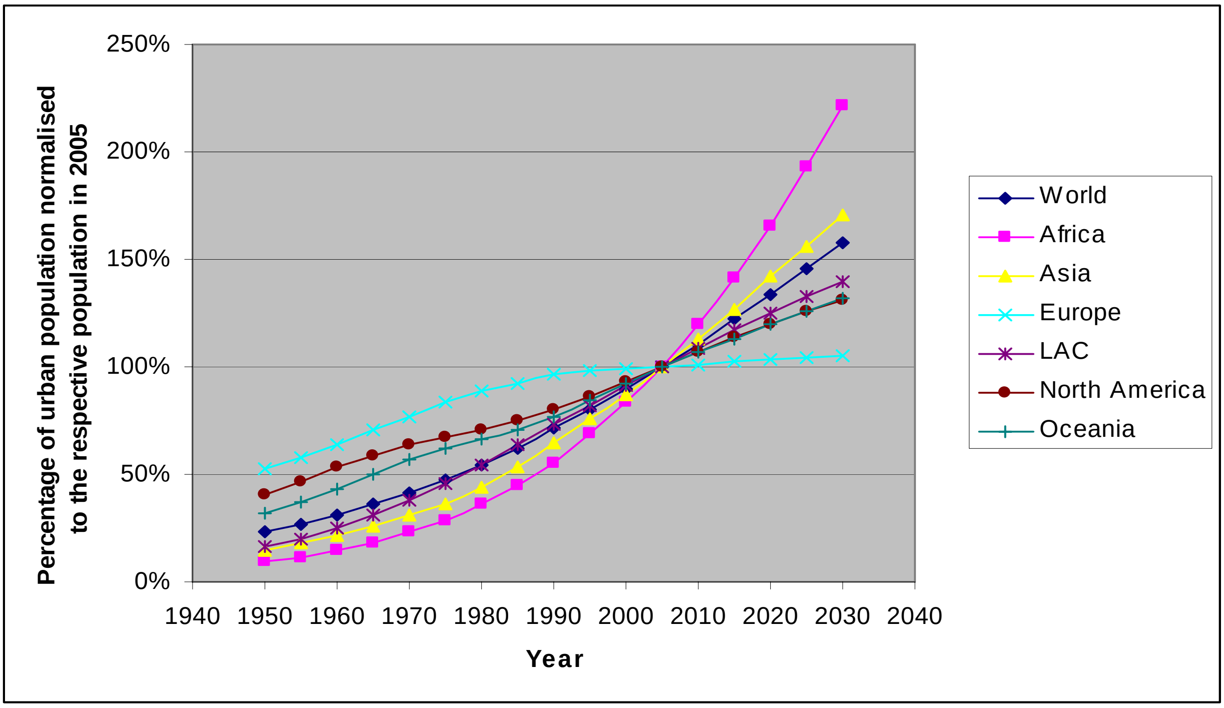

Figure 1.1: Urban population growth rates for the World, Africa, Asia, Latin America and the Caribbean (LAC), Oceania, Europe, and North America

Source: UN (2007)

Rapid urbanisation means increase in motorisation and economic activity which in turn leads to increased air pollution if countermeasures are not taken. In view these linkages addressing urban AQ in SSA is particularly important.

In addition to water and solid waste problems, SSA is facing substantial challenges in terms of urban AQ. Some of the challenges are: old vehicles without emissions control, increased vehicle fleets, poor or absence of proper vehicle maintenance, lack of cleaner fuels, absence of or poor regulatory framework specific to vehicle emissions, and poor enforcement of laws and regulations when they exist.

Air pollution in Sub Saharan cities appears to be on the rise with respect to many key pollutants. In some cities where monitoring has been performed levels of air pollution exceed World Health Organization recommended guidelines (WHO, 2006). The main cause of urban air pollution is the use of fossil fuels in transport, power generation, industry and domestic sectors. In addition, the burning of firewood, agricultural and animal waste also contributes to pollution levels. Pollutant emissions have direct and indirect effects (e.g. acidification, eutrophication, ground-level ozone, stratospheric ozone depletion) with a wide range of impacts on human health, ecosystems, agriculture and materials.

There is a growing need to determine the state of urban AQ and the challenges posed to solve it and identify the most effective measures to protect human health and the environment. Learning from experience and successes in urban AQ management (AQM) from other countries can assists in the formulation and implementation of strategies to achieve better AQ in Sub Saharan Africa.

The Clean Air Initiative in Sub-Saharan African Cities (CAI-SSA), the United Nations Environment Programme (UNEP) and the Air Pollution Information Network Africa (APINA) collected AQ information from the Ministries of Environment of countries participating in the *Better Air Quality in Sub-Saharan Africa 2006 (BAQ-SSA)* conference, organised by a partnership of CAI-SSA. World Bank, UNEP, APINA, SEI and US EPA and held at UNEP HQ, Nairobi, July 25-28, 2006. For each country, the AQ information collected was gathered along the following themes:

- Status of urban air pollution in the country.
- Eventual projects concerning the management of urban AQ – either recently achieved, or in progress, or planned – which could likely serve as model for other cities of Sub-Saharan Africa, or which the country would like to be replicated in the country if funds were available.
- Existing official standards regarding the regulation and control of AQ as well as official guidelines for motorized vehicle emission.
- Existing official fuel quality specifications for unleaded gasoline.
- Existing official fuel quality specifications for diesel.
- Existing National Action Plans and priorities concerning the improving of urban AQ.

A total of 25 countries replied, providing country reports upon the above-mentioned topical themes. These countries are Benin, Botswana, Burkina Faso, Burundi, Cameroon, Republic of the Congo (Congo-Brazzaville), Democratic Republic of the Congo (Congo-Kinshasa), Ethiopia, Gabon, Ghana, Guinea, Kenya, Liberia, Madagascar, Mali, Mauritius, Mozambique, Nigeria, Rwanda, Senegal, Swaziland, Tanzania, Togo, Uganda, and Zimbabwe. The reports provided range from a one page email to extensive compilations of existing information on more than 20 pages with an attached study report or project proposal. As a result, the information is available in an unsystematic form and at different degrees of quality, depth and completeness. In order to compile it in a consistent structure and to supplement it where necessary and as far as time constraints allowed, additional material was collected from published papers and the internet.

This report compiles the information provided by the 25countries in a harmonised way and gives an in-depth review of AQ in SSA with AQ profile of each country, presenting the country's main current urban AQ issues, emissions standards, ongoing projects, lessons learned from good/bad practices. It was attempted to compile this information also for additional SSA countries from available publications and internet sources. Candidate countries for this effort are Malawi, South Africa, Sudan, and Zambia for which either fact sheets exist within the APINA network or a country report was available at the BAQ 2004 workshop (APINA 2003; BAQ 2004). For time constraints it was only possible to update the APINA fact sheet for Malawi and Zambia and include this country in section 3.

This status report is intended by CAI SSA to be disseminated to the Region to have an updated overview of urban AQ in SSA and foster exchange of good practices among countries which have been requesting assistance in AQ issues.

The material was collated according to the Driving forces – Pressures – State – Impacts – Responses (DPSIR) framework developed by the European Environmental Agency (Figure 1.1).

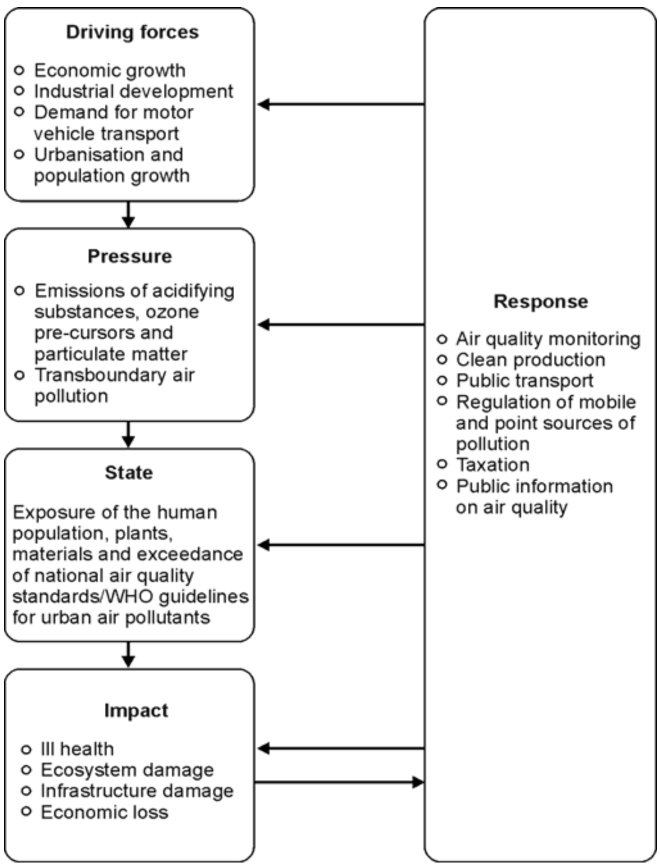

Figure 1.1: The Driving Force-Pressure-State-Impact Response (DPSIR) Framework
Source: Schwela et al., (2006)

Driving forces in Sub Saharan African countries were identified as rapid growth of the population, urbanization, migration, motorization, striving for economic growth. These Driving Forces lead to **Pressures** such as rapidly growing vehicle fleets, which are major energy consumers and a major source of air pollution in urban areas. The growth of two-wheelers (motor bikes and mopeds) is uncontrolled and dramatic. When estimated, average trip lengths are low leading to a non-efficient engine use. Daily emissions of carbon monoxide, nitrogen oxides and hydrocarbons from the transport sector are high. Vehicles in cities of Sub Saharan Africa are badly maintained and of an elevated age, the mean age in many cities being around 14 years. Insufficient infrastructure contributes to the problem of re-suspended dust emissions. Petroleum products in certain markets are of doubtful quality and adulteration is frequent.

Industries and households also play an important role in energy consumption and outdoor air pollution. Industrial plants are mostly old using obsolete technologies and without control measures. In some countries such as Congo Brazzaville additional sources of air pollution were identified including forest fires of natural origin and windblown dust. In most SSA countries open burning of solid waste and agricultural burning add to these pressures.

The **State** is characterised as follows. Emissions inventories for air pollutants are lacking in all countries; some initial estimation exists for greenhouse gases which were developed in fulfilment of the obligations of countries that have signed the Convention on Climate Change and relate to the year 1994. AQ monitoring in urban areas is often not performed or if monitoring networks are installed hampered by breakdown of monitoring devices. Only seven countries (Botswana, Ethiopia, Ghana, Guinea, Tanzania, Zambia and Zimbabwe) reported that they are monitoring routinely or have ad hoc monitoring campaigns. Key pollutants include particulate matter, nitrogen dioxide, sulphur dioxide, carbon monoxide, volatile organic compounds and hydrocarbons.

The **Impacts** of air pollutants on human health and the environment are rarely assessed in Sub Saharan African countries. Nigeria reports that a human health impact survey was performed and other studies addressed acid precipitation, pollutant levels in biological species, and urban climate.

National responses to air pollution in Sub Saharan African countries should be based on an Environmental Act that has been promulgated in almost all countries. All further legislation builds upon the Environment Act and addresses fuel specifications, emission standards, and air quality standards (AQS). Specific legislation on AQM, however, does not appear to exist in all countries except South Africa. An integral approach would include emission inventories, inventories of air pollutant levels, estimates of health and environmental impacts, control measures and cost-benefit estimations.

1.2 Countries summary

The situation in the 27 countries with respect to AQM is summarised as follows.

1.2.1 Policies

All countries are parties to the Convention on Climate Change and the Montreal Protocol on Substances depleting the Ozone Layer. Most countries have also signed the Kyoto Protocol. Legislation on environmental protection has been developed in the majority of countries. Only Congo-Kinshasa, Guinea, Liberia, Malawi and Rwanda seem to not have promulgated Environmental Protection Acts.

The Environment Act covers air pollution. Comprehensive legislation specific for air pollution sometimes exists, e.g. in the Atmospheric Pollution Prevention Act of Botswana. The Environment Act is complemented by regulations and rules which specify fuel parameters, emission standards and AQS. While 16 countries have set fuel specifications for gasoline and 14 for diesel, only 5 countries have promulgated emission standards for vehicles and 8 have set AQS.

Most countries address AQM in an ad hoc fashion, only Madagascar appears to develop a full-fledged AQM system addressing revision of legislation, emissions, dispersion, air pollutant concentrations, control measures, impacts and cost-benefit analysis, and Ghana and Tanzania are on the way to develop an AQM system. Benin's legislation refers only to mobile sources which are apparently considered the most significant source. Thus, industrial sources, uncontrolled fires, waste deposits and transboundary air pollution are disregarded. Botswana's air pollution legislation is very old and covers only industrial sources. Updating this legislation would make the AQM approach more realistic.

In the Republic of the Congo (Congo Brazzaville), the legislation relating to air pollution is diluted in many partly overlapping texts among the different sectors of the environment, energy and transport. This makes an integrated approach to AQM difficult. Guinea, Liberia, the Democratic Republic of the Congo (Congo-Kinshasa), Rwanda and Uganda have no official legislation for regulating and managing air pollution. Regulations on fuel parameters for petrol and diesel do not exist. In view of the substantial PM concentrations and their potential health impacts the promulgation of legislation regulating AQM is very urgent. Kenya is in a similar situation since a comprehensive urban AQM programme is lacking.

In Nigeria, little activities in relation to AQM have taken place and ad hoc measures are adopted. This procedure bears the risk of making wrong decisions. Togo's two policies on energy development and transport and the strategy to combat air pollution have the character of ad hoc measures rather than being integrated policies. This makes them not very suited towards rational AQM. In addition, the implementation of these strategies has not yet started due to lack of funding and logistics.

Zambia's legislation has the goal to control pollution but does not legally bind for maintenance, monitoring and sustenance of AQ. In consequence, monitoring is not performed by the government but rather delegated to industry with respect to their sources. This, in turn implies that exposures related to vehicular emissions are only controlled via fuel specifications and emission standards if promulgated.

1.2.2 Governance

Challenges in almost all 27 African countries include the lack of monitoring equipment; prevalence of ad hoc awareness raising; and poor participation of stakeholders including the public and the media. Further challenges are the high costs of awareness raising programmes; the design and implementation of AQM strategies, which are often based on poor knowledge and inadequate regulatory, institutional, planning, technical, social, and financial capacities for AQM. E.g. in all African countries industrial facilities are obsolete and poorly maintained. Growing vehicle fleets are mostly consisting of aged cars, trucks and buses. Institutional set-up is often characterised by responsibilities shared by several ministries without a lead agency for the implementation of environmental goals, policies and strategies. Roles and responsibilities are often not well defined, documented, communicated and enforced. Human resources and specialized skills are lacking in many countries as are technological and financial resources.

A revision of the institutional set-up in countries and introducing transparency in institutional mechanisms will enhance the capability to implement AQM policies, enforce laws and regulations and review their effectiveness. Establishing a lead agency for the implementation of environmental goals, policies and strategies can assist in consolidating responsibilities, ensure integrated approaches, and can avoid duplication of work. The implementation of AQM needs the provision of human resources, specialized skills, technology and financial resources.

Awareness of the impacts of air pollution on human health and the environment, risk perception and risk communication are poorly developed in most African countries. This is particular true for the health impacts of indoor air pollution. Awareness raising is essential in order to strengthen the participation of all stakeholders such as the public, academia, industry, NGOs in AQM and particularly in projects on health impacts due to air pollution. As the need for training in African counties is noted for almost all countries under consideration specialized programmes and training modules are necessary to enhance capacity in AQM. In the design and implementation of these tasks all stakeholders should be involved. The capacity for regular public information on the importance of AQ and AQM necessity should be enhanced as well. All stakeholders should have a well-defined role in AQM and receive relevant information regularly.

1.2.3 Emissions

Five countries have set or proposed emission standards for mobile sources, either petrol- or diesel-driven or both: Botswana, Burkina Faso, Kenya, Madagascar, and Uganda. These standards relate to emissions of CO, CO_2, NO_x, HCs and VOCs. Emission standards for stationary source exist or are being set in four countries: Botswana, Burkina Faso, Kenya and Mauritius. Mauritius has developed a most comprehensive set of emission standards for several source types and a number of pollutants, as is shown in Annex Mauritius_2 (Section 6).

Source apportionment has been performed in Ethiopia for PM_{10} and is reported for GHGs by only two countries: Congo Brazzaville and Togo. Emission inventories do not exist in any of the 26 countries. This lack of emissions inventories mean that quality assured emission data are not available and dispersion modelling cannot be applied. A good starting point for all countries, therefore, would be to compile rapid inventories of all sources using well-known procedures such as that developed by the World Health Organization (WHO, 1993) and the Air Pollution Information Network Africa (APINA 2006). These rapid assessment systems start from emissions factors for key compounds and allow estimate the emissions of stationary and mobile sources in a cost-effective manner. An emissions inventory also allows the verification of source apportionment estimates.

1.2.4 Air Quality Monitoring

Out of 27 countries only seven have operational routine monitoring systems: Botswana, Ethiopia, Ghana, Madagascar, Tanzania, Zambia, and Zimbabwe. Ethiopia perform occasionally monitoring campaigns; Senegal is initialising a monitoring network in Dakar. In Zambia, monitoring is performed by industrial companies; in the other countries the Environmental Protection Agency or the ministry of Environment is responsible for monitoring. All other countries either do not have installed any monitoring system or a monitoring station which was initially operational broke down and could not be revamped. Out of the 19 countries without monitoring at present, only Nigeria appears to have experience from previous monitoring campaigns. A challenge in all these African countries is that there is only limited or no spatial coverage of cities by outdoor AQ monitoring. Therefore baseline data do not exist in most countries, and they are of limited spatial representativity in the seven countries which perform monitoring. As far as standard operating procedures are applied and monitoring follows a quality assurance/quality control plan the quality of data is known. The case of Nigeria shows deficiencies in the maintenance of monitoring systems and in procuring spare parts. None of the countries which perform some monitoring assesses transboundary air pollution. Monitoring is not very systematic with respect to the pollutants chosen and the coverage of urban and peri-urban areas.

Air pollutant concentration monitoring is used to test compliance with AQS. AQS have been set or proposed in nine of the 27 countries – i.e. Botswana, Burkina Faso, Ghana, Kenya, Mauritius, Nigeria, Tanzania, Uganda, and Zambia. In Kenya enforcement is weak and in Nigeria AQS cannot be enforced for lack of monitoring results. Countries which are monitoring but do not have promulgated AQS use US EPA standards or WHO guideline values for the compliance test. For the countries which do already monitor it is recommended to improve the quality of their data by strictly following standard operating procedures and assure the quality of data at each step of the monitoring procedure – sampling, weighing, analysing, evaluating. Quality assurance and quality control (QA/QC) are the backbone of any AQ monitoring programme.

Countries which do not yet monitor should perform pilot projects to start monitoring campaigns with a combination of simple monitoring devices such as diffusive monitors and simple devices for particulate matter monitoring (such as minivols and dustTraks). A combination of a few automatic samplers and a multitude of diffusive samplers which are sited to monitor air pollution in a spatially and time representative way are the most cost-effective monitoring methods. Sites for monitoring lie usually in residential areas. It may be useful to monitor in commercial and industrial areas including hotspots in order to assess exposure at highly polluted locations in close proximity to sources. Kerbside monitoring may also be needed to especially assess exposure to pollutants emitted by vehicles.

1.2.5 Modelling

AQ modelling is hardly applied in the 27 countries. This is due to the lack of quality assured emission data and source apportionment experience. Dispersion models are useful in determining the spatial and time distribution of pollutants from different sources in an urban area. Dispersion models allow estimate concentrations from existing and planned sources and the contribution from transboundary air pollution in a particular country. Dispersion modelling also helps determine the most appropriate sites for monitoring.

1.2.6 Impacts

Information on the impacts of air pollution on human health and the environment is rare in the 26 countries. Three countries – Benin, Botswana and Ghana – dispose of a few studies each on health impacts. Zimbabwe has compiled some anecdotal evidence on health effects. In Burkina Faso and Senegal estimates on the costs of air pollution in terms of percent reduction of the gross domestic product have been performed. Guinea, Mali, Uganda and Zambia suggest on the basis of qualitative and anecdotal observations that respiratory symptoms and other public health impacts may be due to air pollution. Mali, in addition, reports an increase of accidents due to reduced visibility caused in part by particulate matter pollution. Some studies have been performed in Benin, Botswana, Ghana, and Nigeria. The most comprehensive ones are studies of blood lead levels in Ghana before and after the phase-out of lead, a study on the linkage of air pollution and health impacts. In Nigeria, studies are being planned on acidification, urban temperature, solar irradiance, greenhouse gas effects and human health in Nigeria. In Botswana small scale studies performed in the city of Selebi Phikwe investigated impacts of SO_2 on the population and the environment. The POLAIR project of Gabon plans to estimate human health impacts caused by air pollution through epidemiological studies. In view of this situation, there is a lack of short- and long-term studies of health, environmental and economic impacts due to air pollution in practically all 27 African countries. This shortcoming is also reflected by the absence of AQ monitoring capability in at 19 SSA countries. Insufficient institutional capability and the lack of national health surveillance systems may also be causes of the scarcity of health and environmental studies. Without a health surveillance system, it is impossible to assess the contribution of air pollution to morbidity and mortality. The system can be expanded to report morbidity and mortality cases associated with air pollution on a regular basis. The use of rapid assessment techniques for epidemiological studies and evaluation of the data of the surveillance system is a starting point for estimates on the impacts of air pollution on human health and their social costs. Social costs of air pollution can be used in cost-benefit analysis comparing costs of control and costs of avoided health and environmental impacts.

1.2.7 Finances

In view of the necessity of financial sustainability of AQM, challenges in African countries include a low priority for AQM funding, under-funding of AQM and lack of transparency on the use of resources. There is also a lack of sufficient funding for capacity building and awareness raising; poor knowledge of existing market mechanisms; and a lack of adherence to the 'polluter pays' principle. As health and a sound environment are basic human rights often laid down in the Constitutions of African countries governments have the responsibility to reduce emissions of air pollutants and improve AQ. This includes the awareness among decision makers on the need to financing AQM to improve the health of their populations and the environment. In this respect it would be helpful if governments would share information on AQM with the private sector and give incentives to all stakeholders to find ways for fund-raising. The support of international development agencies is crucial to enhance the capacity of countries in reducing air pollution and to provide incentives for sound AQM.

1.4 Some Best Practices in the SSA Region

1.4.1 Fuel specifications

In 15 of the SSA countries considered in this report, fuel specifications have been formulated for fuels to be imported, produced, stored and distributed. Leaded gasoline has been phased out in SSA since January 2006 but countries have not yet set or updated specifications for the content of fuels for sulphur, aromatics and olefins. Refineries in SSA are confronted with the challenge of reducing sulphur contents in diesel and gasoline. The World Bank will initiate a study with the objective to facilitate setting up regional harmonised specifications. This study will also consider the costs of required fuel upgrades in comparison to other alternatives such as vehicle maintenance or measures to improve traffic flow.

Table 1.1 shows the reporting of countries with respect to fuel specifications, emission standards and AQS. According to this table 16 and 14 countries have reported on fuel specifications for petrol and diesel, respectively. Fuel specifications for stationary source were reported by none of the countries.

1.4.2 Emission standards

Four countries – Burkina Faso, Kenya, Madagascar and Uganda – have reported emission standards for petrol- and diesel-driven vehicles. Burkina Faso has set emission standards for emissions of CO, NOx, HCs and VOCs for petrol-driven vehicles. Five countries – Botswana, Burkina Faso, Kenya, Mauritius and Nigeria – dispose of emission standards for stationary sources. E.g. Burkina Faso has promulgated emission standards for power plants, industrial plants, cement factories and brick kilns.

In Mauritius emission standards are set for stationary sources of all industries, power plants and industrial boilers. They are based on the best available technology locally available. Emission standards are set for

- PM_{10} emitted from all industries and power plants,
- SO_2 emitted from thermal power stations (new and existing) and industrial boilers,
- NOx applicable to all industries and power plants
- CO emitted from all types of plants
- VOCs emitted from all types of plants.

These emission standards follow essentially World Bank recommendations.

Mauritius has also regulated stack design and operation of boilers with respect to efficient combustion and compliance with emission standards. Mauritius' legislation also deals with cleaner production and efficient use of energy.

The countries which reported emission standards are shown in Table 1.1

Table 1.1: Country reporting of fuel specifications, emission standards, and air quality standards

Country	Fuel specification petrol	Fuel specification diesel	Fuel specification stationary	Emission standards petrol-driven vehicles	Emission standards diesel-driven vehicles	Emission standards stationary	Air quality standards
Benin	X						
Botswana				X	X	X	X
Burkina Faso	X	X		X		X	X
Burundi							
Cameroon	X						
Congo Brazzaville	X	X					
Congo-Kinshasa							
Ethiopia							
Gabon	X**	X					
Ghana	X	X					X
Guinea							
Kenya	X	X		X	X	X	X
Liberia							
Madagascar	X	X		X	X		
Malawi							
Mali	X						
Mauritius	X	X				X	X**
Mozambique	X	X					
Nigeria	X	X				X	X
Rwanda							
Senegal	X	X					
Swaziland		X					
Tanzania	X	X					X
Togo	X	X					
Uganda				X	X		X
Zambia	X	X					X
Zimbabwe							

** Proposed

1.4.3 Air quality standards

According to the reports provided, AQS have been promulgated or are being considered in Botswana, Burkina Faso (Table Burkina_Faso_5, Section 6), Ghana, Kenya, Mauritius (see Table Mauritius_1, Section 6), Nigeria, Tanzania, Uganda and Zambia, see Table 1.1. The most comprehensive set of proposed AQS appears to exist in Mauritius. AQS should be promulgated in all SSA countries and subsequently enforced, eventually in a stepwise process.

WHO air quality guidelines AQG can assist AQS setting, WHO AQG are recommended values for limiting air pollutant concentrations at levels at which the risk for health effects is low. AQG base on purely epidemiological and toxicological evidence and do not take into account issues such as background concentrations, technological and financial feasibility, and cultural and traditional issues all of which have to be considered when setting AQS.

The current WHO AQG are compiled in Table 1.2 (WHO 2006; 2000).

1.4.4 Action plan

The Air Quality Monitoring Capacity Building Project (AQMCBP) that was launched in Tanzania in August 2005 in three municipalities of Dar es Salaam city is an approach to AQM that could be applied in other countries.

AQMCBP is a multi-stakeholder project that aims at enhancing capacity of participating institutions for monitoring of specific air quality parameters. AQMCBP aims at contributing significantly into development of AQS in a country/region. The project focuses on surveys related to air pollution and its links to adverse health effects. The project also aims at increasing levels of awareness among policy makers, authoritative organizations, stakeholders and the general public. The monitoring results will form basis for the development of long term monitoring programme and formation of database to be utilized by different stakeholders. The objective of AQMCBP is to build capacity on management of air quality and establish baseline data and information on levels of selected air impurities. The expected outputs of the project include a comprehensive and consistent database on the quality of air in urban centres. The project is also expected to provide information that would assist in the process of standards setting.

Table 1.2 WHO air quality guidelines for a number of compounds.

Compound	Averaging time	Guideline value [μg/m^3]	Reference
PM_{10}	1 year	20	WHO (2006)
	24 hours	50	
$PM_{2.5}$	1 year	10	
	24 hours	25	
SO_2	24 hours	20	WHO (2006)
	15 min	500	WHO (2000)
NO_2	1 year	40	WHO (2000)
	24 hours	200	
O_3	8 hours	100	WHO (2006)
CO	8 hours	10,000	WHO (2000)
	1 hour	30,000	
	30 min	60,000	
	15 min	100,000	
Pb	1 year	0.5	WHO (2000)
Mn	1 year	0.15	
Cd	1 year	0.05	
Hg	1 year	1	
Volatile Organic Compounds			
Formaldehyde	30 min	100	WHO (2000)
Ethyl benzene	1 year	22,000	
Styrene	1 week	260	
	30 min	70	
Toluene	1 week	260	
	30 min	1,000	
Xylenes	1 year	870	
	24 hours	4,800	
Diesel exhaust	1 year	5.6	
Carcinogenic compounds		**Unit risk**	
Benzene	Lifetime	(4.4-7.5) x 10^{-6}	WHO (2000)
Benzo[a]pyrene		8.7 x 10^{-2}	
Diesel exhaust		(1.6-7.1) x 10^{-5}	

The main components of AQMCBP include capacity building; with sub-activities including; training of the teams involved in routine monitoring activities, establishing and upkeep of sampling sites (need to conform to international sampling protocols), and conducting air monitoring and sampling activities. Laboratory work also forms a significant part of the projects' activities as sampling equipment and filters requires conditioning before and after each round of sampling activity.

Although the project suffers from some inherent shortcomings, the ansatz to address AQM is sound and well transferable to other countries, which all encounter similar challenges. An extensive description of the AQMCBP can be found in the Annex Tanzania (Section 8).

1.4.5 Monitoring network

The USAID, US EPA, and UNEP in July 2004 selected the city of Accra, Ghana as one of two cities in Africa to benefit from an air quality monitoring capacity building project. The project seeks to accurately characterise the severity and nature of air pollution problems in Accra and to make recommendations for the development of a broad base AQM strategy for Ghana. The main objectives of the project are to:

- Build and establish local capacity in air quality monitoring;
- Collect and analyse ambient air quality data on key pollutants;
- Provide policy makers with a 'snapshot' of the air quality situation in Accra and provide a basis to further develop an AQM strategy; and
- Provide recommendations on next steps in developing a broad base AQM strategy for Ghana.

To achieve the above objectives, the following tasks were set out and implemented:

- An inception meeting with relevant stakeholders was convened with responsibility for decision-making on all aspects of the project.
- A Quality Assurance Project Plan (QAPP) for the implementation of the project was drafted.
- Air quality sampling sites in accordance with the air quality-monitoring plan were established
- A workshop to disseminate the outcomes of the air quality-monitoring programme was organised.

As part of the project implementation plan, a number of monitoring sites have so far been established in representative residential, commercial, industrial and roadside sites

Key pollutants such as particulate matter (PM_{10}), SO_2, NO_2, CO, O_3, Pb and Mn in particulate matter are being monitored at these sites.

Sampling is conducted in accordance with a 6- day routine schedule. Data collection is performed in accordance with the standard operating procedures (SOPs).
Results of the air quality monitoring show that vehicular exhaust emissions, open burning of waste and other materials, road dust, emissions from industrial sources, residential

cooking, commercial activities and wind-blown dust are all major contributors to the air quality measured at the permanent and roadside sites. The results also revealed that roadside locations and commercial areas have high particulate concentration, which is likely to affect the health of the populace.

Other countries should consider start similar projects.

1.4.6 Follow up to the leaded gasoline phase-out. Monitoring blood lead levels in high risk groups

As a party to the World Bank Clean Air Initiative in Sub-Saharan African Cities (CAI-SSA), Ghana successfully phased-out leaded gasoline in December 2003. As part of the phase-out programme, the EPA carried out sampling and analysis of lead levels in soil, air and blood of high-risk groups during one year. The Agency and the Ghana Health Service are currently conducting a follow-up study to monitor trends in blood lead levels of high-risk groups after the phase-out of leaded gasoline. The results of this study can be compared to the results of the previous one. The comparison will probably show a significant decrease in average blood lead levels if no other lead sources such as tap water and leaded paints have contributed to blood lead levels of high risk groups.

1.5 Conclusion

Despite some progress being made to address air pollution in Sub Saharan African countries, air pollution continues to pose a threat to human health, environment and quality of life in cities. The concoction of increasing migration, motorization and uncontrolled urban growth has all contributed to the intensification of air pollution, which currently poses a significant challenge to all Sub Saharan African cities.

This report assesses the current status and challenges in urban air pollution in 27 African countries, based on country reports collected by the World Bank, UNEP and the APINA network. The results of this assessment are compiled in Table 1.3. As a result, AQM can be considered comprehensive only in South Africa and advanced in Ghana; the AQM capability of Botswana, Madagascar, Zambia and Zimbabwe can be judged as being at an intermediate stage of AQM. Seven countries are at an early stage of AQM: Benin, Burkina Faso, Ethiopia, Mozambique, Nigeria, Swaziland and Tanzania. In eight countries – Cameroon, Congo-Kinshasa, Kenya, Mali, Mauritius, Senegal, Togo and Uganda – AQM is at an initial (very early) stage. AQM is practically absent in seven countries – Burundi, Congo-Brazzaville, Gabon, Guinea, Liberia, Malawi and Rwanda.The results show that AQM is in its early stages in many SSA countries and many ingredients of AQM are not yet in place. Air quality monitoring is patchy in most Sub Saharan cities and monitoring networks if they existed in the past often showed breakdowns after a short time of running. Emissions inventories of key pollutants are lacking as are studies on the adverse impacts of air pollution on human health. However, a highlight and basis for hope for future AQM is the successful phasing-out of lead in gasoline in all SSA countries which was completed by January 2006, see Figure 1.2.

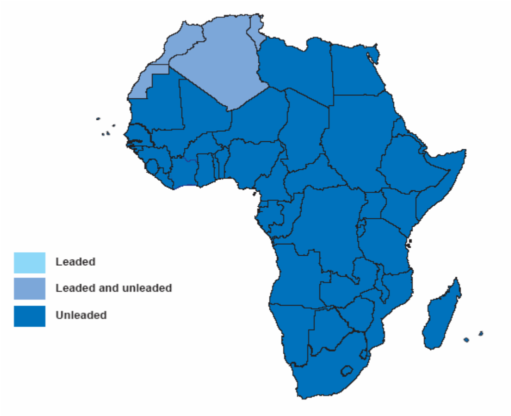

Figure 1.2: Status of leaded gasoline phase-out in SSA (June 2006)
Source: PCFV (2007)

Some countries have developed examples of best practices in specifying fuel standards and developing emission and AQS. A few action plans have the potential of providing guidance for action plans to a larger number of countries outside the country for which they were developed. Most countries have promulgated Environmental Acts and all are concerned about the potential threats of air pollution to their populations.

Much has, however to be done to strengthen and enforce existing legislation, making monitoring networks operational to deliver data of known quality and developing initial emission inventories which permit to implement control measures in Sub Saharan African cities.

With the phase-out of lead in gasoline in all SSA countries and the promulgation of fuel specifications for unleaded petrol in the majority of SSA countries a major step forward to towards quality management has been performed. Further cost-effective steps would be to set fuel specifications for diesel and reduce sulphur in diesel, a major source of fine particles (sulphates), to lower values than the present range of 1,300 -10,000 ppm.

Some countries such as Benin, Burkina Faso, Burundi, Cameroon, Congo Brazzaville, Congo Kinshasa, Gabon, Guinea, Kenya, Liberia, Mali, Mauritius, Rwanda, Swaziland, Togo and Uganda are in an early stage of AQM. Practically, the phase-out of lead was completed and some of these countries have set fuel specifications. An Environment Act exists but public awareness and media and other stakeholder involvement is limited. First steps towards rational AQM would be to strengthen the political will of governments to address air pollution, to raise public awareness about adverse impacts of air pollution on human health and the environment. A cost-effective measure to reduce air pollution would be the reduction of sulphur in diesel. Another action would be to develop and implement initial monitoring stations using cost-efficient sampling methods. By installing a small monitoring network, the contribution of industrial sources, power plants, area sources and that of transboundary dispersion of air pollutants could be assessed. In order to be able to interpret monitoring data in terms of their potential impact on human health

Table 1.3: Synopsis of country AQM capability

Country	Key pollutants	Sulphur content of diesel [ppm]†	Inspection & maintenance for mobile sources	Emissions inventory	Routine monitoring	Health impact assessment	Projects or plans with AQ benefit ongoing	Estimated stage of air quality management
Benin	SO_2, NO_x, NO_2, O_3, CO, HCs, PM.	5,000	No	No	No	Two studies	Yes	Early*
Botswana	SO_2,NOx, NO_2, O_3, CO, HCs	500	No	Yes, but incomplete	Yes	Few qualitative studies	No	Intermediate**
Burkina Faso	PM, SO_2, HCs, NOx, SO_2	5,000	No	Yes, but elementary	No	No	Yes	Early*
Burundi	Pesticides, Persistent Organic Pollutants, Pb	5,000	No	No	No	No	No	Absent[#]
Cameroon	PM, CO, HCs, NOx, SO_2.	5,000	Yes	No	No	No	No	Initial[†]
Congo-Brazzaville	PM, CO, HCs, NO_x	10,000	No	No	No	No	No	Absent[#]
Congo-Kinshasa	PM, SO_2, NO_2, CO, HCs	3,500	No	No	No	No	Yes	Initial[†]
Ethiopia	PM_{10}, CO, SO_2, O_3	10,000	No	No, but source apportionment for PM_{10}	No, only campaign	No	No	Early*
Gabon	PM, CO, HCs, NOx, SO_2	8,000	No	No	No	No	No	Absent[#]
Ghana	SO_2, NO_2, O_3, CO, PM_{10}, manganese	5,000	In progress	No	Yes	Three studies	Yes	Advanced[+]
Guinea	PM_{10}, $PM_{2.5}$, NO_2, SO_2, formaldehyde, benzene	5,000	No	No	No	No	No	Absent[#]
Kenya	PM, CO, HCs, NOx, SO_2	10,000	No	No	No	No	Yes	Initial[†]
Liberia	PM, CO, NOx, SO_2.	5,000	No	No	No	No	No	Absent[#]
Madagascar	PM, CO, HCs, NOx, SO_2	5,000	Yes, mobile sources	No	Yes	No	Yes	Intermediate**
Malawi	PM, SO_2, CO, NOx, HCs	5,000	No	No	No	No	No	Absent[#]
Mali	PM, NOx, CO, HC, VOC, SO_2, Pb	5,000	No	Yes, for transport	No	No	No	Initial[†]
Mauritius	PM, NOx, CO, SO_2	2,500	No	No	No	No	Yes	Initial[†]

Table 1.3 continued: Synopsis of country AQM capability

Country	Key pollutants	Sulphur content of diesel [ppm]	Inspection & maintenance for mobile sources	Emissions inventory	Routine monitoring	Health impact assessment	Projects or plans with AQ benefit ongoing	Estimated stage of air quality management
Mozambique	PM_{10}, $PM_{2.5}$, Black Carbon, SO_2, NOx, CO_2, O_3.	5,500	No	Being developed	No	No	Yes	Early*
Nigeria	CO_2, CO, NO_X, O_3, SO_2, TSP, PM_{10}	5,000	No	Yes, of 1990	No, one non operational station	No	Yes	Early*
Rwanda	Not identified	5,000	No	No	No	No	No	Absent#
Senegal	PM_{10}, $PM_{2.5}$, CO	5,000	No	No	Being initialised	No	Yes	Initial†
South Africa	PM_{10}, $PM_{2.5}$, NOx, SO_2, O_3, CO,Pb	500	Yes	Yes	Yes	Yes	Yes	Comprehensive++
Swaziland	Not identified	500	No	Qualitative	No	No	Yes	Early*
Tanzania	PM, CO, NO_2, SO_2, O_3, Pb	5,000	No	No	Yes	No	Yes	Early*
Togo	Not identified	5,000	No	Yes, initial	No	No	No	Initial†
Uganda	PM, CH_4, H_2S, NH_3, dioxins and furans, HCs, NO_x, SO_x, re-suspended dust	5,000	No	No	No	No	Yes	Initial†
Zambia	SO_2, NO_2, PM, black smoke, dust, CO, CO_2 and odours	7,500	No	Yes, initial, in copper belt	Yes	No	Yes	Intermediate**
Zimbabwe	SO_2, NO_2, PM, CO, VOCs	5,000	Yes, for stationary sources	No	Yes	Anecdotal evidence	No	Intermediate**

† Source: PCFV (2007); # Absent = None of the topics addressed; † Initial Any one topic addressed; * Early = Any two topics addressed; ** Intermediate = Any three topics addressed; + Advanced = Any four topics addressed; ++ Comprehensive = All topics addressed.

and the environment, AQS should be promulgated, which are reasonably enforceable. WHO air quality guidelines may be used in setting standards and averaging times since the criteria for the derivation of air quality guidelines set by WHO are also valid for setting standards. Experience from developed countries may be used to collect information on the number of standards-exceeding values not leading to adverse health or environmental effects. A participatory approach in setting standards which involves stakeholders (e.g. industry, local authorities, non-governmental organizations, media and the general public) assures –as far as possible – social equity or fairness to the parties involved. The provision of sufficient information and transparency in standard setting procedures ensures that stakeholders understand the environmental, health and socio-economic impacts of such standards.

Other SSA countries with more developed AQM capability such as Ghana, Madagascar, Mozambique, Nigeria, Tanzania and Zimbabwe should enhance their ability by extending and/or revamping their monitoring facilities, develop initial emissions inventories using rapid assessment methods and start the use of dispersion modelling. The knowledge of the contribution from different sources will help to set priorities in AQM and permit to decide which sources should be first addressed. Dispersion modelling could be used to estimate pollutant concentrations and by comparison with actual measurement test the validity of the emission estimates.

If not already promulgated, emission and air quality standards should be set. Regulations on emission standards for mobile and stationary sources, AQS, viable dispersion models and reliable monitoring procedures will ensure rational and sound AQM. This includes, where appropriate, the adoption of emission standards based on developed countries' experiences. Best available control technology avoids the problem of inequities among countries and prevents 'social dumping'.

Countries with even more experience – Botswana, Ethiopia, Ghana, Madagascar and Zambia - should stride towards the adoption of Clean Air Implementation Plans (CAIPs) in their cities, tailored for developing countries, as an instrument in achieving policy goals in a structured and transparent manner.

For all SSA countries training in all aspects of AQM is absolutely necessary in order to achieve the goal of cleaner air.

AQM is based on the precautionary, polluters pay and prevention principles. It searches to protect human health and the environment and ensures a cost-effective approach using best available control technologies. A framework for AQM is depicted in Figure 1.3.

Rational AQM includes several approaches: Command and control, application of economic instruments, co-regulation and stakeholder voluntary initiatives, and self regulation. Education and information of the population is also an integral part of AQM.

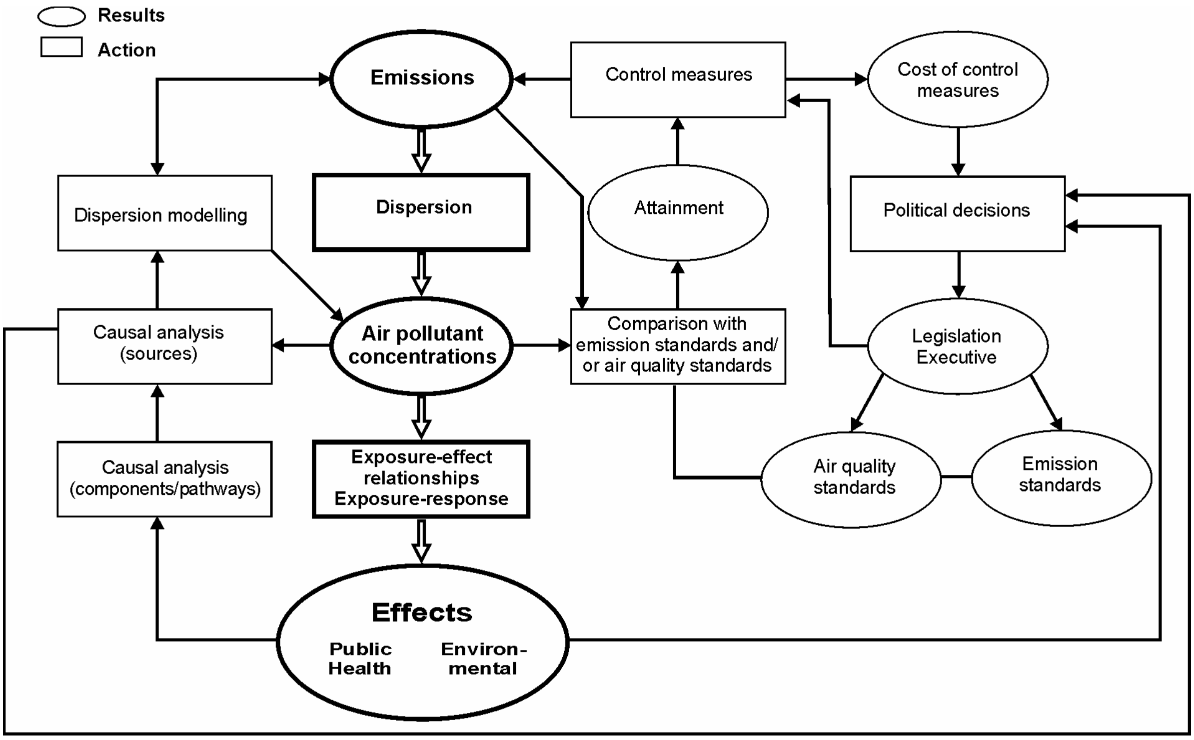

Figure 1.3: A framework for air quality management
Source: Schwela et al. (2006)

Tools for rational and systematic AQM include emission inventories, dispersion models, monitoring networks, epidemiological study approaches, and environmental study approaches. For staring AQM action plans rapid assessment methods are most suitable. Rapid inventory assessment methods allow develop initial emission inventories (WHO, 1993; APINA, 2006). A number of easy-to-handle dispersion models are available on the internet at the US EPA website. Hybrid monitoring networks are minimal sets of monitors with one or few automatic analyzers and a larger number of diffusive tubes for gaseous compounds. For particulate matter simple and easy-to-manage devices are available such as dustTraks and minivols. Rapid epidemiological assessment methods help estimate health effects due to exposure to air pollution by using known exposure-response relationships. A simple tool incorporating emissions, estimated concentrations, estimated health impacts and control actions is e.g. the World Bank SIM/Air programme which allows optimize the costs of health impacts due to air pollution with the costs of source controls.

Table 1.4 summarises the tools that can be useful for various SSA countries to enhance their AQM capability.

Table 1.4: Tools that can be applied in SSA countries to enhance AQM capability

<table>
<tr><th>Country</th><th>Air quality standard setting</th><th>Initial Emissions inventory*</th><th>Routine monitoring**</th><th>Health impact assessment†</th></tr>
<tr><td>Benin</td><td>WHO guidelines</td><td>Rapid inventory assessment (RIA)</td><td>Hybrid network</td><td>More studies needed using REA</td></tr>
<tr><td>Botswana</td><td rowspan="2">National standards exist</td><td>Completion and update by RIA</td><td>Is being performed</td><td rowspan="8">Rapid epidemiological assessment (REA)</td></tr>
<tr><td>Burkina Faso</td><td>Completion and update by RIA</td><td rowspan="7">Hybrid network</td></tr>
<tr><td>Burundi</td><td rowspan="6">WHO guidelines</td><td rowspan="12">Rapid inventory assessment</td></tr>
<tr><td>Cameroon</td></tr>
<tr><td>Congo-Brazzaville</td></tr>
<tr><td>Congo-Kinshasa</td></tr>
<tr><td>Ethiopia</td></tr>
<tr><td>Gabon</td></tr>
<tr><td>Ghana</td><td>National standards exist</td><td>Is being performed</td><td>More studies needed</td></tr>
<tr><td>Guinea</td><td>WHO guidelines</td><td rowspan="3">Hybrid network</td><td rowspan="8">Rapid epidemiological assessment</td></tr>
<tr><td>Kenya</td><td>Exist</td></tr>
<tr><td>Liberia</td><td rowspan="4">WHO guidelines</td></tr>
<tr><td>Madagascar</td><td>Is being performed</td></tr>
<tr><td>Malawi</td><td rowspan="4">Hybrid network</td></tr>
<tr><td>Mali</td><td>Completion and update by RIA</td></tr>
<tr><td>Mauritius</td><td>National standards proposed</td><td>Rapid inventory assessment</td></tr>
<tr><td>Mozambique</td><td>WHO guidelines</td><td>Completion and update by RIA</td></tr>
</table>

* RIA = Rapid Inventory Assessment; ** HN = Hybrid Network; † REA = Rapid Epidemiological Assessment

Table 1.4 (continued): Recommendation to enhance AQM capability

<table>
<tr><th>Country</th><th>Air quality standard setting</th><th>Initial Emissions inventory*</th><th>Routine monitoring**</th><th>Health impact assessment[†]</th></tr>
<tr><td>Nigeria</td><td rowspan="9">WHO guidelines</td><td>To be updated and amended by RIA</td><td rowspan="2">Hybrid network</td><td rowspan="4">Rapid epidemiological assessment</td></tr>
<tr><td>Rwanda</td><td rowspan="4">Rapid inventory assessment</td></tr>
<tr><td>Senegal</td><td>Is being initialised</td></tr>
<tr><td>Swaziland</td><td>Hybrid network</td></tr>
<tr><td>Tanzania</td><td>Is being performed</td><td>More studies needed</td></tr>
<tr><td>Togo</td><td>To be enhanced by RIA</td><td rowspan="2">Hybrid network</td><td rowspan="4">Rapid epidemiological assessment</td></tr>
<tr><td>Uganda</td><td>Rapid inventory assessment</td></tr>
<tr><td>Zambia</td><td>To be amended for vehicles</td><td>Revamping or hybrid network</td></tr>
<tr><td>Zimbabwe</td><td>Rapid inventory assessment</td><td>Is being performed</td></tr>
</table>

* RIA = Rapid Inventory Assessment; ** HN = Hybrid Network; [†] REA = Rapid Epidemiological Assessment

Section 2. Background

In Africa, urban outdoor air pollution is responsible for an estimated 49,000 premature deaths annually with indoor use of solid fuels being responsible for eight times this value, the main burden being borne by Sub Saharan African countries (WHO, 2002). Air pollution, outdoor and indoor, affects the health and life chances of millions of people in Sub Saharan Africa every day. There is a link between air pollution and poverty since poor people are exposed to higher concentrations of air pollutants and tend to suffer disproportionately from the effects of deteriorating air quality. Children in cities exposed to high concentrations of air pollutants will more often develop respiratory ailments which prevent them from learning and developing well. As a consequence they will suffer in adult life from low levels of qualifications and skills. The implication of poorly educated children is not only a reduction of quality of their lives but also an obstacle for the economic development of a country as a whole.

With 3.3 to 3.7 percent annually, African urban population growth rates have been and will continue to be the highest in the world. As indicated in Figure 1.1 African city-based population percentages (normalised to that of the year 2000) are growing faster than their counterparts in all other regions of the world and are estimated to continue to do so in the next two decades and very likely beyond.

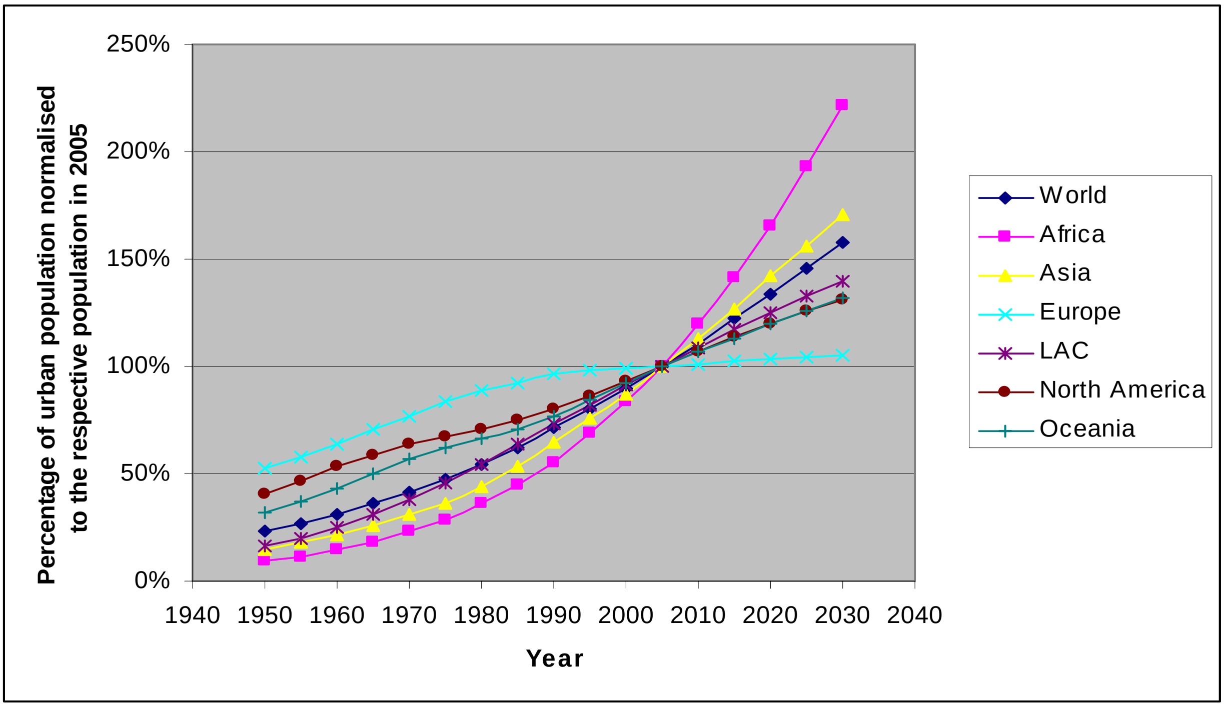

Figure 1.1: Urban population growth rates for the World, Africa, Asia, Latin America and the Caribbean (LAC), Oceania, Europe, and North America

Source: UN (2007)

Rapid urbanisation means increase in motorisation and economic activity which in turn leads to increased air pollution if countermeasures are not taken. In view these linkages addressing urban air quality in SSA is particularly important.

In addition to water and solid waste problems, SSA is facing substantial challenges in terms of urban air quality. Some of the challenges are: old vehicles without emissions control, increased vehicle fleets, poor or absence of proper vehicle maintenance, lack of cleaner fuels, absence of or poor regulatory framework specific to vehicle emissions, and poor enforcement of laws and regulations when they exist.

Air pollution in Sub Saharan cities appears to be on the rise with respect to many key pollutants. In some cities where monitoring has been performed levels of air pollution exceed World Health Organization recommended guidelines (WHO, 2005). The main cause of urban air pollution is the use of fossil fuels in transport, power generation, industry and domestic sectors. In addition, the burning of firewood, agricultural and animal waste also contributes to pollution levels. Pollutant emissions have direct and indirect effects (e.g. acidification, eutrophication, ground-level ozone, stratospheric ozone depletion) with a wide range of impacts on human health, ecosystems, agriculture and materials.

There is a growing need to determine the state of urban air quality and the challenges posed to solve it and identify the most effective measures to protect human health and the environment. Learning from experience and successes in urban air quality management (AQM) from other countries can assists in the formulation and implementation of strategies to achieve better air quality in Sub Saharan Africa.

The Clean Air Initiative in Sub-Saharan African Cities (CAI-SSA), the United Nations Environment Programme (UNEP) and the Air Pollution Information Network Africa (APINA) collected Air Quality information from the Ministries of Environment of countries participating in the *Better Air Quality in Sub-Saharan Africa 2006 (BAQ-SSA)* conference, organised by a partnership of CAI-SSA. World Bank, UNEP, APINA, SEI and US EPA and held at UNEP HQ, Nairobi, July 25-28, 2006. For each country, the Air Quality information collected was gathered along the following themes:

- Status of urban air pollution in the country.
- Eventual projects concerning the management of urban air quality – either recently achieved, or in progress, or planned – which could likely serve as model for other cities of Sub-Saharan Africa, or which the country would like to be replicated in the country if funds were available.
- Existing official standards regarding the regulation and control of air quality as well as official guidelines for motorized vehicle emission.
- Existing official fuel quality specifications for unleaded gasoline.
- Existing official fuel quality specifications for diesel.
- Existing National Action Plans and priorities concerning the improving of urban air quality.

A total of 25 countries replied, providing country reports upon the above-mentioned topical themes. These countries are Benin, Botswana, Burkina Faso, Burundi, Cameroon, Republic of the Congo (Congo-Brazzaville), Democratic Republic of the Congo (Congo-Kinshasa), Ethiopia, Gabon, Ghana, Guinea, Kenya, Liberia, Madagascar, Mali, Mauritius, Mozambique, Nigeria, Rwanda, Senegal, Swaziland, Tanzania, Togo, Uganda, and Zimbabwe. The reports provided range from a one page email to extensive compilations of existing information on more than 20 pages with an attached study report or project proposal. As a result, the information is available in an unsystematic form and at different degrees of quality, depth and completeness. In order to compile it in a consistent structure and to supplement it where necessary and as far as time constraints allowed, additional material was collected from published papers and the internet.

This report compiles the information provided by the 25countries in a harmonised way and gives an in-depth review of Air Quality in SSA with AQ profile of each country, presenting the country's main current urban air quality issues, emissions standards, ongoing projects, lessons learned from good/bad practices. It was attempted to compile this information also for additional SSA countries from available publications and internet sources. Candidate countries for this effort are Malawi, South Africa, Sudan, and Zambia for which either fact sheets exist within the APINA network or a country report was available at the BAQ 2004 workshop (APINA 2003; BAQ 2004). For time constraints it was only possible to update the APINA fact sheet for Zambia and include this country in section 3.

This status report is intended by CAI SSA to be disseminated to the Region to have an updated overview of urban air quality in SSA and ensure exchange of good practices among countries which have been requesting assistance in air quality issues.

Section 3. Urban Air Quality in-depth review in SSA.

This section presents, for each SSA country where information has been collected and is available, the following information:

- Driving forces, pressures and state of air quality
- Summary of air pollution
- Impacts of air pollution
- National response to air pollution
- Emissions of air pollutants
- Reported challenges to AQM
- Summary and analysis of information

The information provided by countries is organised following the DPSIR framework (EEA, 2003) and the requirements as formulated in the TOR. The DPSIR framework can be used to understand urban air pollution in Africa (see Figure 3.1).

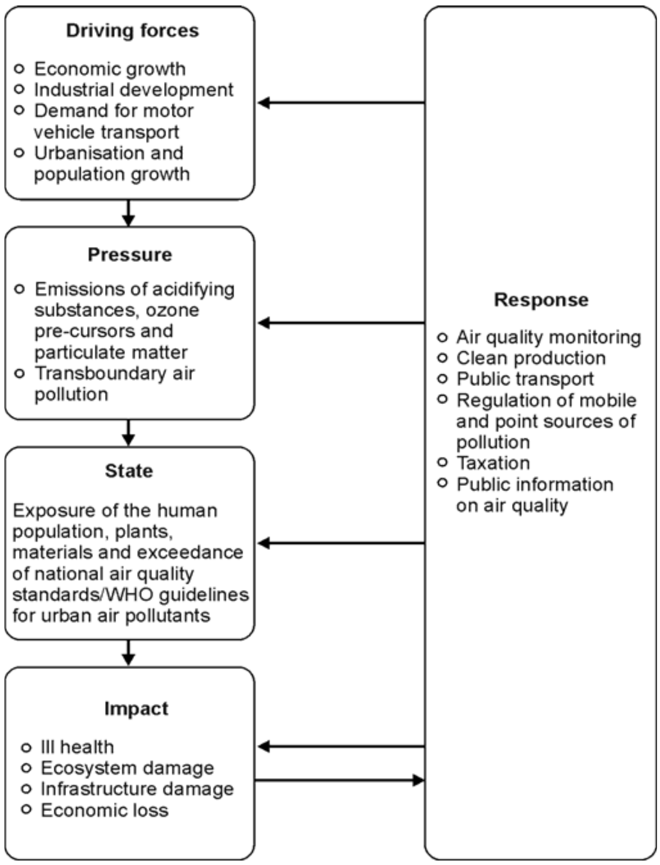

Figure 3.1: The Driving Force-Pressure-State-Impact Response (DPSIR) Framework
Source: Schwela et al.,(2006)

The following country profiles provide a description of the state of air pollution in the various countries and their efforts to reduce the air pollutant concentrations and consequent impacts on human health and the environment. The legislation, action plans, and projects are reviewed and suggestions for the way forward in combating air pollution are intended to help develop a rational framework for air quality management (AQM) in Sub Saharan African cities. AQM is based on the precautionary, polluters pay and prevention principles. It searches to protect human health and the environment and ensures a cost-effective approach using best available control technologies. A framework for AQM is depicted in Figure 3.2.

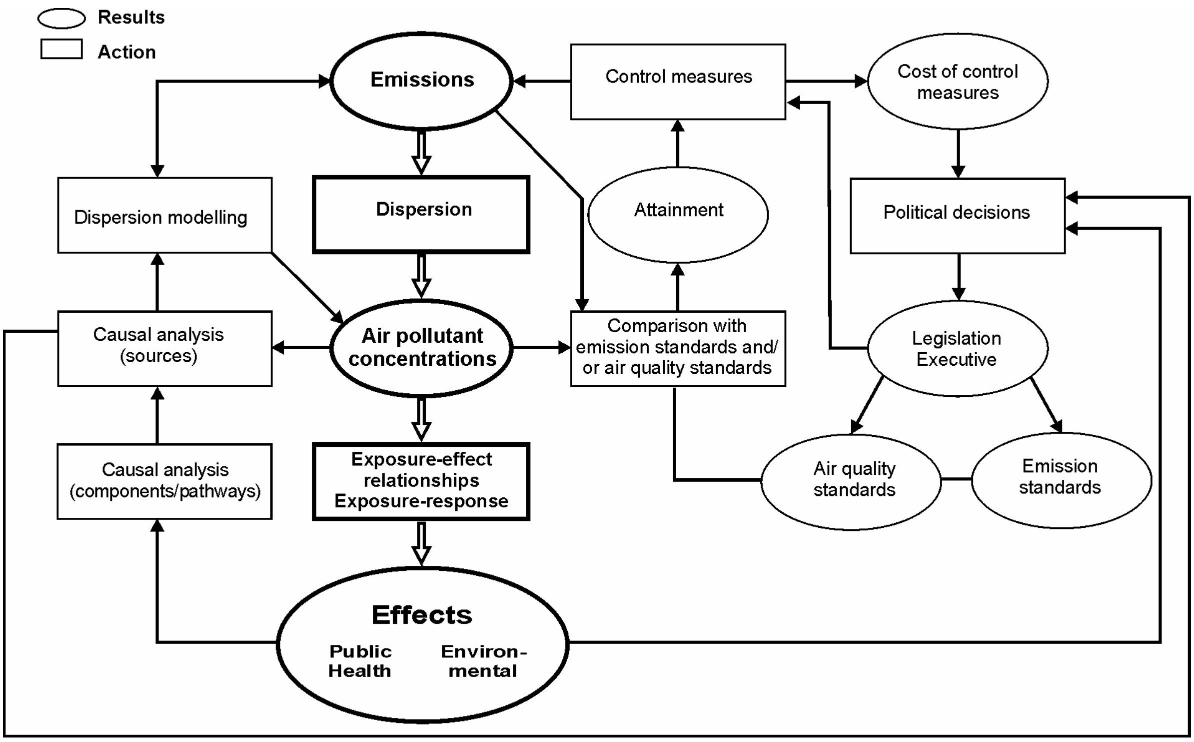

Figure 3.2: A framework for air quality management
Source: Schwela et al. (2006)

Rational AQM includes several approaches: Command and control, application of economic instruments, co-regulation and stakeholder voluntary initiatives, and self regulation. Education and information of the population is also an integral part of AQM. Table 3.1 gives a description of these approaches and some examples.

Table 3.1 Types of environmental regulation (after WHO, 2000a; Schwela et al., 2006)

Type	Description	Example
Command and control	Issue of licences, setting of standards, checking for compliance with standards, sanctions for non-compliance	Air pollution control regulations Government monitoring Emission standards Enforcement policies
Economic instruments	Use of pricing, subsidies, taxes, and charges to production and consumption patterns	Load-based emission charges Tradeable emission permits Differential taxes True cost pricing of resources
Co-regulation and voluntary initiatives	Adoption of rules, regulations and guidelines, negotiated within prescribed boundaries Voluntary adoption of environmental management measures	National registers of pollution emission inventories Environmental management systems
Self-regulation	Self-imposition of rules and guidelines and environmental audits by industry groups	Industry codes of practice Self-audit within industry groups Emission reduction targets
Education and information	Education and training Community right-to-know Corporate reporting programmes	Education, training and information programmes Pollution inventories Corporate sustainability reports

The earlier cities recognize during their development that air pollution is a major environmental problem the earlier they can introduce emission control measures to avoid extremely high air pollutant concentrations. This is illustrated in Figure 3.3 which shows five stages of development and the impact of early and late initiation of emission controls.

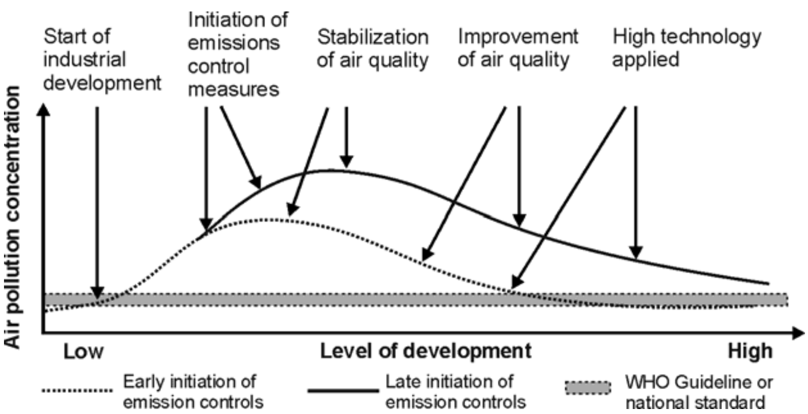

Figure 3.3: Development of air pollution problems in cities
Source: Schwela et al. (2006)

This general model can be used to AQM capacity, economic and air quality development as is shown in Table 3.2 (Schwela et al., 2006).

Table 3.2: AQM capacity, economic and air quality development

Stage	AQM capacity	Level of economic development	Air quality development
I	Minimal	Increased urbanization, industrialization and motorisation. Ad hoc AQM action applied	Deterioration of air quality through rising levels of air pollution
II	Limited	Urbanization, industrialization and motorization continues. Initial systematic AQM procedures applied	High but stabilising levels of air pollution. Serious health and environmental impacts
III	Moderate	Cleaner processes developed. Systematic AQM procedures developed	Air pollution decreasing from high levels
IV	Good	Maturing of cleaner processes and use of cleaner fuels. Mature emission controls.	Further improvement of air pollution
V	Excellent	High technology applied	Low air pollution

Source: Schwela et al. (2006)

The model shown in Figure 3.3 is not necessarily true for all air pollutants. For Asian cities, Schwela et al. (2006) have founds that it may be true for compounds such as SO_2 and CO but not for PM_{10} and NO_2. Reasons for this observation included gaps in implementation and enforcement of existing legislation; annual AQS for PM being less stringent than WHO guideline values; emission standards for mobile sources being too lenient; incomplete or unreliable emissions inventories; and transboundary and hemispheric air pollution. Nevertheless the model is a valuable approach for a better understanding of air pollution and its management.

In detail, the information for each country is arranged in boxes with short hand headings. The box **"Driving forces, pressures and state of air quality"** include the growth of the population, urbanization, migration, motorization, energy use, economic growth. These Driving Forces lead to pressures such as rapidly growing vehicle fleets, which are major energy consumers and a significant source of air pollution in urban areas. The state of air quality describes monitoring capabilities and results from routine monitoring and short-term monitoring campaigns.

The box **Summary of air pollution** provides information on the nature of problem, status of monitoring, monitored or key pollutants, number of monitoring stations, capacity to assess air pollution and existence of AQS in a concise way.

The box **Impacts** of air pollutants include estimates of effects on human health and the environment and effects on the economy. Only those human health and environmental effects are included which are reported as being caused by air pollution.

The box **National responses to air pollution** include the description of legislation, laws and regulations as well as fuel specifications, emission standards, AQS and programmes/projects.

The box **Emissions** of air pollutants describe the information available from simple emission estimates, source apportionment or emission inventories.

The box **Reported challenges** to AQM (AQM) display the challenges as identified in the country report.

The box **Summary and analysis** briefly summarizes the reported information and gives an analysis of its content together with suggestions for the way forward.

References are quoted in a last box.

3.1 Benin [1]

Driving forces, pressures and state of air pollution

Due to rapid growth of the population of 2.7 per cent (CIA, 2007) and economic growth the following pressures are reported to exist in Benin:

- Rapidly growing vehicle fleet
- Uncontrolled growth of urban transport by two-wheelers
- Bad state of the vehicle fleet of an elevated age
- Insufficient infrastructure
- Doubtful quality of used petroleum products
- Industrial emissions

Benin's industry centres on construction material, chemical production, textiles, and the processing of agricultural goods. The industrial sector accounted for 14% of GDP in 2001 (EN, 2006). The vehicle fleet constitutes the main source of air pollution. The transport sector in Benin consumes 62 per cent of oil while the industrial sector consumes around 16 per cent only.

In 2000, a study (World Bank, 2002) on air quality in Cotonou has been performed. The results indicated high concentrations for CO (up to 18,000 $\mu g/m^3$) and HCs (estimated to be up to 2,000 $\mu g/m^3$) at certain traffic intersections. Three different scenarios regarding urban mobility were evaluated and compared to the no-change scenario – optimization of transport, establishment of a public transport system, and improvement of fuels and vehicles.

Routine air pollution monitoring is not yet being performed in Benin. A recent short-term study showed a high gradient in ultrafine particle (UFP) number concentrations between Cotonou urban, suburban and rural areas (Avogbe, 2004), see Figure Benin_1.

Summary of air pollution information

Nature of problem	Energy Production. Vehicles.
Status of monitoring	A surveillance system has to be implemented
Key pollutants	CO, HCs, SO_2, NO_2, O_3
Number of monitoring stations	0
Capacity to assess air pollution	Capacity is absent
Air quality standards	Standards have to be promulgated

Reported challenges

1. Implementation of the National Strategy for Combating Air pollution and enforcement
2. Obligatory control of exhaust gases of vehicles
3. Incentives for use of public transport
4. Implementation of a surveillance system on air quality in the principal cities
5. Education of automobile and motorcycle mechanics
6. Information and awareness campaigns
7. Air quality monitoring
8. Assessment of impacts

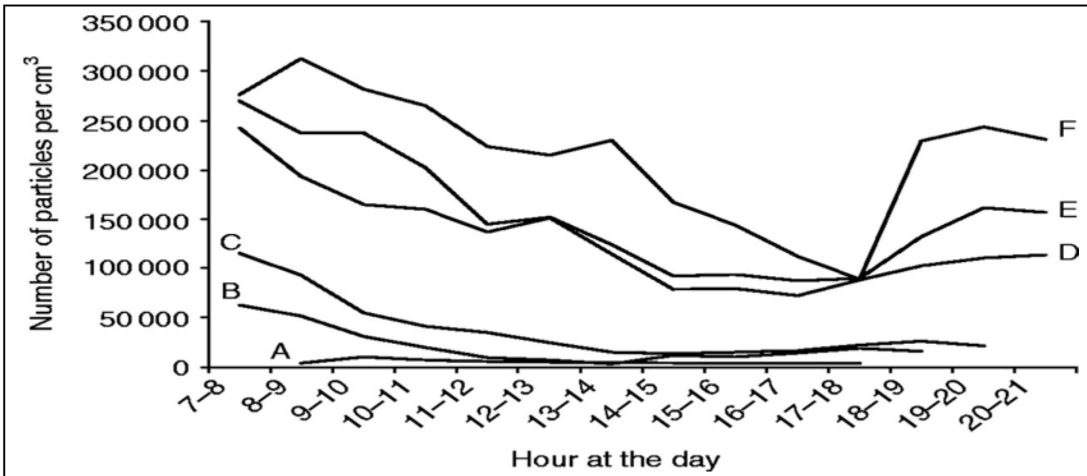

Figure Benin_1. Concentration of UFP at different locations (as numbers/cm^3). Lines are rural (**A**), suburban (**B**), city background (**C**), intersection on balcony (**D**), traffic circle (**E**) and intersection in the street (**F**)

[1] Based on Worou (2006)

Emissions

In the World Bank study emissions from traffic for CO and HCs have been estimated to amount to 292,000 and 127,750 metric tons per year, respectively. If no measures are taken to improve fuels and vehicles, emissions are expected to double by 2010 (World Bank, 2002).

Impacts

Potential risks of air pollution mentioned in the country report in Benin include diverse effects on health such as respiratory ailments, eye and mucous membrane irritation and an enhanced risk of attracting cancers. A study of hospital data shows that air pollution in Cotonou is responsible for an enhanced frequency of respiratory infections. According to the World Bank (2002) study the costs of air pollution in Cotonou amount to 1.2 per cent of the country's gross domestic product (GDP).

A recent epidemiological study in Cotounou urban, suburban and rural areas showed that subjects living in an urban areas heavily polluted by traffic emissions had high levels of oxidative DNA damage in mononuclear blood cells. The level of oxidative DNA damage correlated with the benzene exposure gradient. The level of ambient ultrafine particles (UFP) also showed an exposure gradient similar to that of benzene exposure (Avogbe et al., 2004).

National response to air pollution

Benin considers the right to a sound environment as a human right which is supported by its constitution and stated in the law on the environment. The government of Benin is committed to reduce air pollution in the long term, in agreement with the objectives of the National Agenda 21. Benin is party to the Climate Change Convention, Kyoto Protocol, Ozone Layer Protection, Ship Pollution, Desertification (CIA, 2006)

Benin developed as policies and strategies

- The "National Strategy of Combating Pollution in the Benin Republic"
- The "Declaration on the Policy on Urban Mobility"

An Action Plan for the Implementation of the Policy on Urban Mobility has been formulated

Legislation. Table Benin_1 quotes the major laws and regulations

The responsible agency for AQM is the Ministry of Environment, in collaboration with other partners. Its mandate includes the identification of mechanical workshops for automobiles and motorcycles as privileged actors based on local expertise, the establishment of an agreement and/or convention process between the mechanical workshops and the vehicle concessionaries in order to incite vehicle drivers to voluntary inspection and maintenance, and the organisation of obligatory controls, , especially in Cotonou since November 2001. As of July 2006, 292 mechanics have been educated and support the Ministry of Environment in the implementation of the strategy of combating air pollution.

Fuel standards.
Benin has developed fuel standards for mobile sources. These are compiled in Table Benin_2 (Section 6).

National response to air pollution (continued)

Projects/Programmes
Ongoing programmes include

- Public awareness raising through a sustainable campaign (public announcements and posters, television and radio debates, newspaper reporting, and publications
- Initialisation of the use of lead-free gasoline and recommendation and regulation of the use of catalytic converters and gasoline specifications as fixed in the Ministerial Decree N° 11/MMEH/DC/SGM/CTRNE/CTJ/DGE/SA
- Labelling of lead-free gasoline at the service stations of Benin
- Control of vehicles to be imported with respect to the Ministerial Decree

Projects having an AQ benefit include

- Rigorous implementation of the National Strategy for Combating Air Pollution
- Obligatory controls of exhaust gases
- Pursuit of obligatory control of exhaust gases of vehicles
- Decreasing the age of the automobile fleet
- Promotion of four-stroke motor cycles
- Development of public transport through busses
- Use of good-quality fuels
- Implementation of a surveillance system on air quality in the principal cities
- Pursuance of the education of automobile and motorcycle mechanics and of the agreement and convention process
- Pursuance of information and awareness campaigns
- Pursuit of the promotion of green spaces
- Implementation of the national action plan for the socio-professional reorganisation and re-insertion or re-conversion of taxi drivers

Table Benin_1: Key laws and regulations

Legis-lation	N°	Content (Date of promulgation)
Act	98-030	Environmental law (12.02.1999)
Decree	2001-096	Creation, competence, organisation, and function of the environmental police (20.02.2001)
Decree	2000-671	Import, commerce, and distribution of equipment (29.12.2000)
Decree	2000-110	Air quality standards (04.04.2001)
Decree	2004-710	Import of vehicles with catalytic converter (30.12.2004)
Rule	0041/MEHU/MCAT/MMEH/DC/SG/DE/ SEL/SA	Standards for oil percentage in gas oil in two-wheelers (13.09.2000)
Rule	23/MMEH/DC/SG/CTRNE/CTJ/DGE/SA	Standards for petroleum quality (07.05.2004)
Rule	11/MMEH/DC/SGM/CTRNE/CTJ/DGE/SA	Standards for the quality of lead-free gasoline (24.02.2006)
Rule	0045/MEHU/DC/SG/DE/DPE/SA	Conditions and modalities for staff of environmental police (23.10.2002)

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Summary and Analysis

Benin has promulgated a ground laying framework of laws and regulations to combat air pollution. It has agreed to fulfil the obligations from several international conventions and protocols including the Convention on Climate Change and the Montreal Protocol on the Depletion of the Ozone Layer. When implementing the obligations following from its own legislation and internationally, and enforcing fuel standards a significant step is made to reduce air pollution. There are lacking, however, several elements necessary for a rational AQM.

First of all, it is assumed that vehicles are practically the only source and other sources do not contribute significantly. This may not be the case due to transboundary contributions from its neighbour countries and to sources such as uncontrolled open fires, waste deposits, industry and commerce, unpaved roads etc. Therefore, it would be necessary to identify other potential sources and estimate their contributions in an initial emissions inventory using rapid assessment methods.

Second, Benin does not dispose of a routine monitoring network. Thus, the efficiency of the action taken to reduce emissions from mobile sources cannot be verified. Without routine monitoring it cannot be ensured that the action taken leads to a substantial reduction of air pollutant concentrations in the cities of Benin.

Third, a striking point is that the report does not mention particulate matter as a key pollutant. The age of the vehicle fleet and the uncontrolled growth of two-wheel vehicles suggest that fine PM should also be considered as a key pollutant.

Fourth, impact studies are rare in Benin. The study mentioned in the report does not elucidate how the causal association between the enhanced frequency of respiratory infections and urban air pollution was assessed and which pollutants were responsible.

Fifth, no mention is made of dispersion modelling as a potential tool for estimating concentrations for existing or planned sources or helping to provide information on source apportionment.

The consideration of these elements of AQM could help to successfully combat air pollution in Benin.

3.2 Botswana[2]

Driving forces, pressures and state of air pollution

The population growth in Botswana is -0.04 per cent (CIA, 2007) and therefore not a drving force for urbanisation. However, agriculture, industrialization in the copper-nickel mining area, and indoor wood burning for cooking are driving forces which lead to the following pressures in Botswana:

- Emission from a strongly growing vehicle fleet
- Emissions from indiscriminate waste burning at landfills and within households
- PM Emission from Veld fires and windstorms (UNDP, 2005)
- Smoke from wood-burning cooking fires (UNDP, 2005)
- Emissions from smelters in Selebi-Phikwe, power plants and industries in few other places

The vehicle fleet constitutes the main source of air pollution in cities other than Selebi-Phikwe.

There are twenty one air pollution monitoring stations in Botswana operating under the Department of Waste Management and Pollution Control (DWMPC). Eleven (11) of these are operating in two cities and two towns the rest is distributed among ten major villages. Parameters being monitored at these monitoring stations include SO_2, NO_x, O_3, CO, methane (CH_4), PM and hydrocarbons (HCs). since 1996. In Selebi Phikwe SO_2 hourly concentrations above 1000 μg/m^3 have been recorded several times (Mmolawa, 2004). However, monthly averages comply with the standard of 160 μg/m^3. Monthly NO_2 levels in Francistown and Lobatse comply with the monthly standard. In Gaborone the monthly objective was exceeded for PM_{10} for nine months in 2002. Monthly concentrations for PM_{10} are shown in Figure Botswana_1. Measurements of O_3 have indicated high levels in Maun, a village/town in the Northern part of the country.

Summary of air pollution information

Nature of problem	Vehicles Mining Mineral Processing. Energy Production. Waste deposits Solid fuel use
Status of monitoring	Monitoring exists.
Pollutants monitored	SO_2,NOx, NO_2, O_3, CO, HCs.
Number of monitoring stations	21
Capacity to assess air pollution	Exists and mainly by the Department of Mines.
Air quality standards	The emission and air quality standards setting is stipulated in the Atmospheric Pollution Prevention Act (APPA).

Impacts

Small scale studies on quantification of human exposure to certain air pollutants such as lead (particulate), respirable dust (PM_{10} and $PM_{2.5}$) have been carried out. Measured concentrations of the pollutant gases SO_2, NO_2 and O_3 indicate potential impacts of air pollution on vegetation and human health. Botswana air quality guidelines for SO_2, NO_2 and O_3 are exceeded. The SO_2 guideline is especially exceeded in Selebi Phikwe downwind of the smelter.

Recent studies undertaken on the impacts of smelter emissions show that there are serious impacts both on vegetation and on the population living in Selebi Phikwe and the surrounding villages. The studies have not however quantified the extent of the impacts.

Air pollution problems can be seen especially in winter. Little attention is being paid to areas with high concentrations of pollutants because of lack of information.

Emissions

In the copper-nickel mining town of Selebi-Phikwe, air pollution is caused by SO_2 emissions from the smelter chimneys and the evaporation of waste liquids from the mine dump. The coal-fed power plant at Moripule and the tanneries at Pilane have also been identified as causes of air pollution (UNDP, 2005). In 1991/92 it was estimated that over 90% of the sulphur emission for Botswana originated from the copper/nickel smelter at Selebi Phikwe. NO_x emissions are mostly from combustion of fossil fuels (e.g. coal, diesel, fuel oil) and biomass, but only an incomprehensive emissions inventory has been produced focusing on urban areas. However, NOx and volatile organic carbons (VOCs) emissions due to petroleum consumption, calculated by the Department of Mines in 2000 using the Intergovernmental Panel on Climate Change (IPCC) Method, estimated NO_x at 7,000 tonnes and VOCs at 9,000 tonnes. (APINA, 2003)

[2] Based on Mmolawa (2006)

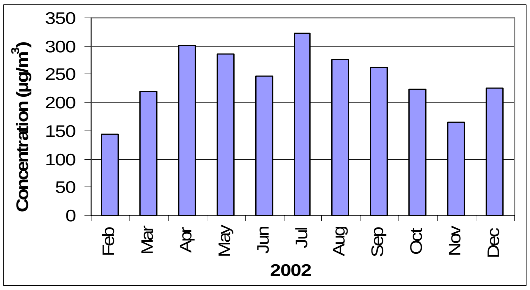

Figure Botswana_1: Monthly concentrations for PM_{10} in 2002 in Gaborone

Reported challenges:

1. Update of the Atmospheric Pollution Prevention Act
2. Development of an action plan for improving air quality
3. Development of fuel specification, emission and air quality standards
4. Quantification of the extent of the impacts of air pollution emitted from the smelters in Selebi Phikwe.
5. Implementation of control measures in the smelters of Selebi Phikwe.

National response to air pollution

The *Atmospheric Pollution Prevention Act* (APPA) was promulgated in 1971. The APPA provides for the prevention of the pollution of the atmosphere from industrial processes. It is administered by the Air Pollution Control Division of the Department of Mines. The Act specifies fines that may be imposed on anyone convicted under the Act.

The setting of emission and air quality standards is stipulated in the APPA. Air quality objectives were published by the Department of Mines in its annual report for 2000 (CSO, 2002) and reported by Mmolawa (2004) during the BAQ 2004 Workshop. They are compiled in Table Botswana_1 (Section 6).

The *Environmental Impact Assessment Act No. 6 of 2005* provides for the Environmental Impact Assessments to be used to assess the potential effects of planned developmental activities; to determine and to provide mitigation measures for effects of such activities as may have a significant adverse impact on the environment; to put in place a monitoring process and evaluation of the environmental impacts of implemented activities (DEA, 2006).

The Law on Mines and Mineral of 1977 prohibits wasteful mining and processing.

Botswana has acceded to the Vienna Convention for the Protection of the Ozone Layer, the Montreal Protocol on substances that deplete the Ozone Layer and its London and Copenhagen Amendments, the United Nations Framework Convention on Climate Change, Agenda 21, and the Stockholm Convention on Persistent Organic Pollutants (CIA, 2006)

References:

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WHO 1993 Assessment of sources, of air, water, and land pollution. A Guide to rapid source inventory techniques and their use in formulating environmental control strategies. Part One. Rapid inventory techniques in environmental pollution. By A. P. Economopoulos. World Health Organization, Geneva.

Summary and analysis:

The government of Botswana is committed to conserve the environment. This is evidenced by its accession to international conventions and protocols, the National Conservation Strategy, which promotes environmental conservation and sustainable development in the country, and the Act on Environmental Impact Assessment. The National Conservation Strategy does not yet cover explicitly the conservation of clean air. Challenges in Botswana include emissions from vehicles, indiscriminate waste burning at landfills and within households, emissions from the industrial complexes in Selebi Phikwe.

Botswana's legislation specific to air pollution is very old and only covers industrial sources. An update of the legislation would be useful and should include control measures for vehicular sources, prohibition of uncontrolled waste burning, control of agricultural fires, address the issue of transboundary air pollution, control of other contributing sources, and specify fuel and emission standards. Botswana has already got a network of air pollutant monitoring stations, which monitors key air pollutants. At present only PM_{10} and SO_2 are pollutants which do not always comply with monthly standards. In relation to 24 hour WHO guidelines of 50 μg/m^3 for PM_{10} and 20 μg/m^3 for SO_2, the respective Botswana standards are relatively high. Botswana's other air quality objectives are comparable to those of the WHO and the US EPA developed to protect human health.

For the city of Selebi Phikwe it appears necessary to develop an emissions inventory by applying rapid assessment methods such as the APINA procedure (APINA, 2006) or the rapid assessment system of the WHO (WHO, 1993). The expansion of World Banks' SIM-AIR model to include control measures for the industrial processes used in the copper belt could also be beneficial. Botswana could also benefit from the development of an action plan for improving air quality, a quantification of the impacts of air pollution due to and implementation of control measures in the smelters of Selebi Phikwe.

3.3 Burkina Faso[3]

Driving forces, pressures and state of air pollution

Rapid population growth of 3 per cent (CIA, 2007), migration of the rural population to urban areas, and the striving for economic growth resulted in the following pressures in Burkina Faso:

- Urbanisation rate of 4.8 per cent per year in Ouagadougou
- Emissions from a rapidly growing vehicle fleet
- Uncontrolled and dramatic growth of urban transport by two-wheelers
- Poor state of the vehicle fleet of an elevated age
- Insufficient infrastructure
- Doubtful quality of used petroleum products
- Emissions from households

In 1996 Ouagadougou had a population of 700,000 inhabitants. By 2010 the population is expected to increase to 1.7 million assuming a mean growth rate of 6.5 per cent per year. By 2010 the population of Bobo-Dioulasso is expected to reach 1 million (Diallo, 2002). Both cities are the administrative, political and economical centres of the country. The vehicle fleet constitutes the second main source of air pollution after the households. The transport sector in Burkina Faso consumes 56 per cent of oil and is the largest consumer of energy. Therefore, transport is a major air pollution source in Burkina Faso, especially in Ouagadougou.

The average age of registered vehicles in the capital is 14 years and the youngest vehicles are 10 years old. The number of motorcycles is difficult to estimate because most of them are not registered. A study of the modal split in daily trips shows that two-wheelers are dominant with 39 per cent, in comparison with 6 per cent for private cars and 3 per cent for public transportation (Diallo, 2002). Between 1991 and 2000 more than 400,000 two-stroke mopeds were sold in Burkina Faso. The total number of mopeds increased each year by 25,000. In 1993 the mobility was estimated to amount to almost four trips per day; 50 per cent of trips were undertaken using motor vehicles. Of these motorized trips 80 per cent were undertaken using motorcycles. In 1999 the daily lengths of congestion .was estimated to be 5 km. Assuming a BAU scenario by 2010 it is expected to be approximately 45 km in Ouagadougou.

In certain areas of Ouagadougou, the concentrations of HC are above 7 mg/m^3. The short-term NO_2 guideline value of the WHO is exceeded on kerbside locations of the principal streets during rush hours

Summary of air pollution information

Nature of problem	Vehicle emissions. Household emissions Energy Production.
Status of monitoring	Monitoring has to be set up.
Key pollutants	PM, SO_2, HCs, NOx, and SO_2 in the city of Ouagadougou
Number of monitoring stations	0
Capacity to assess air pollution	Only by simulation model
Air quality standards	Standards have been adopted

Impacts

In 1999 the costs of air pollution due to transport were estimated as to amount to 1.6 per cent of the GDP.

Emissions

In 1998, CO_2 emissions in Burkina Faso amounted to 1,009,000 metric tons, of which 989,000 were emitted due to the use of liquid fuels (WRI, 2006). In 2003, the transport sector in Ouagadougou emitted 469 metric tons of CO_2 per day.

In Ouagadougou daily emissions are estimated to be 102 tons CO (77 per cent of which are due to two-wheelers) and 38 tons of HC (95 per cent of which are due to 2-wheelers). For NO emissions two-wheelers contribute between 7 and 12 per cent while four-wheelers are responsible for between 88 and 93 per cent (Diallo, 2002). By 2013 emissions are estimated to reach 221 metric tons for CO and 1265 metric tons for CO_2 per day.

[3] Based on Anonymous_2 (2006)

National response to air pollution

Legislation.
Burkina Faso is party to the Climate Change Convention, Hazardous Wastes Convention, and Depletion of the Ozone Layer Protocol (CIA, 2006).
Existing national legislation and regulations include an environment Act and several decrees and are summarised in Table Burkina_Faso_1.

Table Burkina_Faso_1: Acts and decrees

Legislation	N°	Content (Date of promulgation)
Act	005/97/ADP	Environment Act (30.01.1997)
Act	23/97/II/AN	Law on the running of mines (22.10.1997)
Act	23/94/ADP	Law on Public Health (19.05.1994)
Decree	2000-143/PRES/PM/MEE	Organisation of the Ministry of Environment and Water (17.04.2000)
Decree	2001-185/PRES/PM/MEE	Standards for emissions of air pollutants (30.12.200)

The Ministry of Environment and Water, in collaboration with other stakeholders is responsible for AQM.

Action plans. The "CLEAN AIR" project aims to develop an action plan for the implementation of clean air in Ouagadougou. Based on 1999 and 2003 studies the following priorities have been envisaged to be incorporated in the action plan.

- Reduction of the mean age of the vehicle fleet
- Introduction of catalytic converters in new cars
- Reduction of the sulphur content in diesel to 0.2 per cent (2000 ppm)
- Improvement of public transport
- Improvement of traffic flow
- Implementation of a transport plan
- Improvement of highways
- Enhancement of the capacity of different stakeholders
- Enforcement of stricter regulations for two-wheelers

Fuel standards. Specifications exist for lead-free gasoline and diesel. For lead-free gasoline the olefin and aromatics contents have not been regulated. The sulphur content of diesel is up to 1 per cent (10000 ppm).

Emission standards. The emission standards for automobiles and mopeds are compiled in Tables Burkina_Faso_2 and Burkina_Faso_3 (Section6). Burkina Faso has also introduced emission standards for power plants and industrial plants as shown in Table Burkina_Faso_4 (Section 6).

The direct emission into the air of the following compounds is forbidden: Halogenated, phosphorylated and tannic organics, carcinogenic, teratogenic and mutagenic substances, mercury and cadmium compounds, cyanides, and persistent organic pollutants.

Air quality standards. Outdoor air quality standards are compiled in Table Burkina_Faso_5 (Section 6).

On-going projects. In Ougadougou, a transport demonstration project aimed to address the challenge of urban traffic congestion and increase the share of public transport use. The objectives are to

- Encourage the use of mass transport
- Reduce the duration of trips by a separate lane for busses
- Enhance the capacity of institutions involved in transport
- Increase stakeholder participation

Reported challenges

- Control of the growth of two-wheelers and their regulation
- Improvement of the state of the vehicle fleet
- Ensuring the quality of petroleum products
- Extension of public transport
- Implementation of the CLEAN AIR action plan
- Reduction of sulphur content in diesel
- Encouraging the use of mass transport
- Separate lane construction for busses
- Capacity enhancement of institutions involved in transport
- Enhancement of stakeholder participation

References

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Summary and analysis

The situation in Burkina Faso, especially Ouagadougou is characterised by a rapid population growth, an unprecedented increase in vehicle emissions, especially two-wheelers. This situation is exacerbated by the age and poor maintenance of vehicles and the adulteration of fuels. Although a routine monitoring network appears not to exist and concentrations modelling of air pollutant predict kerbside concentrations will exceed air quality standards. The "Clean Air" action plan is designed to counteract this development by a set of measures including the phase-out of old vehicles, introduction of catalytic converters in new cars, enforcement of strict regulations for two-wheelers, improvement of public transport, the road network and the traffic flow, and the implementation of a transport plan. This action plan marks a significant progress in addressing air pollution in Ouagadougou and is a decisive action to reduce transport emissions.

Routine monitoring is not yet undertaken in the cities of Burkina Faso. Conclusions are drawn on the basis of simulation models. Unless based on reliable emission estimates and validated through quality assured monitoring campaigns or routine monitoring, simulation models may give misleading results. The use of invalidated modelled results could lead to introduction of inefficient control measures. It is advisable therefore to establish a small hybrid network of monitoring stations which combine a few automatic samplers with a larger number of diffusive samplers. While automatic samplers provide time series of monitoring data, diffusive sample are very useful for providing spatially representative data at a lower time resolution.

For the successful implementation of the "Clean Air" action plan public participation and stakeholder involvement are indispensable elements, in particular with regard to the acceptance of public transport and of those AQM measures which are envisaged to reduce the age of vehicles and the import of new vehicles with catalytic converters.

Inspection and maintenance of vehicles, even of new ones with catalytic converters, is also an issue which should be considered but does not appear to be part of the project and action plan as it is formulated. Lack of maintenance makes catalytic converters inefficient after a couple of years.

Finally, the application of market mechanisms such as taxes, congestion charges and regulatory measures controlling the import of vehicles are useful means to reduce the number of trips and encourage the use of public mass public transport.

3.4 Burundi[4]

Driving forces, pressures and state of air pollution

Population growth in Burundi amounts to 3.7 per cent (CIA, 2007). There is a rapidly growing vehicle fleet in Burundi due to this population growth. Urbanisation and economic growth are also driving forces in Burundi.

The vehicle fleet constitutes the main source of air pollution.

Burundi's largest industry is agriculture, which accounted for 58% of GDP in 1997.

Besides agriculture, other industries include light consumer goods; assembly of imported components; public works construction; food processing

Summary of air pollution information

Nature of problem	Vehicle emissions. Energy Production. Agriculture.
Status of monitoring	A surveillance system his not implemented
Key pollutants	Pesticides, Persistent Organic Pollutants, Pb
Number of monitoring stations	0
Capacity to assess air pollution	Capacity is absent
Air quality standards	Standards have not been introduced

National response to air pollution

Legislation.
Burundi is party to the Convention on Climate Change, Kyoto Protocol, Hazardous Wastes, and Ozone Layer Protection (CIA, 2006). The Environment Act No 1/010 has been adopted in 2000 (MLPET, 2005). The responsibility for AQM is with the Ministry of Land-use Planning, Environment and Tourism.

Action plans.
Initiatives for actions are envisaged but lack funding.
In June 2004, the NGO "Sanitation, Environment and Health (Propreté, Environnement et Santé, PES)" convened a National Workshop in Burundi to discuss the phase-out of leaded petrol. A workshop report is available (UNEP, 2004). Recommendations of this workshop to the government of Burundi include to

1. Promote a clear policy for stakeholder participation in combating leaded fuel and encourage NGOs and other associations to develop initiatives;

Raise awareness of the public on the risk of exposure to lead;

2. Establish mechanisms to reduce progressively the import of leaded fuel and vehicles operating on leaded fuel;
3. Promote research and improve the capacities of existing analytical laboratories;
4. Review of legislation related to trade in harmony with the Environment Act;
5. Conduct a concerted action with NGOs such as PES on order to determine the impacts of lead.

Summary and analysis:

Burundi is at a very early stage of AQM. Practically, only the phase-out of lead has been initiated. While an Environment Act exists, only the NGO Sanitation, Environment and Health (PES) has been instrumental in pushing forward air quality issues and the recommendations to the government formulated at the 2004 workshop on the phasing-out of lead. Public awareness and media involvement is very limited. Steps are necessary tot strengthen the political will of the government to address air pollution, to raise public awareness about adverse impacts of air pollution on human health and the environment. A cost-effective measure to reduce air pollution would be the reduction of sulphur in diesel and to implement an initial monitoring network using simple sampling methods.

References:

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4 Based on Nshimirimana (2006)

3.5 Cameroon[5]

Driving forces, pressures and state of air pollution

Driving forces are rapid growth of the population of 2.04 per cent (CIA, 2007), urbanisation, industrialisation and economic growth. Pressures include emissions from the growth of industries, the growing vehicle fleet and uncontrolled waste burning including household filth and used tyres. Industries include agriculture processing enterprises, extensive petroleum refineries, cement plants, aluminium factories, wood pulp and rubber factories, and sawmills (EN, 2006).

The growth of the vehicle fleet is considered as a matter of concern.

Summary of air pollution information

Nature of problem	Industrial production Energy Production. Vehicles Uncontrolled waste burning.
Status of monitoring	Monitoring does not exist.
Key Pollutants	PM, CO, HCs, NOx, SO_2.
Number of monitoring stations	0.
Capacity to assess air pollution	Has to be enhanced.
Air quality standards	Have to be promulgated.

Emissions

An emissions inventory for GHGs was produced with the aim to search for opportunities to reduce the emissions of gases in various sectors of the national economy. Emissions for other air pollutants from the various sources have not yet been quantified. Surveillance centres for controlling the technical quality of vehicles and analysing exhaust gases were recently installed. These centres use “Multigaz XR 842” gas analysers for gasoline-driven vehicles and automatic devices of the type “Passimetre” for diesel-driven vehicles.

National response to air pollution

Legislation. An important goal of the Government of Cameroon is to preserve a sustainable sound environment. According to the Constitution of the country, each citizen has a right to clean environment. The Framework Act for Environmental Management devotes a section to the protection of the environment. In order to preserve air quality it is considered imperative to assess carefully the actual situation and follow the legislation which regulates the control of air pollution in urban areas. The responsibility for AQM is with the Ministry of Environment, in collaboration with other partners. Surveillance centres are responsible for controlling the technical quality of vehicles and analysing exhaust gases.

Promulgated laws and decrees in Cameroon are shown in Table Cameroon_1.

Table Cameroon_1: Laws and decrees

Legis-lation	N°	Content (Date of promulgation)
Act	96/12	Environment Act (05.08.1996)
Decree	000012/2004/MINEE/MINDEC	Specifications of refined, imported and consumed fuel (18.05.2004)
Decree	?	Technical control of vehicles in test centres (?)
Decree	2001-185/PRES/PM/MEE	Standards for emissions of air pollutants (30.12.2004)

5 Based on Ngongangmeppa (2006)

National response to air pollution (continued)

International conventions.
Cameroon has acceded to the United Nations Framework Convention on Climate Change (UNFCC), Kyoto Protocol, Ozone Layer Protection, and the Stockholm Convention.

Action plans. Issues of the development of a national action plan and the setting of priorities for clean air implementation are being discussed.

Fuel standards. According to Decree 000012/2004/MINEE/MINDEC the maximal lead content of fuel "Super" can still be 0.013 g/l, measured with ASTM method D3341. The fuel specifications for super gasoline are shown in Table Cameroun_2. The sulphur content of diesel is 5,000 ppm. No specification of other characteristics of diesel is presently available in Cameroon.

Projects/programs. A study on the emissions of greenhouse gases (GHGs) and their effects on the atmosphere at the national level was performed by the Government of Cameroon in 1997 under the obligations of the UNFCC.

A study to quantify emissions of dioxins and furans under the obligations of the Stockholm Convention has been initiated.

References:

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WHO 2000 Polluted cities: The air children breathe. World Health Organization. Website: http://www.who.int/ceh/publications/11airpollution.pdf

Summary and analysis:

Cameroon has developed a Framework Environment Act which has incorporated air pollution as an important issue for which the situation should be carefully accessed. Surveillance centres for the control of vehicle emissions have been established which are able to survey the emissions of petrol-driven cars and test compliance with fuel specifications. Similar surveillance for diesel vehicles is not possible due to lack of corresponding gas oil specifications. A routine network of air pollutant monitoring is not implemented in spite of the stipulation in the Environment Act to assess the air quality situation. Thus, the contribution of industrial sources, power plants, area sources and that of transboundary dispersion of air pollutants cannot be assessed. Emission estimates only exist for greenhouse gases.

Necessary steps towards a rational AQM system would include the specification of characteristic diesel parameters since it can be assumed that diesel vehicles constitute a major source of soot, fine particulate matter and sulphates. The implementation of a cost-effective network of monitoring stations consisting of diffusive monitors for providing spatial representativity in the monitoring of gaseous compounds and one or two automatic samplers for gaseous compounds and DustTraks for fine particulate matter can substantially help improve the assessment of the air quality situation. Particulate matter concentrations may be enhances in cities in view of the estimation of the WHO that the overall PM_{10} concentrations in Cameroun range between 16 and 20 µg/m^3 (WHO, 2000). Setting air quality standards would help formulate control measures in case of non-attainment of the standards in certain areas. The assessment of the perception of people on air pollution and to raise public awareness of the potential impacts of key air pollutants is important.

3.6 Republic of the Congo (Congo Brazzaville)[6]

Driving forces, pressures and state of air pollution

Due to rapid growth of the population of 2.6 per cent (CIA, 2007), the striving for economic growth and poverty the following pressures exist in Congo Brazzaville:

- Forest fires of natural origin
- Windblown dust
- Biological agents such as bacteria and fungi
- Chemicals released from plants and animals
- Emissions from a growing vehicle fleet
- Emissions from industrial plants (smelters, refineries, petrol terminals, power plants and incinerators)
- Emissions from open stove cooking and heating indoors in the absence of efficient ventilation
- Malnutrition, overpopulated dwellings,
- Insufficient infrastructure for health services and sanitation, and water distribution

Industries and the vehicle fleet constitute the main consumers of energy and the main sources of air pollution.

The vehicle fleet consists mostly of aged second-hand cars as shown in Table Congo_Brazza_1 (Section 6).

Figure Congo_Brazza_1 illustrates the steep increase in the number of new vehicles and the even steeper increase and about 10 times larger numbers of second-hand vehicles in Brazzaville.

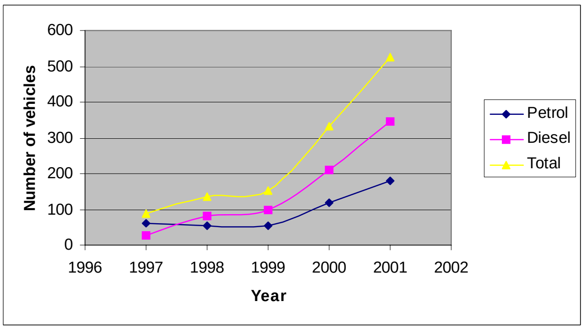

Figure Congo_Brazza_1: Number of new vehicles 1997-2001

In the projection of the energy demand of 1994 to that of 2030 a growth rate of 3.4 per cent annually is estimated. Energy demand increases at a higher rate than the population growth of 2.8 per cent. Transport and household are the main energy consumers. GHGs are projected to grow by 4.6 per cent per year and are dominated by CO_2 and CH_4.

The industrial sector in the Republic of the Congo is based largely on oil and support services,

Summary of air pollution information

Nature of problem	Household emissions Energy Production. Vehicles.
Status of monitoring	Monitoring has to be set up.
Key pollutants	PM, CO, HCs, NO_x.
Number of monitoring stations	0
Capacity to assess air pollution	Capacity is absent
Air quality standards	Not yet promulgated

Impacts

Studies on impacts of air pollution do not exist. It is pointed out that malnutrition; contaminated water and the use of solid fuels indoors are responsible for one fourth of all deaths. These variables would be confounders for epidemiological assessments.

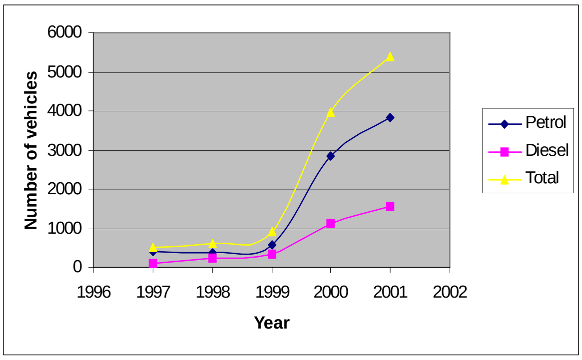

Figure Congo_Brazza_2: Number of second hand vehicles 1997-2001

[6] Based on Kombo (2006)

Emissions

The transport sector is the largest consumer of conventional energy and emits about 32 per cent of the total of emissions. In order to estimate emissions of the vehicle fleet, average trips lengths are reported. The average trip lengths between the residence of a worker and his workplace depend on the area where the worker lives and was estimated to be

- 15 km if the worker lives in a peri-urban area
- 8 km if the worker lives in a sub-urban area, and
- 5 km if the worker lives near to the workplace.

These estimates have not yet been used to actually estimate emissions.

The energy sector is one of the sources of GHGs and in 1994 was estimated to emit in 1994 846.13 Gg. 74.5 per cent of this amount are CO_2, 21.84 per cent CH_4 and 3.66.per cent N_2O. The distribution to the various sectors are depicted in Figure Congo Brazza_3. They show the large contribution of the transport sector followed by those of the power plants

The gases emitted during the petrol pumping are estimated to amount to 400-600 million cubic metres which are mostly flared and, to a smaller degree re-injected.

The partition of the total gaseous emissions by air pollutant is depicted in Figure Congo_Brazza_4. The percentages are essentially determined by CO2 and CO emissions; the emissions of the residual gases are of the order of at most 2 per cent.

The potential emissions of air pollutants (CO, NOx, NMVOC) and GHGs (CO_2, CH_4, N_2O) were estimated and are shown in Table Congo_Brazza_2 (Section 6). These data estimates are, however relatively old. More recent figures for CO_2 emissions show a stagnant trend around 3 million metric tons (EIA, 2004)

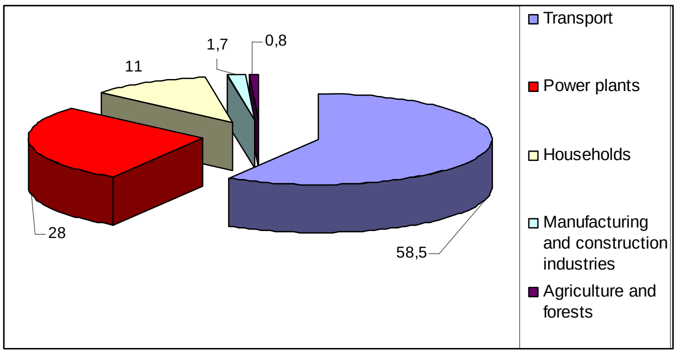

Figure Congo_Brazza_3: CO_2 emission percentage by sector

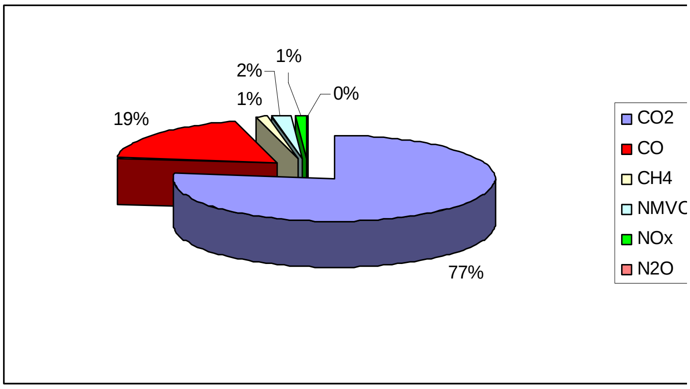

Figure Congo_Brazza_4: Partition of total gaseous emissions by pollutants.

Reported challenges.

- Implementation of monitoring network
- Rising emissions of CO_2 due to an ageing car fleet
- Create clean technology centres
- Incite vehicle owners to maintain their vehicles in appropriate centres
- Regulation of the import of second-hand vehicles
- Implementation of control measures

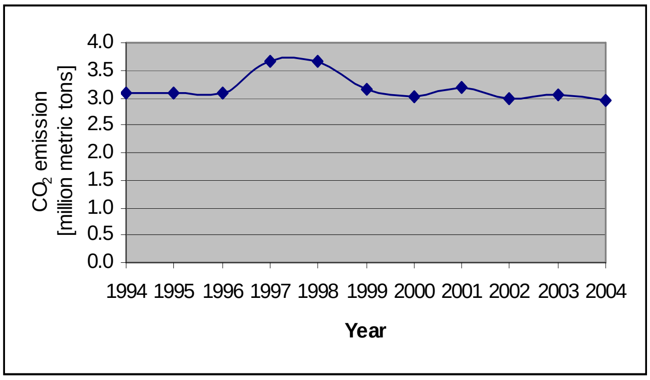

Figure Congo Brazza_5: Trend of CO2 emissions 1994-2004

National response to air pollution

Legislation.
The legislation relating to air pollution is diluted in many partly overlapping texts among the different sectors of the environment, energy and transport. The responsibility for AQM is with the Ministry of Environment, Ministry of Transport, and the Ministry of Energy and Hydrocarbons, in collaboration with other stakeholders. The Ministry of Transport has the mandate to implement the national policy regarding urban and inter-urban transport, railway and aerial transport. Otherwise, the sectorial responsibilities are not well defined.

The Republic of the Congo is a party to the Conventions on Climate Change and the Ozone Layer Protection.

Action plans. The Republic of Congo has formulated a National Plan for Environmental Action (NPEA/PNAE) which is to implement appropriate instruments in the industrial sector.

Projects/programmes,
In project PRC98G31 which was initiated by the obligations of the FCCC data of vehicle import were collected. The data of Table Congo_Brazza_1 show substantial increases in automobiles (more than ten-fold) and public transport vehicles (more than six-fold) between 1997 and 2004. For Brazzaville, an action plan for waste management was developed with the support of UNDP which provides for a certain number of infrastructural measures to improve air quality.

Table Congo Brazza_1: Imported vehicles 1997-2004 (measured by total weight of all vehicles)

Imported vehicles [tons]	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Individual vehicles	574	4 843	2 696	5 265	2 667	2 747	5 930	7 138
Vehicles for public transport	585	3 679	523	12 056	6 436	6 083	945	3 691
Vehicles for goods transport	1 495	60	1 941	613	_	937	4 088	1638

Presently no projects or programmes having an AQ benefit appear to exist in Congo Brazzaville. The report proposes that any programme should address the energy sector in order to implement the application of the cleanest existing technology in energy production, for refineries, for fuel terminals etc. For the municipalities measures are not proposed yet. The results of the study on GHGs could lead to envisaging a specific programme to improve air quality. Expertise and financial support by UNEP and other UN agencies is necessary in order to implement any project or programme relating to air pollution in the Republic of the Congo.

Summary and analysis:

The emissions from a strongly growing and ageing fleet of second-hand vehicles are a major challenge in the cities of Congo Brazzaville. Industries and the vehicle fleet constitute the main consumers of energy and the main sources of air pollution. Industrial emissions and emissions from gas flaring constitute localised problems. Legislation is dissipated in the sectors of environment, energy and transport and in part overlapping. Congo Brazzaville has formulated a National Plan for Environmental Action which is to implement appropriate instruments in the industrial sector. The Ministry of Transport is aware of the environmental dimension of its policy and attempts to follow an integrated ansatz for transport.

AQM in the Republic of Congo is still in its infancy. AQM is not yet considered as an issue that has to consider the emissions from all types of sources in order to decide on the priorities for cost-efficient control measures. The distribution of the responsibility for AQM to different ministries apart from the Ministry for Environment is a major obstacle for integrated AQM.

The WHO has estimated that the average concentrations of PM_{10} in Congo Brazzaville would range between 16 and 20 $\mu g/m^3$ (WHO, 2000). In urban areas PM_{10} concentrations could be substantially higher. A monitoring network is being envisaged by the government. If implemented together with a quality assurance/quality control plan, the network will constitute a first step to rational AQM. Efficient training and sufficient supply of spare parts will help make the network sustainable. A National Plan for Environmental Action that will address fuel specifications, standards for imported vehicles, and other control measures will supplement the action plan for industrial control and constitute a big step forward to AQM.

References:

CIA 2007 Congo, Republic of the. . The World Fact Book. Central Intelligence Agency, Washington. Website: https://www.cia.gov/cia/publications/factbook/geos/cf.html

EIA 2006 International Energy Annual 2004. Energy Information Administration. Website: http://www.eia.doe.gov/pub/international/iealf/tableh1co2.xls

Kombo G 2006 Congo-Brazzaville-AQ Status_071406. Contribution to the Planning and Implementation of the Policy Makers Session of the BAQ 2006 Conference, Nairobi, 26 – 27 July 2006.

WHO 2000 Polluted cities: The air children breathe. World Health Organization. Website: http://www.who.int/ceh/publications/11airpollution.pdf

3.7 Democratic Republic of the Congo (Congo-Kinshasa)[7]

Driving forces, pressures and state of air pollution

Due to rapid growth of the population of 2.07 per cent (CIA, 2007) and economic growth the following pressures exist in the Democratic Republic of Congo (DRC):

- Strongly growing vehicle fleet
- Obsolete industrial facilities and extremely polluting processes
- Emissions from waste deposits dues to lack of an waste management system

The population of Kinshasa grew from almost 400,000 in 1960 to almost 8 million in 2005.

Main industries include agriculture and mining of cobalt and copper in Katanga. In 1997, industry accounted for 16.9 per cent of GDP. The vehicle fleet and, locally, the mining industry, power plants and uncontrolled waste burning presumably constitute the major sources of air pollution.

National response to air pollution

The DRC is party to the Conventions of Climate Change and Ozone Layer Protection (CIA, 2006). A framework law on environmental management and AQM in particular has yet to be promulgated. The responsibility for AQM is with the Ministry of Environment, in collaboration with other partners. Leaded petrol was phased out in February 2005.

Projects/programs

On-going projects include

- Development of an Environment Act
- Awareness raising campaign for the use of catalytic converters
- Reduction of sulphur levels in diesel from July 2006 onwards

The implementation of the on-going projects will have an AQ benefit

Summary of air pollution information

Nature of problem	Energy Production. Vehicles.
Status of monitoring	A surveillance system has to be implemented
Key pollutants	PM, SO_2, NO_2, CO, HCs.
Number of monitoring stations	0
Capacity to assess air pollution	Capacity is non-existent
Air quality standards	Standards have to be promulgated

Reported challenges

- Absence of a legislative framework for AQM
- Development of a general environmental legislation and regulations and specifically legislation on air pollution
- Realisation of adequate infrastructures with regards to air quality surveillance and control
- Lack of enforcement due to institutional weakness
- Review and strengthening institutions responsible for implementation and enforcement of legislation and regulations relating to air quality
- Assessment of the state of air pollution in major cities
- Need of financial help from partners

References

CIA 2007 Congo, Democratic Republic of the. . The World Fact Book. Central Intelligence Agency, Washington. Website: https://www.cia.gov/cia/publications/factbook/geos/cg.html

Kabala M. 2006 Projet d'amélioration de la quali é de l'air de l'environnement urbain en République Démocratique de Congo (Kinshasa). Planning and Implementation of the Policy Makers Session of the BAQ 2006 Conference, Nairobi, 26 – 27 July 2006.

[7] Based on Kabala (2006)

Summary and analysis

A strongly growing vehicle fleet and obsolete industrial facilities and extremely polluting processes are responsible for air pollution. In addition, emissions from waste deposits and uncontrolled waste burning contribute significantly. A framework law on AQM does not exist. There are no regulations about fuel specifications, emission or air quality standards. A monitoring network is not in place. On-going projects include the development of an Environment Act, the implementation of the phase-out of leaded petrol, an awareness campaign for the use of catalytic converters, and reduction of sulphur in diesel.

The capacity and capability to assess and manage air pollution in the Democratic Republic of Congo is undeveloped. The promulgation of framework law on AQM should be accelerated and fuel specifications, emission and air quality standards and the development of action plans for the reduction of exposure to air pollutants of the population enforced. Programmes for awareness raising and training should be among the first steps toward AQM. A pilot project on monitoring of key air pollutants supported and accompanied by an agency from a developed country could be a useful starting point for initializing AQM. The results of well-planned air quality monitoring, which provides data of known quality can be used to set enforceable air quality standards. WHO air quality guidelines and intermediate values (WHO, 2006) may be used in setting standards and averaging times.

Regulations on emission standards for mobile and stationary sources, air quality standards, viable dispersion models and reliable monitoring procedures will ensure rational and sound AQM. This includes, where appropriate, the adoption of emission standards based on developed countries' experiences. The application of the best available control technology avoids the problem of inequities among countries and prevents 'social dumping'.

Quantification of the contribution from different sources will help set priorities in AQM which permit to decide which sources should be addressed first. Dispersion modelling will help estimate pollutant concentrations and by comparison with actual measurement test the validity of the emission estimates.

The development and adoption of a Clean Air Implementation Plan (CAIP) including energy efficiency, use of cleaner resources and land-use planning, tailored for the DRC, as an instrument for implement effective environmental policy can assist in achieving policy goals in a structured and transparent manner.

3.8 Ethiopia[8]

Driving forces, pressures and state of air pollution

Due to rapid growth of the population, amounting to 2.3 per cent (CIA, 2007), the striving for economic growth and poverty pressures include emissions from a growing vehicle fleet and indoor air pollution through use of solid fuel for cooking and heating. The vehicle fleet may constitute the main source of air pollution.

A pilot study was performed during the period January to February 2004. The objective of the study was to obtain preliminary information on air pollution in Addis Ababa and to find out how serious the problem is in the capital city of Ethiopia. The timing of the study coincided with the implementation of the complete phase-out of lead from gasoline imported to Ethiopia. Specific objectives of the study were to measure PM_{10} and its daily fluctuations, to analyze the samples on lead, and to determine the levels of CO, SO_2 and O_3.

A monitoring campaign was initiated. For sampling 11 sites were selected: 6 urban sites, 3 suburban/peripheral sites, and 2 residential sites in Addis Ababa. Monitoring took place in the dry season because the highest concentrations of pollutants were expected during this time (Figure Ethiopia_1). PM_{10} was collected on filters using a minivol sampler (Figure Ethiopia_2). A DustTrak sampler (Figure Ethiopia_4) and a GRIMM particle size distribution analyzer (Figure Ethiopia_5) were also applied for short-term PM_{10} monitoring at different times of the day. CO was monitored at different times of the day with a Draeger CO sensor. In addition diffusive tubes were used for CO, SO_2, and O_3 monitoring.

PM_{10} levels are shown in Figure Ethiopia_3and compared with the 24-hour level of the US EPA.

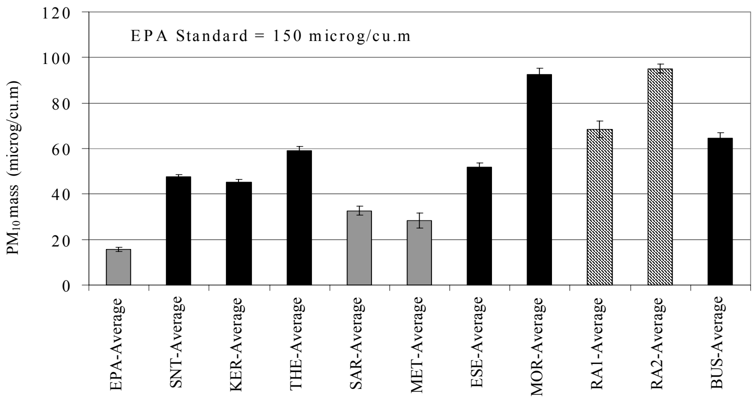

Figure Ethiopia_3: PM_{10} concentrations at various sites of Addis Ababa

PM_{10} concentrations range between less than 20 µg/m^3 and almost 100 µg/m^3, complying with the US EPA standard of 150 µg/m^3 but being mostly above the WHO guideline value of 20 µg/m^3. The daily variation of PM_{10} in Figure Ethiopia_6 (see Annex Ethiopia_1, Section 8) shows a peak in the early morning hours, which at one station reaches a value of 1,800 µg/m^3. At most other stations the peak value is below 600 µg/m^3. Also the CO concentrations at various monitoring stations show a similar peak in the early morning hours (Figure Ethiopia_7 in Annex Ethiopia_1, Section 8). If these data are typical for daily exposure, it can be inferred that probably 1-hour and 8-hour CO guideline values and US EPA standards are not exceeded at kerbside sites in Addis Ababa. Lead concentrations are below 0.07 µg/m^3 (Figure Ethiopia_8 in Annex Ethiopia_1, Section 8). The very low values indicate a successful implementation of the phase-out of lead in petrol-driven vehicles. From these data it can safely be assumed that the 3-month standard of the US EPA of 1.5 µg/m^3 is not exceeded.

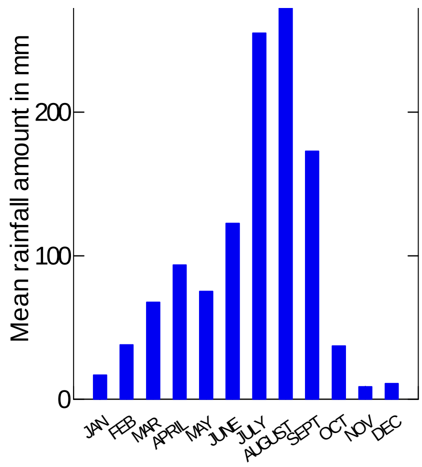

Figure Ethiopia_1: Monthly values of rainfall in Addis Ababa

Figure Ethiopia_2: Minivol sampler

8 Based on Wondimaghegn (2006)

Impacts

The following additional conclusions were drawn from the monitoring campaign:

- Sulfur dioxide concentrations were below detection limits
- Midday ozone concentrations never exceeded 45 ppb, well below the 120 ppb US EPA standard

Figure Ethiopia_4: GRIMM Particle size analyser

Summary of air pollution information

Nature of problem	Household emissions Energy Production. Vehicles.
Status of monitoring	Monitoring exists.
Key pollutants	PM_{10}, CO, SO_2, O_3.
Number of monitoring stations	11.
Capacity to assess air pollution	Capacity exists
Air quality standards	Do not appear to be promulgated. US EPA standards are used.

Emissions

PM_{10} samples were analysed for organic carbon, element carbon, sulphates, nitrates and geologic compounds. The results depicted in Figure Ethiopia_9 allow a crude source apportionment.

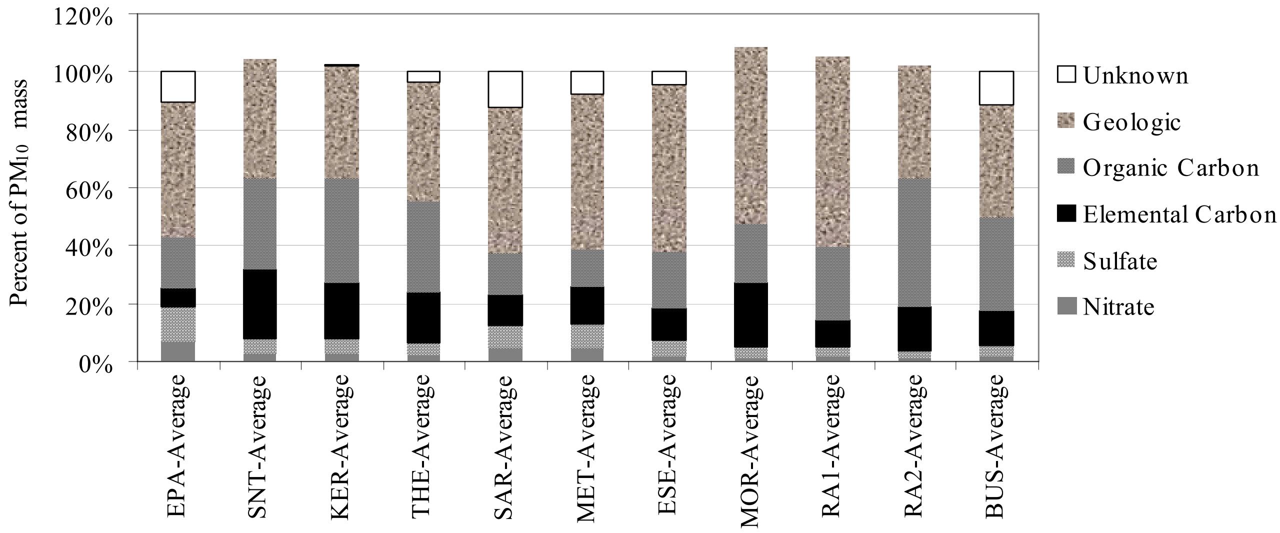

Figure Ethiopia_9: Source apportionment of PM_{10}

The majority (~ 85%) of the PM_{10} was caused by elemental carbon (EC), organic carbon (OC), and geologic material with almost equal contributions from EC, OC, sulphates and nitrates (52 per cent) and geologic compounds (48 per cent), respectively. This result indicates that windblown particulate matter of geologic origin accounts for half the concentration values of PM10 in Addis Ababa, reflecting a strong natural PM component in addition to the traffic-related component.

Figure Ethiopia_5: TSI DustTrak PM10 monitor

Reported challenges.

- Due to the short study period concentrations may have been underestimated
- Trends should be determined
- Apart from PM_{10} fine particulate matter ($PM_{2.5}$) and CO and O_3 should be measured
- Source apportionment should be refined
- Indoor air pollution should be addressed since concentrations of toxic pollutants may be much higher than outdoor concentrations

National response to air pollution

Legislation.

The Ethiopian Proclamation No. 1/95 of 1995 (Constitution of Federal Democratic Republic of Ethiopia) states all people have the right to a clean and healthy environment. In 1997 the Environmental Policy and Conservation Strategy of Ethiopia were adopted, followed by the Pollution Control Proclamation in 2002 (FDRE, 2002). The Proclamation regulates the responsibilities of the Environmental Protection Authority (EEPA) and national regional governments, endorses the polluter pays principle, addresses the management of hazardous and municipal wastes, air and noise pollution, and determines offences and penalties. The EEPA, in consultation with other competent agencies, is charged with formulating air quality and emission standards, noise standards. Another law is the Ethiopian Impact Assessment (EIA) Proclamation of 2002. The EIA serves to bring about a thoughtful development by predicting and mitigating adverse environmental impacts that a proposed development activity is likely to cause as a result of its design, location, implementation and other characteristics. The EEPA has prepared procedures, regulations, guidelines and standards to effectively implement and enforce the EIA law. Guidelines focus on agriculture, transport, industry, and tanneries amongst others (Tekelemichael, 2002; MacDonald, 2004).

The Ministry of Energy and Mining together with its partner is responsible for fuel specifications. An important stakeholder is the Forum for Environment which is a platform for environmental advocacy and communication among people concerned with the Ethiopian environment. The Forum acts as a catalyst for networking people and organizations working in environmental issues and promoting environmentally sound action. (UNEP, 2005)

Fuel specifications.

Under the auspices of the Ministry of Energy and Mining supported by the Sudanese Petroleum Corporation and the Export and Import Administration Ethiopia has promulgated specifications for unleaded gasoline (Table Ethiopia_1, Section 6) and diesel (Table Ethiopia_2, Section 6).

References:

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WHO 2000 Polluted cities: The air children breathe. World Health Organization. Website: http://www.who.int/ceh/publications/11airpollution.pdf

Summary and analysis:

Air pollution in Addis Ababa has been assessed in a short-term screening study. In this initial study levels of PM_{10}, CO, SO_2 and O_3 were found low to moderated, complied with US EPA standards and turned out to be much smaller relative to other African cities such as Cairo or Johannesburg. Diurnal behaviour of CO and O_3 concentrations correspond to those found in other cities with peaks during the morning rush hour. As the study started after the phase-out of leaded fuels in vehicles only traces of lead were found, supporting the conclusion that lead phase-out in Ethiopia was successful. Motor vehicle exhaust, residential wood burning, and dust from roads are the probable major sources of PM_{10}. These sources emit elemental carbon, organic carbon, sulphates and nitrates which constitute 52 per cent of the total PM_{10} mass concentration. Geologic material contributes 48 per cent of the measured PM_{10}. This indicates the influence of substantial natural PM sources such as deserted areas and eroded soils. According to the estimate of the WHO, average PM_{10} concentrations in Ethiopia range between 16-20 $\mu g/m^3$ (WHO, 2000).

The major environmental laws are the Pollution Control Proclamation which addresses important issues in AQM, and the Environmental Impact Assessment Proclamation, which serves to predict and mitigate adverse environmental impacts of planned projects. Both Proclamations were promulgated in 2002. The Ethiopian Environmental Protection Authority is in charge of the implementation of these laws including the setting of standards.

Due to lack of funding actions plans or projects relating to AQM are not being performed in Ethiopia.

Fuel specifications for gasoline and diesel have been promulgated while emission and air quality standards have not yet been set. The sulphur content of diesel set at 1% or 10,000 ppm is relatively high leading to increased sulphate emissions. A next step towards AQM should be to lower this value.

Compared with the new WHO guideline value for PM_{10} of 50 $\mu g/m^3$, PM concentrations in Addis Ababa are already relatively high. At least this compound is an air pollutant of concern in the capital. A permanent network of monitoring stations for PM and other air pollutants will help obtain baseline data on the exposure of the population in Ethiopian cities. Air pollutants of interest would include PM_{10} and $PM_{2.5}$, NO_2 and O_3. Due to the low concentration values observed in the screening study, the monitoring of CO and SO_2 could be considered necessary only in a secondary step.

3.9 Gabon[9]

Driving forces, pressures and state of air pollution

Due to rapid growth of the population of 2.1 per cent (CIA, 2007), the striving for economic growth, a growing vehicle fleet and increased industrialization the following pressures exist in Gabon:

- Emissions from industrial plants such as cement factories and municipal waste incinerators, particularly heavy metals,
- Emissions from a growing vehicle fleet
- Emissions from aircraft, ships and other mobile sources
- Bad state of the vehicle fleet of an elevated age

Gabon´s industry is centred on petroleum, manganese mining, and timber processing. Most industrial establishments are located near Libreville and Port Gentil. Timber processing includes five veneer plants and a large 50-year–old plywood factory in Port Gentil, along with two other small plywood factories. Other industries include textile plants, cement factories, chemical plants, breweries, shipyards, and cigarette factories (EN, 2006).

The vehicle fleet constitutes the main source of air pollution

Lead has been phased out in Gabon and analyses of petrol have indicated lead levels below the detection limit.

An air pollution monitoring network has not yet been installed due to shortage of funding.

A WHO study estimated the average PM_{10} concentration in Gabon between 21 and 25 $\mu g/m^3$ (WHO, 2000).

Impacts.

Because epidemiological and exposure studies do not exist, the government of Gabon applies the precautionary principle to mitigate or avoid adverse health and environmental impacts due to air pollution and improve air quality in its cities. This is done by adopting the recommendations of BAQ 2006, which aim to ameliorate the air quality in urban areas.

Summary of air pollution information

Nature of problem	Mining & Mineral Processing. Energy Production. Vehicles.
Status of monitoring	Monitoring does not exist due to lack of equipment.
Key pollutants	PM, CO, HCs, NOx, SO_2
Number of monitoring stations	0.
Capacity to assess air pollution	Financial and expert support is needed to build the capacity
Air quality standards	Have not been set

Emissions

According to the national strategy on climate change, 94 per cent of CO_2 emissions of 8382.95 Gg originate in the energy sector. Since 1994 the carbon dioxide emissions from consumption and flaring of fossil fuels in Gabon have been slightly decreasing (Figure Gabon_1)

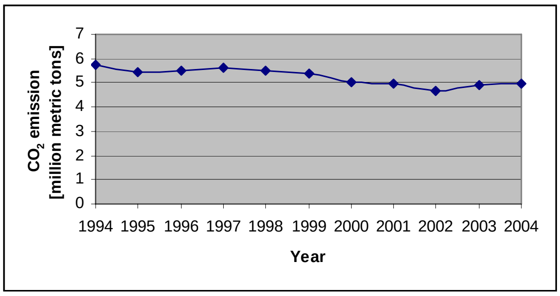

Figure Gabon_1: CO_2 emissions form fossil fuel consumption and flaring
Source: EIA (2006)

9 Based on Molly (2006)

National response to air pollution

Legislation.
While epidemiological studies are non-existent in Gabon, the main objective of the government of Gabon is to progressively ameliorate air quality. The Environment Act is the law No 16/93 regarding the protection and improvement of the environment. It was promulgated on 26 August 1993. In chapter 4 the act describes general criteria to regulate air pollution. The responsibility for AQM is with the Ministry of Environment, Nature Protection, Research and Technology, with the support of the Inter-ministerial Commission to address the elimination of lead in petrol (CONASEPE), the National Anti-Pollution Centre and specialised centres for combating air pollution. The National Anti-Pollution Centre is a public agency with administrative and scientific tasks in air pollution.

Gabon is party to the United Nations Framework Convention on Climate Change and acceded to the Montreal Protocol on the Depletion of the Ozone Layer and its Amendments.

Fuel standards.
The Inter-ministerial Commission to address the elimination of lead in petrol (CONASEPE) has recently proposed a decree for the specification of lead-free petrol. This decree has not yet been promulgated. No other juridical or technical specification related to petrol exists. In contrast, several specifications exist for diesel in order to guarantee a good performance of diesel-driven engines. In order to avoid the use of diesel of insufficient quality, the government has started to harmonise the specifications of this fuel. The diesel which is presently distributed to consumers has got an increased sulphur content of 8000 ppm. The government has stated its intention to move to 5000 ppm sulphur in diesel (PCFV, 2005)

Projects/Programmes.
The planned project POLAIR aims to improve living conditions of the people of Gabon. The project will define an information exchange platform integrating all stakeholders involved in air quality. Stakeholders include professionals working in the fields of environment, transport, energy, industry, health, non-governmental organisations, academia and economy. An approach will be used to evaluate the socio-economic, institutional and juridical impacts of rational air pollution management at the local and sub-regional levels. The costs of air pollution management will be evaluated with respect to the regulation of transport, import of second-hand vehicles and other engines, and the implementation of emission standards. Another aspect of the project will be health and environmental impacts of air pollution and raising public awareness. An objective of the project is also to develop a decision support system which takes into account the costs and benefits of AQM. The necessity of starting such a project follows from the non-existence of any pilot study on air pollution in Gabon. The report states that actions which are necessary for the improvement of air quality are based on

- An emissions inventory including road, railway, air traffic, power stations, waste incinerators, …
- Measurements of air pollutant concentrations
- Evaluation of impacts
- Financial evaluation of control measures

No public agency is presently in a position to measure air pollution because the equipment is lacking. In consequence it is necessary to enhance the capacity of the ministries responsible for combating air pollution. In addition, in order to conduct successfully this project external financial means must be mobilised since the government is not in a position to finance the whole project.

Two phases are envisaged to develop methodologically the project under the leadership of the Ministry of the Environment. Phase 1 will implement the coordination mechanisms while Phase 2 is to plan and conduct the necessary actions in agreement with the defined objectives.

It is envisaged to start the project in 2007 and its duration will be 26 months. The costs amount up to 380 985 000 FCFA (US $ 765,000). 20 per cent of these costs are to be covered by the government budget and 80 per cent and are to be financed by partners to be determined. International expertise and financial support are needed to implement POLAIR.

Reported challenges:

- Need for a national action plan
- Lack of emissions inventory
- Lack of monitoring equipment and consequent ignorance about the magnitude of existing concentrations and exposure of the population
- Lack of funding for POLAIR

References:

CIA 2007 Gabon. The World Fact Book. Central Intelligence Agency, Washington. Website: https://www.cia.gov/cia/publications/factbook/geos/gb.html

EIA 2006 International Energy Annual 2004. Energy Information Administration. Website: http://www.eia.doe.gov/pub/international/iealf/tableh1co2.xls

EN 2006 Gabon. Encyclopaedia of the Nations. Website: http://www.nationsencyclopedia.com/Africa/Gabon-INDUSTRY.html

Molly S 2006 Rapport sur l'état des lieux et réglementation du contrôle de la pollution de l'air en milieu urbain au Gabon. Contribution to the Planning and Implementation of the Policy Makers Session of the BAQ 2006 Conference, Nairobi, 26 – 27 July 2006

PCFV 2005 Sub Saharan Africa sulphur levels in diesel fuel. Last updated on 26 July 2005. Partnership for Clean Fuels and Vehicles. http://www.unep.org/PCFV/documents/AFRICASULPHURSUMMARYJul2005.pdf

WHO 2000 Polluted cities: The air children breathe. World Health Organization. Website: http://www.who.int/ceh/publications/11airpollution.pdf

Summary and analysis:

Sources of air pollution are the vehicle fleet and industrial plants such as cement plants, breweries and waste incinerators, power plants, and mineral mining and processing The vehicle fleet is badly maintained and ageing.

The government of Gabon is concerned about the air quality in its urban areas and wishes to implement the recommendations of the BAQ conference.

No surveillance network exists for air quality due to lack of monitoring devices, experience and funding. Emissions from stationary and mobile sources are not known except for carbon dioxide. Health and environmental impacts assessments are not performed.

The phase-out of leaded petrol has been successful. Fuel specifications have yet to be adopted for petrol. For diesel, existing different specifications are to be harmonized. Presently, the sulphur content of diesel is relatively high (8000 ppm) leading to the emission of larger quantities of sulphates by diesel-driven vehicles.

The planned project POLAIR aims to evaluate the socio-economic, institutional and juridical impacts of rational air pollution management at the local and sub-regional levels. The plan includes already main ingredients of AQM such as an emission inventory and a monitoring network. This project, if implemented, can provide a good starting point for rational AQM in urban areas of Gabon.

The planned emissions inventory will be useful for estimating key air pollutant concentrations by dispersion modelling and can help to build up a cost-effective monitoring network.

The promulgation of emission and air quality standards and their enforcement will help effectively control sources and interpret monitoring results with respect to their threats to public health and the environment.

3.10 Ghana[10]

Driving forces, pressures and state of air pollution

Due to rapid growth of the population of 2.07 per cent (CIA, 2007) and the striving for economic growth, a growing vehicle fleet and increased industrialization the following pressures exist in Ghana:

- Emission from a growing vehicle fleet
- Bad state of the vehicle fleet of an elevated age
- Emissions from industries
- Indoor air pollution

Food, cocoa, and timber processing plants lead a list of industries that include an oil refinery, textiles, vehicles, cement, paper, chemicals, soap, beverages and shoes. As part of its chemical industry, Ghana produces rubber, aluminium, and pharmaceuticals. The aluminium smelter at Tema is one of Ghana's largest manufacturing enterprises (EN, 2003).

The vehicle fleet constitutes the main source of air pollution as 80 per cent of pollution is estimated to originate from this source (Africaclean, 2006).

Ghana's Environmental Protection Agency (EPA) started an air quality-monitoring programme in five cities namely Accra, Tema, Kumasi, Takoradi and Tarkwa in 1997. The air pollution indicators and climatic variables that were monitored included SO_2, CO, black smoke, particulate matter (PM_{10}) and total particulate matter (TSP). This programme continued until August 2001, when the stations started experiencing frequent breakdown of equipment, thus making data unreliable and lacking the integrity for reporting. Until 2004 the Agency was trying to revamp its air quality-monitoring programme.

In 2005, in a project supported by USAID, US EPA, and UNEP ten monitoring stations were established in representative residential (3), commercial (1), industrial (2) and roadside (4) sites. Sampling of key pollutants is conducted in accordance with a 6- day routine schedule. Data collection is on-going in accordance with the standard operating procedures (SOPs). Present results of the air quality monitoring in Accra, show that vehicular exhaust emissions, open burning of waste and other materials, road dust, emissions from industrial sources, residential cooking, commercial activities and wind-blown dust are all major contributors to the air quality measured at the permanent and roadside sites. The results also revealed that roadside locations and commercial areas have high particulate concentrations, which are likely to affect the health of the populace. More information on this project can be obtained from RTI (2005)

Summary of air pollution information

Nature of problem	Mining Mineral Processing. Energy Production. Vehicles.
Status of monitoring	Monitoring exists
Key pollutants	SO_2, NO_2, O_3, CO, PM_{10}, manganese
Number of monitoring stations	10.
Capacity to assess air pollution	Capacity exists but support is needed to enhance it
Air quality standards	Not yet promulgated

Impacts

Prior to the phase out of leaded gasoline in Ghana in December 2003, the EPA carried out sampling and analysis of lead levels in soil, air and blood of high-risk groups (November 2002 to December 2003).The study showed high levels of lead in excess of 10 µg/dl in the blood of some subjects. The Agency is currently implementing a follow –up study to determine the trends in the blood –lead levels.

A study of the Ghana Health Service (GHS), conducted in collaboration with EPA Ghana revealed that children living in areas of high traffic volume and elevated pollutant levels reported to hospitals increasingly of upper respiratory tract infections (GHS, 2006).

Vehicle emissions are responsible for a number of deaths in Ghana that cannot be quantified (Africaclean, 2006).

Reported challenges:

- Enforceable air quality and emission standards have to be developed
- Gaseous pollutant are currently analysed at ECOLAB which needs an ion chromatograph to expand the programme
- External expertise and financial support is needed
- Upgrade and enhancement of a mass transport system
- Lack of adequate capacity for testing roadworthiness by the Driver and Vehicle Licensing Authority (DVLA)

[10] Based on Nerquaye-Tetteh (2006)

National response to air pollution

Legislation. The responsibility for AQM was defined in Act 490, the Environmental Agency (EPA) Act, promulgated in 1994. The responsible agency, therefore, is the Ghana EPA, in collaboration with partners such as the Ecological Laboratory (ECOLAB) at the University of Ghana. The EPA has the mission to co-manage, protect and enhance the country's environment. Key functions of the EPA are to develop a comprehensive environmental quality database to guide policy formulation and implementation, and to prescribe guidelines, standards and regulations for environmental management. The air quality monitoring activities of the Agency are therefore geared towards the realization of the following objectives:

- Coordination of all activities in respect of the monitoring of atmospheric air quality.
- Scientific determination of levels of various air pollutants resulting from natural and anthropogenic sources.
- Development of enforceable air quality standards and regulations to improve air quality and protect human health.

Fuel specifications.

For domestic and imported unleaded gasoline and for diesel (automotive gas oil) Ghana has set technical fuel specifications. These are compiled in Tables Ghana_1 (domestic petrol), Table Ghana_2 (imported petrol), and Table Ghana_3 (diesel) in Section 6.

Projects/Programmes.

The USAID, US EPA, and UNEP in July 2004 selected the city of Accra, Ghana as one of two cities in Africa to benefit from an air quality monitoring capacity building project. The main reasons, among others, for selecting Accra include Ghana's successful phasing out of lead in gasoline.

The project seeks to accurately characterise the severity and nature of air pollution problems in Accra and to make recommendations for the development of a broad base AQM strategy for Ghana.

The main objectives of the project are to:

- Build and establish local capacity in air quality monitoring
- Collect and analyse ambient air quality data on key pollutants
- Provide policy makers with a 'snapshot' of the air quality situation in Accra and provide a basis to further develop an AQM strategy and
- Provide recommendations on next steps in developing a broad base AQM strategy for Ghana.

To achieve the above objectives, the following tasks were set out and implemented:

1. A Stakeholder Committee comprising relevant stakeholders was established in November 2004 with responsibility for decision-making on all aspects of the project.
2. Developed a Quality Assurance Project Plan (QAPP) for the implementation of the project.
3. Organised an Inception Workshop and Hands-on Training programmes with technical support provided by US EPA and Research Triangle Institute of USA.
4. Established air quality sampling sites in accordance with the air quality-monitoring plan
5. Organized a workshop to disseminate the outcomes of the air quality-monitoring programme.

As a party to the World Bank Clean Air Initiative in Sub-Saharan African Cities (CAI-SSA), Ghana successfully phased-out leaded gasoline in December 2003. As part of the phase-out programme, the EPA carried out sampling and analysis of Lead levels in soil, air and blood of high-risk groups (November 2002 to December 2003).The Agency and the Ghana Health Service are currently conducting a follow-up study to monitor trends in blood lead levels of high-risk groups after the phase-out of leaded gasoline.

The EPA is also carrying out a 'free' tail pipe vehicular exhaust emissions testing under the DANIDA funded vehicular emission programme. The aim of this project is to demonstrate to vehicle owners that maintenance pays and also to collect data for the development of vehicular emissions standards and regulations. Data from this project will also serve as input into the strategic environmental assessment of the transport sector, currently being carried out. The project is implemented in three phases:

a. Phase I of the vehicular exhaust emission programme involves determination of driving patterns, actual measurement of vehicular exhaust emissions, and analysis of data and development of vehicular exhaust emission standards and regulations;
b. Phase II of the programme deals with strategic environmental assessment of the transport sector; and
c. Phase III covers implementation of policies and enforcement of vehicular emission standards and regulations.

National response to air pollution (continued)

Projects having an AQ benefit:

The Government of Ghana has adopted a number of initiatives aimed at reducing industrial wastes and pollutants; decongesting the roads; reducing vehicular exhaust emissions and assessing health impacts associated with vehicular exhaust emissions. The following strategies have been adopted in Ghana to control urban air pollution:

1. Monitoring of air quality in residential, commercial, industrial and roadside areas to provide data for the development of enforceable standards and regulations to control air pollution in Accra and other parts of Ghana
2. Free testing of all categories of vehicles under the DANIDA funded vehicular emission sub-component of the transport sector programme. The aim of the programme is to develop vehicular exhaust emissions standards to facilitate the formulation and implementation of existing laws on air pollution and the control of vehicular exhaust emissions.
3. Expansion of road network across the country to facilitate easy movement of vehicles, goods and services and to reduce traffic congestion.
4. Introduction of Mass Transport System in 2001 to phase-out older vehicles and improve urban transport and air quality.
5. Assessment of lead reduction in the blood of high-risk groups

Indoor air pollution is another issue that is being addressed by EPA. The EPA plans to carry out extensive indoor air quality monitoring as part of CAI SSA and the 5-year strategic action plan on AQM, in collaboration with the Ministry of Energy and Enterprise Works of Ghana. This pilot project is expected to be funded by the Shell foundation. The project aims to produce and supply improved stoves for the rural/peri-urban population, and to assess and monitor indoor air pollution in the country (PCIA, 2006).

References:

Africaclean 2006 Ticking time bomb: Ground air pollution potential impact to the natural resources and socio-economic, human health development in Ghana – a rising concern. Africaclean Ghana Network. Website: http://www.africaclean.sn/IMG/doc-65.pdf

CIA 2007 Ghana. The World Fact Book. Central Intelligence Agency, Washington. Website: https://www.cia.gov/cia/publications/factbook/geos/gh.html

EN 2003 Ghana. Encyclopaedia of the Nations – Africa. Website: http://www.nationsencyclopedia.com/Africa/Ghana-INDUSTRY.html

GHS 2006 Annual Report 2005. Ghana Health Service, Accra. Website: http://www.ghanahealthservice.org/includes/upload/publications/GHS_2005_Report.pdf

Nerquaye-Tetteh EN 2006 Report on the status of air quality monitoring in Ghana. Contribution to the Planning and Implementation of the Policy Makers Session of the BAQ 2006 Conference, Nairobi, 26 – 27 July 2006.

PCIA, 2006 Partner Profile: Environmental Protection Agency, Ghana. Partnership for Clean Indoor Air, Washington. Website: http://www.pciaonline.org/partner.cfm?id=60

RTI 2005 Air sampling in Ghana and Tanzania to lead to public health improvements. RTI International. Website: http://www.rti.org/page.cfm?nav=647&objectid=8F381C17-B122-4ACF-B86C224F9CBFB770

Summary and analysis:

Key pollutants in the cities of Ghana are SO_2, NO_2, O_3, CO, black smoke, particulate matter (PM_{10}), total particulate matter (TSP) and lead. Vehicular exhaust emissions, open burning of waste and other materials, road dust, emissions from industrial sources, residential cooking, commercial activities and wind-blown dust are major contributors to air pollution.

Environmental legislation including fuel specifications for petrol and diesel is promulgated and enforced. Emission and air quality standards are still lacking. Several projects are being implemented in Ghana:

- Capacity enhancement to assess the nature and severity of the air pollution problems in Accra
- Emission testing to enhance public participation in control measures, develop emission standards and regulations, and reduce vehicular emissions
- Introduction of a mass transport system
- Follow-up of the lead study to assess reduction of lead blood levels in vulnerable persons
- Reducing industrial wastes and pollutants
- Decongesting the roads
- Assessing health impacts associated with vehicular exhaust emissions.

The USAID-US EPA-UNEP project and the projects already initiated by Ghana EPA present a good entry into AQM in Ghana. The continuation of air quality monitoring can be used to set enforceable air quality standards. WHO air quality guidelines may be used in setting standards and averaging times. The criteria for the derivation of air quality guidelines set by WHO are also valid for setting standards. Experience from developed countries may be used to collect information on the number of standards-exceeding values not leading to adverse health or environmental effects. A participatory approach in setting standards which involves stakeholders (e.g. industry, local authorities, non-governmental organizations, media and the general public) assures –as far as possible – social equity or fairness to the parties involved. The provision of sufficient information and transparency in standard setting procedures ensures that stakeholders understand the environmental, health and socio-economic impacts of such standards.

Regulations on emission standards for mobile and stationary sources, air quality standards, viable dispersion models and reliable monitoring procedures will ensure rational and sound AQM. This includes, where appropriate, the adoption of emission standards based on developed countries' experiences. Best available control technology avoids the problem of inequities among countries and prevents 'social dumping'.

Quantification of the contribution from different sources will help to set priorities in AQM which permit decide which sources should be first addressed. Dispersion modeling used to estimate pollutant concentrations would help test the validity of the emission estimates by comparison with actual measurement.

3.11 Guinea[11]

Driving forces, pressures and state of air pollution

Due to rapid growth of the population of 2.6 per cent (CIA, 2007), increased urbanisation and growth of industries the following pressures exist in Guinea:

- Emissions from a growing second-hand vehicle fleet
- Substantial and uncontrolled emissions from industrial plants (mining, power plants and incinerators)
- Emissions from open stove cooking and heating indoors in the absence of efficient ventilation
- Emissions from uncontrolled open air burning
- Insufficient road infrastructure

Industries include mining operations, an alumina smelter at Fria, agro-food processors, a textile complex, cement and plastic factories at Conakry, power plants, and a number of construction plants (EN, 2006).

No systematic scientific study has been performed and Guinea does not dispose of an air quality monitoring system in urban areas.

CO_2 emissions of Guinea during past years are estimated to be at the relatively low value of 1.3 million metric tons (EIA, 2006)

A pilot study on air quality in Conakry has been performed by the US EPA in collaboration with the Laboratory for Environmental Control and Expertise (EnvLabo) of the Ministry of the Environment from 11 January to 22 February 2004. In the vicinity of suspected sources, $PM_{2.5}$ and PM_{10} were monitored in minivol samplers and the lead content determined. NO_2, SO_2 and benzene were monitored using diffusive tubes. The data were analysed and results compared with US EPA standards and WHO guideline values. Lead was analysed by x-ray fluorescence spectrometry. $PM_{2.5}$ and PM_{10} concentrations were above the US EPA standards and WHO guideline values Formaldehyde concentrations also exceeded US EPA standards and WHO guideline values. NO_2, SO_2 and benzene concentrations were below the detection limit. Lead content was enhanced by an order of magnitude as compared to background concentrations due to the use of leaded gasoline in vehicles. As the refineries in Senegal and Ivory Cost, which provide fuels to Guinea, are producing only unleaded petrol, Guinea's air lead concentrations should be significantly reduced.

Summary of air pollution information

Nature of problem	Energy Production. Vehicles.
Status of monitoring	A routine surveillance system does not exist
Key pollutants	PM_{10}, $PM_{2.5}$, NO_2, SO_2, formaldehyde and benzene
Number of monitoring stations	0
Capacity to assess air pollution	Some capacity is present at the Laboratory for Environmental Control and Expertise
Air quality standards	Standards have to be promulgated

Impacts

The results of the US EPA pilot study suggest that the particulate matter levels affect public health. The increase in air pollution is partly responsible for the increase in respiratory illnesses such as asthma, bronchitis and respiratory infections observed during recent years.

National response to air pollution

Legislation.
At present, Guinea has no official criteria for regulating and managing air quality or official emission standards for mobile sources. Regulations to improve air quality and set fuel specifications for unleaded petrol and for diesel also do not exist. In order to overcome these challenges and formulate a plan of action for better air quality, international assistance is needed.

The responsibility for AQM is in the Ministry of Environment, supported by the Laboratory for Environmental Control and Expertise.

[11] Based on Kaloga (2006)

National response to air pollution (continued)

Planned projects having an AQ benefit. The following projects for improving air quality are envisaged:

- Identification of the means to promote better air quality in urban areas, mining zones and industrial areas
- Monitoring of principal pollutants: Lead and other pollutants including an assessment of the impacts of air pollution on public health in urban areas and the control of industrial sources
- Evaluation of the impacts of air pollutants on ecosystem equilibrium and public health
- Raising awareness and dissemination of information
- Regulation of emissions from stationary and mobile sources
- Phase out of lead in petrol.

The assistance of the ESMAP programme and support from international aid agencies is necessary to allow Guinea implement better air quality. An enhancement of the capacities of the existing institutions, notably those of the EnvLabo, would help to achieve this goal.

References:

CIA 2007 Guinea. The World Fact Book. Central Intelligence Agency, Washington. Website: https://www.cia.gov/cia/publications/factbook/geos/gv.html

EIA 2006 International Energy Annual 2004. Energy Information Administration. Website: http://www.eia.doe.gov/pub/international/iealf/tableh1co2.xls

EN 2005 Guinea. Encyclopaedia of the Nations – Africa. Website: http://www.nationsencyclopedia.com/Africa/Guinea-INDUSTRY.html

Kaloga S 2006 Etat des lieux et réglementation du contrôle de la pollution de l'air en milieu urbain en Guinée. Contribution to the Planning and Implementation of the Policy Makers Session of the BAQ 2006 Conference, Nairobi, 26 – 27 July 2006. Ministry of Environment,

Summary and analysis

According to a pilot study performed by US EPA air pollutant concentrations in Guinea for $PM_{2.5}$, PM_{10} and formaldehyde concentrations exceed US EPA standards and WHO guideline values in the vicinity of sources. Elevated concentrations of these compounds are due to emissions from an ageing fleet of vehicles and industrial and power plants without emission control devices. When Guinea had not yet phased out lead in gasoline, lead content in PM_{10} was enhanced by an order of magnitude. Now, since only unleaded fuel is provided by the refineries of neighbouring countries to Guinea, lead content should have decreased substantially. In the US EPA study NO_2, SO_2, and benzene concentrations were below their respective detection limits.

A routine monitoring system for particulate and gaseous compounds does not yet exist. Guinea did not yet promulgate legislation related to AQM. Projects to develop action plans for AQM are envisaged but their implementation needs the assistance of international programmes and agencies with respect to expert advice and funding.

AQM is, practically not existing in Guinea. Expertise is limited to conduct some small-scale monitoring with the support of US EPA. In order to increase expertise in AQM, a good starting point could be the setting of fuel specifications for new and imported second-hand vehicles. This includes the identification within a legislative and juridical framework of stakeholders in importation/production, distribution and storage to ensure the quality of petrol; setting specifications for new technologies; addressing regulatory aspects related to the import of vehicles; and raising stakeholder awareness.

The installation of a small network of permanent monitoring stations would help estimate the concentrations of PM. This is important because the results of the US EPA pilot study already indicate that the US EPA air quality standards are exceeded and corresponding health impacts such as respiratory ailments and symptoms are likely to occur in the population of Conakry. Other compounds such as SO_2 and NO_2 are probably of less concern since the initial results of the pilot study indicate very low values even in the vicinity of emitting sources. The problem of formaldehyde is likely to be very localized since according to the experience in developed countries formaldehyde usually is not widely distributed in an urban area.

Monitoring of particulate matter and subsequent analysis of its components can serve to apportion the contribution of various types of sources to the total PM concentration. This in turn will allow set priorities on which types of sources control measures will reduce outdoor air pollution most cost-efficiently.

3.12 Kenya[12]

Driving forces, pressures and state of air pollution

Due to rapid growth of the population of 2.57 per cent (CIA, 2007), increased migration and urbanisation the following pressures exist in Kenya:

- Emissions from a strongly growing vehicle fleet
- Bad state of the vehicle fleet of an elevated age
- Emissions from open air burning of waste and solid fuels, as illustrated in Figure Kenya_1.
- Emissions of uncontrolled waste incinerators

Major industrial centres in Kenya are found in the urban areas of Mombassa and Nairobi. Most of the manufacturing work is linked to the processing of agricultural products. Imported crude petroleum is refined on the coast.

Emission estimates only exist for CO_2.They show a slight increase during 1994-2004 to a value of 9 million metric tons (EIA, 2006).

Lead in gasoline has been phased out in Kenya since December 2005. The import of only unleaded gasoline was allowed from 1999 but the local refinery produced leaded petrol until 2005.

The Kenya Meteorology Department monitors ozone on a weekly basis on Mt. Kenya Station. The Kenya Medical Research Institute (KEMRI) and Kenya Energy and Environment Organizations (KENGO) did some studies on reported air pollution in Thika town on SO_x, NO_x, and particulate matter in 1996-1998 and 2000. The Global Atmospheric Watch (GAW) programme currently monitors background carbon dioxide on Mt. Kenya station. Prof. Gachanja of Jomo Kenyatta University has done some research on monitoring emissions from a few chemical industry and road site air quality along Nairobi –Mombasa highway.

Research performed by the Institute of Nuclear Science on suspended particulate matter in Nairobi indicates that the levels are 1.5-fold above 1987 WHO guidelines.

However, the results from monitoring air pollutants in laboratories using available monitoring equipments are considered as not reliable and do not represent the actual status of air quality in Kenya.

Indoor air quality studies by Intermediate Technology Development Group (ITDG) in rural houses in Kajiado indicated that the inhabitants are exposed to over 100 times

Summary of air pollution information

Nature of problem	Energy Production. Vehicles.
Status of monitoring	A surveillance system does not exist; monitoring is performed on an ad hoc basis mostly by individual institutions at universities
Key pollutants	PM, CO, HCs, NOx, SO_2
Number of monitoring stations	0
Capacity to assess air pollution	Capacity exists at universities and has to be enhanced
Air quality standards	Standards have to be promulgated

Figure Kenya_1: examples of uncontrolled open air burning

[12] Based on Langwen (2006)

National response to air pollution

Kenya does not have yet a comprehensive urban AQM programme in place. The responsibility for AQM is with the Ministry of Environment and the National Environment Management Authority (NEMA), in collaboration with other partners

Fuel specification.
Fuel standards have been set by the Kenya Bureau of Standards (KEBS) for regular and premium grade petrol (KEBS, 2003). They are compiled in Tables Kenya_1 and Kenya_2 in Section 6.

Air quality standards. The NEMA is charged with the role of formulating and enforcing emission standards and regulations. These legal instruments will cover emissions from stationary and mobile sources. The task force /committee formulating air quality regulations and standards is expected to complete the exercise in August and by September 2006 they should have been gazetted by the Minister of Environment

Projects having an AQ benefit.
The Ministry of Transport recently launched monitoring of emissions from PSV vehicles, which will be extended to all vehicles once NEMA gazettes comprehensive standards.

Reported challenges

- Development of appropriate legislation for effective AQM.
- Promulgation and enforcement of fuel, emission and air quality standards
- Raising public awareness
- Setting up a monitoring programme
- Accreditation of laboratories
- Standardization of sampling and analysis methods

References:

CIA 2007 Kenya. The World Fact Book. Central Intelligence Agency, Washington. Website: https://www.cia.gov/cia/publications/factbook/geos/ke.html

KEBS 2003 Kenya Standards. Motor petrol (Motor gasoline or motor spirits) Specification Part 2: Unleaded motor petrol. Kenya Bureau of Standards. Website: http://www.kebs.org

Langwen B 2006 Kenya's status of AQM. Contribution to the Planning and Implementation of the Policy Makers Session of the BAQ 2006 Conference, Nairobi, 26 – 27 July 2006.

Summary and analysis

Emissions in Kenya, especially Nairobi and Mombassa originate mostly from an ageing fleet of not well maintained vehicles and open air burning of household wastes, wood and charcoal. Emissions from industries such as agro-processing manufacturers, power plants and a refinery are of less importance. AQM is not yet performed in Kenya. The NEMA is charged with the role of formulating and enforcing air quality regulations and standards. Progress has, however, been slow due to lack of funding. A continuous monitoring programme does not exist. Monitoring of particulate matter is performed sporadically and on an ad hoc basis. Other sources of monitoring data include the Global Atmospheric Watch programme of WMO measuring background CO_2, and some studies of KEMRI and KENGO on PM, SO_x and NO_x. The Ministry of Transport recently launched monitoring of emission from PSV vehicles.

The capacity and capability to assess and manage air pollution in Kenya is undeveloped. Apart from fuel specifications for unleaded petrol and diesel emission standards and air quality standards have not been promulgated. A pilot project on monitoring of key air pollutants supported and accompanied by an agency from a developed country could be a useful starting point for initializing AQM. Results of well-planned air quality monitoring, which provides data of known quality can be used to set enforceable air quality standards. WHO air quality guidelines may be used in setting standards and averaging times since the criteria for the derivation of air quality guidelines set by WHO are also valid for setting standards. Experience from developed countries may be used to collect information on the number of standards-exceeding values not leading to adverse health or environmental effects. A participatory approach in setting standards which involves stakeholders (e.g. industry, local authorities, non-governmental organizations, media and the general public) assures –as far as possible – social equity or fairness to the parties involved. The provision of sufficient information and transparency in standard setting procedures ensures that stakeholders understand the environmental, health and socio-economic impacts of such standards.

Regulations on emission standards for mobile and stationary sources, air quality standards, viable dispersion models and reliable monitoring procedures will ensure rational and sound AQM. This includes, where appropriate, the adoption of emission standards based on developed countries' experiences. Best available control technology avoids the problem of inequities among countries and prevents 'social dumping'. Quantification of the contribution from different sources will help to set priorities in AQM which permit to decide which sources should be first addressed.

3.13 Liberia[13]

Driving forces, pressures and state of air pollution

Due to extreme growth of the population of 4.9 per cent (CIA, 2007), increased migration and urbanisation the following pressures exist in Liberia:

- Emissions from strongly growing vehicle fleet
- Bad state of the vehicle fleet of an elevated age
- Uncontrolled power plants

Air pollution is a major concern of the government of Liberia. The situation is characterised by a strongly growing old and badly maintained vehicle fleet, uncontrolled power plants and industries.

National response to air pollution

Liberia is party to the convention on Climate Change, the Kyoto Protocol and to the Montreal Protocol for Ozone Layer Protection (CIA, 2006).

AQM does not exist as a consequence of the war. At present there do not exist any legislation, action plans, projects or programmes relating to air pollution. A campaign for raising awareness of the problem of air pollution is seen as a major challenge.

The Ministry of Environment is the responsible agency.

Summary of air pollution information

Nature of problem	Energy Production. Vehicles.
Status of monitoring	A surveillance system does not exist
Key pollutants	PM, CO, NOx, SO_2.
Number of monitoring stations	0
Capacity to assess air pollution	Capacity is lacking
Air quality standards	Standards have to be promulgated

References

CIA 2007 Liberia. The World Fact Book. Central Intelligence Agency, Washington. Website: https://cia.gov/cia//publications/factbook/geos/li.html

Tarnue R 2006 Liberia-AQ Status_071806. Contribution to the Planning and Implementation of the Policy Makers Session of the BAQ 2006 Conference, Nairobi, 26 – 27 July 2006. Email to Jane Akumu, UNEP

Summary and analysis

As a consequence of the war AQM has not developed in Liberia. However, the Government is aware of the challenge of air pollution. Emissions are mainly from a rapidly growing fleet of old vehicles in a state of poor maintenance and from uncontrolled power plants. As capacity is lacking the first meaningful steps could be to raise public awareness on the impacts of air pollution on human health and the environment and provide some elementary training on the most important issues in AQM such as monitoring using simple monitoring devices within a pilot project. Rapid emission estimates and application of simple dispersion models could also be part of such training.

[13] Based on Tarnue (2006)

3.14 Madagascar[14]

Driving forces, pressures and state of air pollution

Driving forces in Madagascar include a rapid growth of the population of 3.03 per cent (CIA, 2007) and growing energy production for transport, industries and households. Pressures include

Growing fleet of individual vehicles and public transport (minibus) vehicles

- Bad state of the second-hand vehicle fleet of an elevated age
- Insufficient route infrastructure
- Emissions from industries
- Emissions from urban waste deposits

Industry consists largely of processing agricultural products and textile manufacturing. Madagascar runs a fertilizer plant producing urea-and ammonia-based fertilizers. Paper and cement manufactures also exist (EN, 2006). According to initial observations and results from dispersion modelling the vehicle fleet constitutes a major source of air pollution. It has also been shown that over several years the percentage of inept vehicles increases, as is indicated in Figure Madagascar_1.

Leaded petrol was prohibited by 1 January 2006.

At present emission estimates are only known for CO2. Figure Madagascar_2 shows at still small values a doubling of emissions since 2001 (EIA, 2006).

A workshop on air quality relating to technical specifications of fuels and other measures, conducted in collaboration with World Bank on 31 October 2005 in Antananarivo. The results and recommendations of this workshop are presented in Annex Madagascar_1 in Section 8.

A Master Plan for urban planning for several cities of Madagascar was elaborated in 2005

A study on exhaust gas control equipment in the test centre of Antananarivo was completed and delivered statistical information on the compliance of vehicles of different types with emission standards.

Monitoring of air quality compounds (PM, CO, HCs, NOx, and SO_2) was and is being performed at a few sites in Antananarivo by the National Institute of Science and Nuclear Technology (NISNT; INSTN).

Summary of air pollution information

Nature of problem	Industrial and energy Production. Vehicles.
Status of monitoring	Monitoring is performed at several sites in Antananarivo
Key pollutants	PM, CO, HCs, NOx, SO_2
Number of monitoring stations	Several stations exist
Capacity to assess air pollution	Capacity is existent in Antananarivo but need be extended to cover other cities
Air quality standards	Standards are not yet promulgated

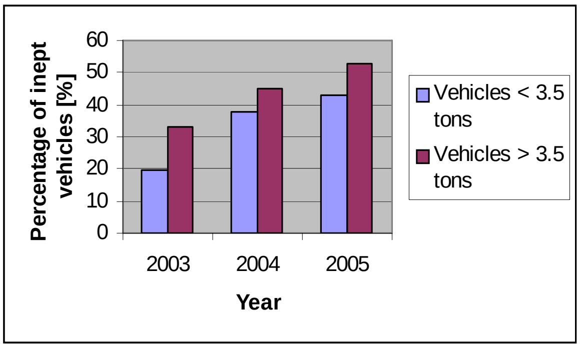

Figure Madagascar_1: Increase of inept vehicles below 3.5 tons and above 3.5 tons during 2003-2005.

[14] Based on Salama (2006)

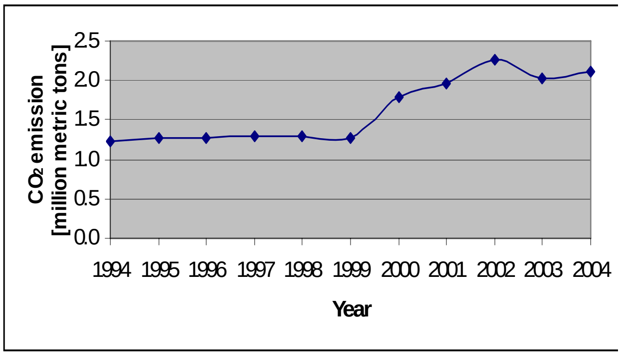

Figure Madagascar_2: CO_2 emissions of Madagascar 1994-2004

Reported challenges

As formulated in the 2005 workshop, the challenges for Madagascar are as follows:

- Prohibition of leaded petrol by 1 January 2006.
- Agree to an extension by 6 months in order to allow stored leaded petrol to be consumed and the cleaning of the tanks
- Allow for two ratings of unleaded petrol in the market SP 91 (red) and SP 95 (green)
- State that the adoption of SP 91 does not affect the financial constraints of importing e.g. SP 93
- Adjust the actual specification to the regional market situation
- Obligation to equip imported vehicles with catalytic converters as soon as the complete phase-out of lead is achieved
- Initiate discussions between OHM/concession holders/oil producers on the advantages of a unique rating of petrol of 91 RON, beginning 2007

National response to air pollution

Legislation. Madagascar has promulgated an Environmental Act and several decrees relating to technical specifications of fuels and emission standards for mobile sources. The laws and decrees are compiled in Table Madagascar_1.

Table Madagascar_1: Key environmental legislation

Legislation	N°	Content (Date of promulgation)
Act		Environmental law
Decree	6941/2000	Emission standards for exhaust gases from automobiles (06.07.2001)
Decree	8913/2002/MEM	Specifications for lead-free "Superpetrol" (31.12.2002)
Decree	155/2006	Specifications for lead free petrol of octane rating 91 (31.01.2006)
Decree	24.539/2004/MEM	Technical specifications for diesel (21.12.2004)
Decree	24.538	Technical specifications for petrol RON 91
Decree	24.540	Technical specifications for petrol RON 95
Decree	24.537?	Technical specifications for petrol RON 87

The responsibility for AQM is with several ministries and agencies including the Ministry of Environment, Water, and Forests, Ministry of Transport and Public Labour, Ministry of Energy and Mines, Urban community of Antananarivo, Madagascar Office for Hydrocarbons, National Environment Protection Agency, and the NISTN (INSTN).

The Ministry of Environment, Water and Forests has the mandate to implement the national action plan and the obligations from the Montreal and Kyoto protocols, the Basel, Stockholm and Rotterdam conventions.

The Ministry of Transport and Public Labour has the mandate to implement (i) the application of technical controls to vehicles though exhaust monitoring, (ii) measures to avoid traffic congestions in Antananarivo, and (iii) to develop a frame for urban planning and a plan for minimising trip length in the agglomeration of Antananarivo.

The National Institute of Science and Nuclear Technology is responsible for monitoring air quality.

National response to air pollution (continued)

Action plans. According to the deliberations during the Workshop on air quality in 2005 a national action plan is being elaborated and priorities set for the improvement of air quality.

Fuel standards. Fuel specifications for lead-free petrol of research octane rating 91 (RON 91) are promulgated in Decree No 155/2006/MEM and shown in Table Madagascar_2 in Section 6. There are also fuel specifications for lead-free petrol of RON 95 (see Table Madagascar_3 in Section 6) and RON 87 (see Table Madagascar _4 in Section 6), promulgated in Decrees No. 24.538 and 24.540 as of 21.12.2004. At the same date fuel specifications for diesel were set in Decree No. 24.539 and are compiled in Table Madagascar_5 in Section 6.

Emission standards. According to Decree No 6941/2000 the exhaust of diesel vehicles is controlled by measuring with an opacimeter (XR 743 NF) and that of petrol-driven vehicles with a gas analyser (XR 842), as approved by the government. The emission standards for diesel-driven vehicles are laid down in Table Madagascar_6 in Section 6; those for petrol-driven vehicles are laid down in Table Madagascar_7 in Section 6.

Projects/Programmes. The Ministry of Energy, the Ministry of Environment, the Ministry of Transport, the city of Antananarivo and the three offices are developing a study on the emissions of all sectors relevant in Antananarivo, i.e. transport sector, urban waste sector, industrial and manufacturing sector, and the energy sector. This study follows the frame of other similar studies that have been performed in Abidjan (Ivory Coast), Cotonou (Benin), Dakar (Senegal), Douala (Cameroon) and Ouagadougou (Burkina Faso) under the umbrella of the CAI-SSA.

Based on the recommendations which were elaborated in 2005 the following projects are envisaged

- Cost-benefit analysis on air quality in major cities
- Surveillance of air quality in Antananarivo
- Estimation of public health impacts of air pollution
- Improvement of urban transport (traffic flow, vehicle fleet composition, congestion charges)
- Revision of national legislation and regulations
- Education and training of bus and truck drivers

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EN 2005 Madagascar. Encyclopaedia of the Nations – Africa.Website: http://www.nationsencyclopedia.com/Africa/Madagascar-INDUSTRY.html

Salama JC 2006 Etat des lieux et réglementation du contrôle de la pollution de l'air en milieu urbain a Madagascar. Ministry of Environment, Water and Forests, Antananarivo. Contribution to the Planning and Implementation of the Policy Makers Session of the BAQ 2006 Conference, Nairobi, 26 – 27 July 2006.

Summary and analysis:

Key pollutants in the cities of Madagascar are PM, CO, HCs, NOx, and SO_2 which are monitored by NISTN (INSTN). The vehicle fleet constitutes the major source of air pollution. Madagascar has promulgated an Environmental Act and several decrees relating to technical specifications of fuels and emission standards for mobile sources. A national action plan is being elaborated and priorities set for the improvement of air quality. A study on exhaust gas control equipment in the test centre of Antananarivo was completed and delivered statistical information on the ability of vehicles to conform to emission standards. Several projects are envisaged relating to cost-benefit analysis, surveillance of air quality, emissions estimation, estimation of public health impacts, and improvement of traffic flow. A workshop was held in Antananarivo in 2005 dealing with the improvement of air quality in Antananarivo and the implementation of complete phase-out of lead in petrol.

Madagascar appears to develop a full-fledged AQM system addressing revision of legislation, emissions, dispersion, air pollutant concentrations, control measures, impacts and cost-benefit analysis. Although most of these projects are in the planning phase, it can be inferred that their implementation will sensibly reduce air pollutant concentration and exposure of the population and the environment. If the extension of public mass transport, use cleaner technologies, efficient energy use and land-use planning is also incorporated in the planned projects in addition to the improvement of traffic flow, Madagascar will have developed an integrated approach solve the transport challenge which can be transferred to other African countries. It would also be beneficial for a cost-effective approach to consider the synergies between reduction of air pollution and reduction of greenhouse gases.

3.15 Malawi[15]

Driving forces, pressures and state of air pollution

Due a high population growth rate of 2.38% per year (CIA 2007), extreme high dependence of the economy on agriculture, and depletion of forestry resources for fuel wood and agriculture and, the following pressures exist in Malawi:

- Emissions from a growing vehicle fleet (see Figure Malawi_1)
- Emissions from manufacturing industry
- Emissions from wild bushfires
- Uncontrolled industrial waste disposal
- Uncontrolled domestic waste disposal

Air pollution and climate change issues are currently relatively small environmental concerns.

Summary of air pollution information

Nature of problem	Vehicular.
Status of monitoring	A surveillance system does not exist
Key pollutants	PM, SO_2, CO, NOx, HCs.
Number of monitoring stations	One non operational at LIA (Lilongwe International Airport)
Capacity to assess air pollution	Capacity is available only at universities and in the private sector
Air quality standards	Standards have to be promulgated

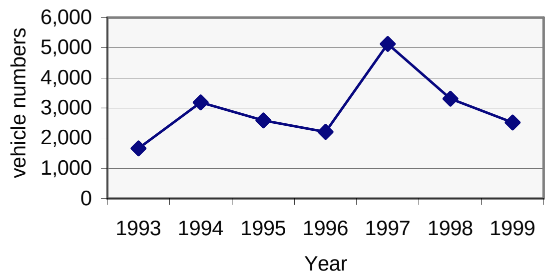

Figure Malawi_1: National vehicle population during 1993 - 1999

Source: APINA Factsheet 2003

Challenges

Reported challenges are (Malawi Vision 2020, 2005)

- enacting legislation on air pollution
- establishing regulations
- monitoring emissions of hydrocarbons nitrogen oxides and carbon monoxides
- proper management of hazardous substances and wastes
- use of ozone friendly technology
- promoting education on climate change issues.

Emissions

Emissions in Malawi have been estimated in 1995. For sulphur dioxide, nitrogen oxides, carbon monoxide, and volatile organic compounds emissions amounted to 16,000, 44,000, 1,300,000, and 127,000 metric tons, respectively (WRI, 2007). These emissions of these pollutants contribute about 0.3%, 0.4%, 0.7%, and 0.7%, respectively, of the emissions of SSA in 1995.

In 2000, emissions of nitrogen oxides were estimated to be 89,300 metric tons or 0.6% of SSA emissions (WRI, 2007).

Impacts

Samples of rain collected from an air pollution monitoring station at LIA (Lilongwe International Airport) have shown traces of sulphuric and nitric acid (MMT, 2006)

[15] Based on Apina Factsheet (2003) and Malawi Vision 2020

National response to air pollution

Malawi is party to the conventions on Climate Change, Hazardous Wastes, Desertification, Ship Pollution, the Kyoto Protocol and the Montreal Protocol for Ozone Layer Protection (CIA, 2007).

The main thrusts with respect to air pollution and climate change of the Government of Malawi's National Environmental Policy are (Malawi SDNP, 1999)

- Develop a data base on air pollution through the establishment of a sound air quality monitoring system.
- Develop and promote alternative energy sources to fuel wood and technologies in order to reduce the use of fuel wood and enhance carbon sinks.
- Enact a clean air act.
- Develop and enforce regulations regarding air emissions.
- Strengthen the existing national climate/meteorological database and monitoring networks.
- Assess and monitor the potential impact of climate change on the functioning ecosystems, vegetation patterns and net carbon sinks.
- Use climate data to help guide land-use and economic development decisions.
- Ensure adequate regional and international cooperation for the smooth exchanges of climate information and control of trans-boundary atmospheric air pollution.
- Reduce gas emissions from the transport sector, and the manufacturing industry.
- Support and maintain a National Ozone Protection Unit in order to promote use of ozone friendly technologies.
- Environmental awareness campaigns should include dangers of uncontrolled bush fires and proper management of bush fires

Air pollution issues are addressed by the Environment Management Act of 1996. The Act spells out the national strategy on the environment and environmental action plans. The National Environmental Action Plan (NEAP) addresses inter alia the driving forces mentioned above and some of the pressures on the environment.

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Summary and analysis

Air pollution and climate change issues are currently relatively small environmental concerns. As a consequence AQM has not developed in Malawi. However, air pollution and climate change can easily become serious problems if they go unchecked. The Government is aware of the challenge of air pollution. Emissions are mainly from a growing fleet of old vehicles in a state of poor maintenance and from uncontrolled power plants.

Strategic options to controlling air pollution and managing climate change issues in Malawi include:

- establishing stations to monitor air pollution
- establishing air quality standards;
- initiating supportive legislation and fiscal incentives;
- conducting awareness campaigns on air pollution and climate change;
- enhancing capacity for disaster preparedness through improving monitoring and information systems; and
- phasing out or controlling air polluting and ozone unfriendly or GHGs emitting technologies

As capacity is lacking the first meaningful steps would be to raise public awareness on the impacts of air pollution on human health and the environment and provide some elementary training on the most important issues in AQM such as monitoring using simple devices within a pilot project. Rapid emission estimates and application of simple dispersion models could also be part of such training.

3.16 Mali[16]

Driving forces, pressures and state of air pollution

Driving forces in Mali include a rapid growth of the population of 2.63 per cent (CIA, 2007), growth of industrialization, unprecedented urbanisation, and striving for economic growth. Pressures include

- Strongly growing vehicle fleet
- Uncontrolled growth of urban transport by two-wheelers
- Bad state of the vehicle fleet of an elevated age
- Uncontrolled incineration from open fires
- Insufficient infrastructure
- Doubtful quality of used petroleum products

The ageing and badly maintained vehicle fleet is a major polluter in Mali. Lead in petrol has, however, been phased out, reducing substantially lead exposure. Sulphur in diesel is at 5000 ppm.

The industrial zone is one of the most important causes of air pollution in Bamako. A big number of industrial plants is located in the industrial zone east of the city, with the prevailing wind direction East-West. The industrial zone emits each day gaseous pollutants from combustion processes. Because the city is located in a basin, the gases are slowly dispersed in the atmosphere and the city is exposed to toxic substances with corresponding risks for human health.

Mali has installed 19 power stations which do not use waste treatment facilities. 80 per cent of households use wood and charcoal for cooking and heating and only 20 per cent rely on electricity and other fossil fuels. In a UNEP report in 2000 these activities were identified as the main cause of air pollution in the majority of cities in developing countries.

The ageing vehicle fleet consumes 60 per cent of conventional energy and constitutes a major source of air pollution.

A network of air pollutant stations does not exist. A laboratory for analysis of data does not exist. It is, however, recognised that a surveillance system for air quality including monitoring of meteorological variables should be installed. At present no data exist for the concentrations of hazardous pollutant in Mali or the district of Bamako.

Air quality standards are not yet promulgated in Mali. It is, however, recognised that air quality standards must be established. The National Agency for Sanitation and Pollution Control (DNACPN) has identified the indicators for which standards have to be developed but the Committee for Chemistry and Environment has not yet adopted them.

Summary of air pollution information

Nature of problem	Industrial and energy Production. Vehicles.
Status of monitoring	A surveillance system does not exist
Key pollutants	PM, NOx, CO, HC, VOC, SO_2, Pb
Number of monitoring stations	0
Capacity to assess air pollution	Capacity has to be built
Air quality standards	Standards have to be promulgated

Impacts

At present epidemiological or toxicological studies on the association between the deterioration of air quality and potential health impacts do not exist. In spite of this the report notes that upper and lower respiratory infections affect on average 30 per cent of the total population and 40 per cent of children below the age of five. In a report of the WHO, Mali's PM_{10} concentration was classified between 21 and 25 µg/m3 (WHO, 2000) Studies show that an exposition to PM_{10} concentrations above 30 $\mu g/m^3$ increases the prevalence of bronchitis symptoms and a reduction in lung function parameters (WHO, 2003). Eye irritation and respiratory symptoms due to exposure to gases and suspended particles from traffic and waste incineration are supposed to be felt by pedestrians, particularly when waiting at traffic lights. Thus, increased PM_{10} concentrations in Mali could explain the increase in respiratory problems.

It is recognised that public participation and awareness raising on the effects of air pollution on public health and the environment is necessary.

[16] Based on Farota (2006)

National response to air pollution

Political will to improve the environment exists as is manifested by the creation of the Ministry for Environment and Sanitation. Mali has signed and ratified a large number of international conventions, accords and treaties which refer to the protection of the environment. These include the Vienna Convention, the Montreal Protocol, and the Biodiversity Convention.
It is recognised that the average age of the vehicle fleet should be reduced and technical controls be introduced as well as modifications in industrial processes are necessary with respect to raw materials, fuels, the treatment of emissions before they are expulsed though the chimneys.

Legislation. Acts on the environment and the control of pollution and nuisances have been promulgated in Mali. They are compiled in Table Mali_1.

Table Mali_1: Environmental legislation

Legis-lation	N°	Content (Date of promulgation)
Act	98-058	Environment Act (17.12.1998)
Decree	98-027/P-RM	(25.08.1998)
Act	01-020	Pollution and nuisance control (30.05.200)
Decree	01-394	Modalities of management of air pollutants (06.09.2001)

The Responsibility for AQM is with the Ministry of Environment and Sanitation (MEA), in collaboration with other partners such as the National Agency for Sanitation and Pollution Control (DNACPN) and the Technical Committee for Chemistry and Environment. The mission of the National Agency for Sanitation and Pollution Control is to elaborate the elements of the national policy with respect to sanitation and the control of pollutants and nuisances. Among other issues the agency is responsible for assuring pollution control and enforcement of the legislation.

Action plans.
A project with the title “Project of air quality surveillance in the District of Bamako” was elaborated by DNACPN. It comprises mobile and fixed monitoring stations, control of emissions and standard setting. Its realisation could ´lead to emergency planning and information to the public if certain thresholds are exceeded. The project is described in detail in Annex Mali_1 in Section 8.

Fuel standards. Since January 2006 the import of leaded fuel is prohibited. The following fuel standards for petrol of RON 91 have been adopted as shown in Table Mali_2 in Section 6.

Emissions

The per cent distribution of emissions for six pollutants emitted from different modes of transport are shown in Figure Mali_1

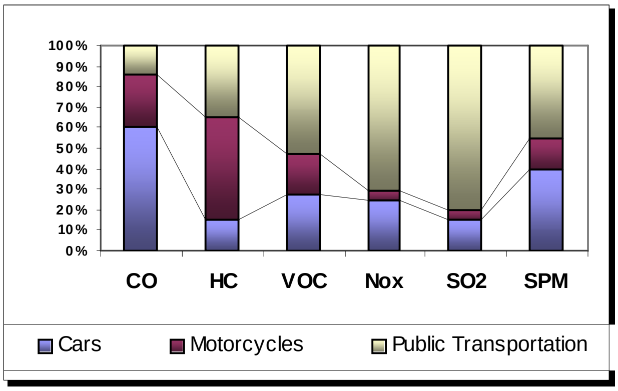

Figure Mali_1: Per cent emissions of cars, motorcycles and public transport
Source: Wane, 2001

Figure Mali_1 shows that 50 per cent of hydrocarbons are mainly emitted by motorcycles while 60 per cent of CO and 40 per cent of PM is emitted by cars. Public transport is responsible for about 80 per cent of SO_2 emissions, 70 per cent of NO_x emissions, 55 per cent of VOC emissions and 40 per cent of PM emissions.

Reported challenges

- Legislation for a rational AQM
- Reducing the age of the vehicle fleet
- Installation of a monitoring network
- Promulgation of emission and air quality standards
- Technical controls and modifications of industrial processes necessary
- Lack of financial means

References

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Summary and analysis

Key pollutants in the cities of Mali are PM, NO_x, CO, HC, VOC, SO_2 and Pb. Industrial sources in the vicinity to urban areas and the strongly growing vehicle fleet are major polluters in Mali. Leaded fuels were replaced by unleaded petrol of RON 91. The ageing vehicle fleet consumes 60 per cent of conventional energy and constitutes a major source of air pollution. Polluting industrial facilities are located near urban areas, especially in the city of Bamako, which is directly exposed to air pollution originating in the east of the city and dispersing in the main wind direction east-west. A network of air pollutant stations does not exist. No data exist for the concentrations of hazardous pollutant in Mali or the district of Bamako. The WHO has estimated that the mean concentrations of PM_{10} in Mali are ranging between 21-25 µg/m^3 (WHO, 2000). As this estimate includes rural areas and excludes indoor air pollution, PM_{10} concentrations in urban areas may be much higher. A laboratory for analysis of sampled data does not exist. Political will to improve the environment has recently been developed; as is shown in the promulgation of environmental legislation and the recent setting of fuel specifications for unleaded petrol. Emission and air pollutant standards are not yet promulgated although proposals by the DNACPN were presented for deliberation of the Committee for Chemistry and Environment.

With the promulgation of fuel specifications for unleaded petrol Mali made a step forward to initiate sound AQM. As Figure Mali_1 reveals public transport is responsible for most of SO_2 and NO_x emissions, half of VOC emissions and about 40 per cent of PM emissions. Replacing diesel for public buses by CNG, reducing the age of the bus fleet and introducing an inspection and maintenance programme could greatly reduce air pollution in the cities of Mali. These measures could even be taken without an extensive monitoring programme.

The project for air pollution surveillance in the city of Bamako as envisaged by the DNACPN is a very elaborate and costly one. It foresees monitoring in two phases using mobile stations with analyzers and a network of diffusive samplers in the first phase of 'moderate air pollution' and fixed stations equipped with automatic analysers and the diffusive sampler network in the second phase of 'serious air pollution'. It is assumed that between 2006 and 2011 air pollutant concentrations in Bamako are enhanced but comply with international air quality standards and can, therefore, be termed 'moderate' (phase I). After 2011 it is expected that international standards including WHO air quality guidelines are exceeded ('serious air pollution', phase II). This approach is very rigid and has some shortcomings: It emphasizes extensive and expensive monitoring without having an initial idea of the magnitude of air pollution levels in Bamako, which could be estimated in an elementary pilot programme or by dispersion modelling based on a rapid emission inventory. It assumes 'moderate' air pollution although the situation in parts of Bamako could already be 'serious'. It further uses criteria for 'moderate' and 'serious' air pollution which do not fit in the usual interpretation of data (e.g. in an air pollutant index where air pollution is considered 'serious' if standards or guidelines are exceeded by a factor of two or more).

A less sophisticated approach employing simple monitors and rapid assessment techniques for the assessment of emissions and health impact assessment could lead faster to cost-efficient results.

3.17 Mauritius[17]

Driving forces, pressures and state of air pollution

Population growth in Mauritius is low at 0.82 per cent (CIA, 2007). Driving forces in Mauritius include the growth of industrialization, urbanisation, and striving for economic growth. Pressures include

- Strongly growing vehicle fleet with a high percentage of older vehicles (Figure Mauritius_1)
- Poor state of diesel-driven buses, trucks and older passenger cars
- Low fuel quality

Motor vehicles are a major source of urban air pollution. Lead has been phased out in 2001. From 01 January 2003, only petrol-driven vehicles capable of running on unleaded gasoline are registered in Mauritius. The lead concentrations in air were reduced from an average of 0.1 $\mu g/m^3$ to trace levels.

Industries include food processing (largely sugar milling), textiles, clothing; chemicals, metal products, oil factories, dye factories, transport equipment, non-electrical machinery; and tourism. Power plants and industrial boilers are causing most of the pollution originating from stationary sources.

Air quality data for compounds other than lead are not reported. An emissions inventory does not exist. Impacts on human health and the environment have not been assessed.

Summary of air pollution information

Nature of problem	Industrial and energy Production. Vehicles.
Status of monitoring	A surveillance system does not exist
Key pollutants	PM, NOx, CO, SO_2.
Number of monitoring stations	0
Capacity to assess air pollution	Some capacity is existent but has to be enhanced
Air quality standards	Standards were set in 1998 and are under review

National response to air pollution

Legislation.
Acts on the environment and decrees on road traffic promulgated in Mauritius. They are compiled in Table Mauritius_1. The responsibility for AQM is with the Ministry of Environment, in collaboration with other partners, and the National Transport Authority.

Table Mauritius_1: Environmental legislation

Legislation	N°	Content (Date of promulgation)
Act	?	Environment Act (?)
Regulation	GN No. 105	Environment Protection (Standards for Air) Regulation (01.02.1999)
Regulation	GN No. 198	Road Traffic (Control of Vehicle Emissions) Regulation (11/2002)
Regulation	GN No. 35	Amendment to GN No. 198 (2003)

The Road Traffic (Control of Vehicle Emissions) Regulations provide for vehicle emissions standards, obligation of owners of large fleet of vehicles, offences and penalties.

The Ministry of Environment and Quality of Life has approved the constitution of a Technical Standards Committee in April 2003 to review the current air quality standards. An in-depth review exercise has been undertaken and recommendations have been formulated and submitted to Government in October 2005. The recommendations are summarised in Annex Mauritius_1, Section 8. The recommendations of the Technical Committee on Chemistry and the Environment are being analysed by Government prior to implementation in the short, medium and long term. The air quality standards of Mauritius as recommended by the Committee are summarised in Table Mauritius_2, Section 6.

[17] Based on Ramjewon (2006)

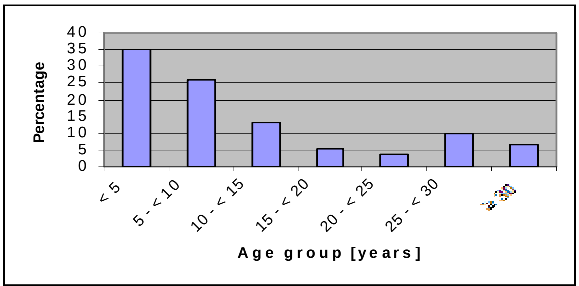

Figure Mauritius_1: Percentage of vehicles in different age groups, 2001.
Source PCFV (2005a)

Reported challenges

- Weaknesses in policy and implementation
- Poor enforcement
- Lack of proper land-use planning
- Lack of regular monitoring needed to assess the impact of poor air quality and to formulate effective policies.
- Irregular maintenance of truck and bus engines, leading to high emissions of NOx, CO and PM. Insufficient application of the cleaner production concept in industry and industrial air pollution abatement technology.
- One of the most important weaknesses in reducing vehicle emissions is the weakness of the local vehicle examination control.
- The financial attractiveness for unscrupulous people to mix kerosene with diesel or petrol for a quick profit is significant (due to a price differential between kerosene and diesel or petrol)
- Local laboratories do not yet have the capacity to measure all parameters; some specifications are tested abroad, incurring high costs
- Equipment to measure levels of CO and HC as per limits set out within the regulations have not yet been procured.
- Recommendations on deregistration of older vehicles (e.g. tax rebate after 12 and 18 years, tighten statutory age limit for heavy utilised vehicles, accreditation of scrap yards to issue certificates) have not been implemented.
- To quantify the different types of industrial pollution at the Vacoas-Phoenix Industrial Estate, analyse the effects of pollution, and propose solutions backed by cost-benefit analysis.

National response to air pollution (continued)

Fuel standards. As of September 2001, sulphur content in diesel is reduced to 0.25% by weight (2500 ppm).
Unleaded petrol of 95 RON is used as of September 2002. Benzene content is capped at maximal 5% by volume. Lab testing facilities have been set up at the Mauritius Standards Bureau to monitor some fuel specifications. Fuel specifications for petrol and diesel (Sexsmith, 2005) are compiled in Table Mauritius_3 and Table Mauritius_4 of Section 6.

Emission standards. Emission standards are set for stationary sources of all industries, power plants and industrial boilers. They are based on the best technology available locally and are summarised in Annex Mauritius_2 of Section 8.

Projects/Programmes. Several projects have been initiated which have or will have an AQ impact:

- Phase-out of lead in gasoline. A brief summary of this project with key challenges, lessons learnt and results is given in Annex Mauritius_3, Section 8.
- Control of vehicle emissions. A detailed description of this on-going project can be found in Annex Mauritius_4, Section 8.
- Introduction of unleaded motor gasoline. This is a project with AQ benefits which started in September 2000 and was completed in September 2002. It is summarised in Annex Mauritius_5, Section 8.
- Environmental Management of Industrial Estates (Vacoas-Phoenix Industrial Estate). This project started in December 2001 and terminated in March 2002. It relates to the use of cleaner production technologies and is a pilot project that will be used as reference for later projects on environmental management of industrial estates in Mauritius. The results are summarised in Annex Mauritius_6 of Section 8.

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Summary and analysis

The major air pollution problem of Mauritius is caused by vehicular emissions which are strongly increasing. Vehicles are old and not well maintained. Diesel driven truck are major polluters. Industry emissions are expected to be relatively low since heavy industry is absent in Mauritius. Most emissions from stationary sources are caused by power plants and industrial boilers.

Mauritius has promulgated an Environment Act and a regulation on road traffic control of vehicle emissions which provides among other issues for vehicle emission standards. Emission standards, based on the best available technology locally, are set for stationary sources of all industries, power plants and industrial boilers. The Government's strategy is to encourage the use of cleaner production technologies by enterprises.

Air quality standards proposed by the Technical Committee are being under consideration by the government. An integrated approach has been proposed towards tackling air pollution, comprising prevention, enforcement, monitoring and education. Sulphur content in diesel has been reduced to 0.25 per cent in 2001. Unleaded petrol was introduced in 2002. Lead concentrations in the ambient air decreased from an average of 0.1 $\mu g/m^3$ to trace levels after the introduction of unleaded petrol.

With the promulgation of fuel specifications for unleaded petrol and diesel, the setting of emissions standards for stationary sources, Mauritius has developed the tools to curb emissions on a command and control basis. The setting of the sulphur content in gas oil to 2500 ppm is among the lower values in Africa (PCFV, 2005b) although still high in comparison to the regulations in the United States and the European Union. As sulphur content in diesel is a major cause of sulphates further progress can be made by lowering this level.

Without knowledge of air pollutant concentrations in the cities of Mauritius, especially Port Louis and Valentina, it is difficult to promulgate enforceable air quality standards. Therefore, assessment of key air pollutants such as PM_{10}, SO_2, NO_2, and CO with simple monitors in a pilot project could help achieve the information for rational AQM. As industrial sources are also a contributor to air pollution in Mauritius although their contribution should be smaller than that from traffic, an initial source apportionment would be helpful to decide which source types should be addressed first with respect to implementing control actions. Source apportionment will also be useful in identifying the magnitude of transboundary air pollution.

3.18 Mozambique[18]

Driving forces, pressures and state of air pollution

Population growth in Mozambique is relatively low at 1.38 per cent (CIA, 2007). Due to rapid growth of the urban population, and the striving for economic growth the following pressures exist in Mozambique:

- Emissions from uncontrolled waste burning in urban areas (Figure Mozambique_1)
- Emissions from uncontrolled savannah, forest and agricultural fires
- Poor drainage, sanitation and waste disposal system
- Emissions of exhaust gases from vehicles
- Emissions from industries (point sources), particularly in Maputo
- Indoor air pollution from use of solid fuel

Industrial facilities include the MOZAL aluminium smelter, factories for titanium extraction and processing and garment manufacturing.

The Mozambique government has phased-out lead in gasoline in November 2005. Progress was however slow and the complete use of unleaded fuel only started by April 2006 (SANF, 2006)

Due to lack of equipment and funding a network to monitor and gases and particles does not exist. It is planned to start an

Impacts:

On 5th September 2000 a high Aerosol Optical Thickness index was observed, corresponding to the event of River of Smoke seen by satellite.

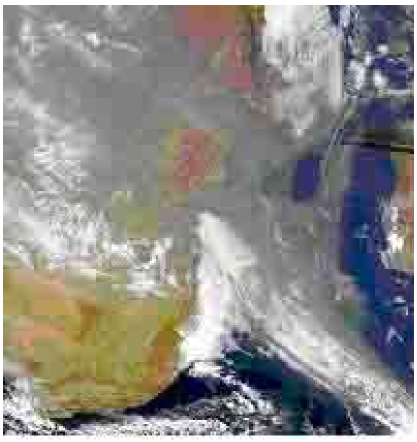
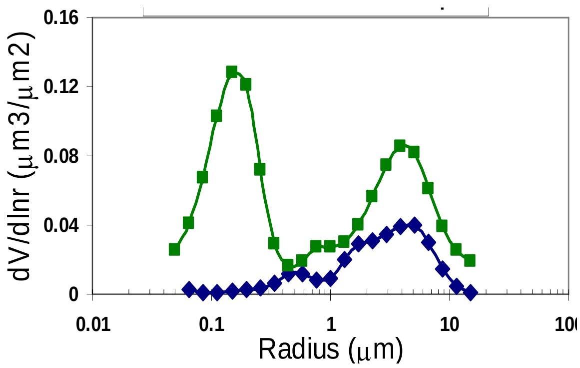


Figure Mozambique_2: Biomass burning smoke and haze exiting off east coast ("River of Smoke") in September 4, 2000 during SAFARI 2000 campaign (Satellite: OrbView-2 Sensor: SeaWiFS, NASA Goddard Space Flight Center)

Summary of air pollution information

Nature of problem	Waste burning Uncontrolled fires Industrial and energy production. Vehicles.
Status of monitoring	Monitoring network does not exist
Pollutants monitored	PM_{10}, $PM_{2.5}$, Black Carbon, SO_2, NOx, CO_2, O_3.
Number of monitoring stations	0
Capacity to assess air pollution	Exists in some University departments. .
Air quality standards	Are not yet promulgated

Figure Mozambique_1: Waste burning in Maputo
Source APINA Fact sheet Mozambique



Aerosol size distribution over Inhaca Island, retrieved from the CIMEL sun photometer.

[18] Based on Paipe (2006)

Impacts

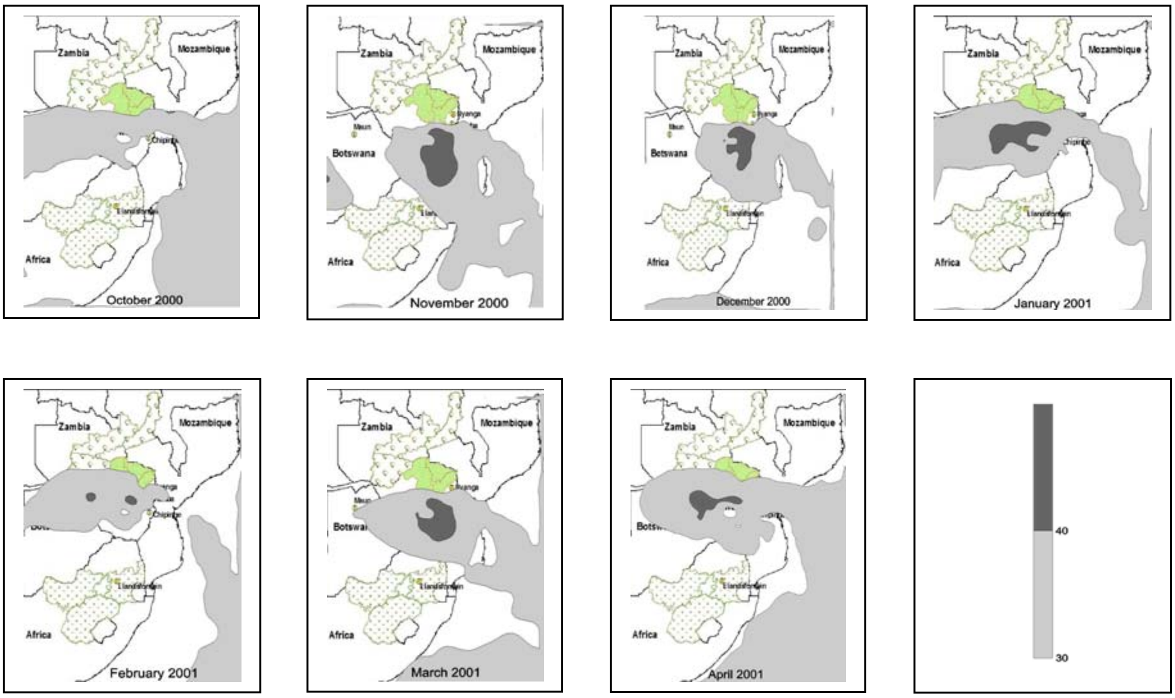


Figure Mozambique_3: Average daylight O_3 concentrations in ppb (van Tienhoven et al, 2006)

The figures show moderate ozone concentrations as a transboundary pollutant covering areas of Mozambique and some of its neighbours.

Reported challenges

- Capacity building in different disciplines;
- Public awareness about air pollution issues;
- Emissions from garbage burning and forest, savannah, and cultivation field fires
- Existence of point industrial sources specially in Maputo city producing dust;
- Emission from vehicles and uncontrolled industries
- Lack of Air Quality Standards;
- Lack of an effective waste management system in the cities;
- Shortcomings in law enforcement;
- Lack of funds to launch a fully fledged Air Quality monitoring program in the three major cities of the country.

Emissions

A rapid emission inventory is being developed on the basis of the APINA Manual. A first National Workshop is being envisaged to implement this project.

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Van Tienhoven AM, Zunckel M, Emberson L, Koosailee A, Otter L 2006 Preliminary assessment of risk of ozone impacts to maize (Zea mays) in southern Africa. Environmental Pollution 140: 220-230.

National response to air pollution

Legislation

Legislation	Content (Date of promulgation)
Act	Environment Act (07.1997)
Decree	Concession of Exploration of the Service of periodical Inspection of Vehicles Automobiles and Towings
Decree	Obligatory Periodical Inspection to the Vehicles Automobiles and Towings
Decree	Phase out of lead in petrol
Decree	Modalities of management of air pollutants

The responsibility for AQM is with the Ministry of Environment, in collaboration with other partners.

Action plans. An action plan was elaborated to raise public awareness on the benefits of the use of unleaded petrol and the phase-out of leaded petrol. An action plan to phase-out leaded petrol was developed in collaboration with several Ministries.

Fuel specifications.
Fuel specifications have been passed for gasoline RON 93 and gas oil in 1994 (Sexsmith, 2005). The specifications are compiled in Table Mozambique_1 and Mozambique_2 of Section 6. The gasoline specifications, however, still allow for leaded petrol. Diesel specifications in Mozambique allow for a sulphur content of 5,500 ppm, a high value when compared to those of its neighbour South Africa (PCFV, 2005).

Projects/programmes
The following activities are ongoing in the framework of APINA and will have an AQ benefit:

Modelling. Regional modelling of ozone distribution to study the impacts of air pollution on crop production (CAPIA network – Crops Air Pollution Information for Africa), see above. This project aims to

- Enhance capacity in dispersion modelling at national level;
- Train in regional scale modelling;
- Apply of models in impact assessment and validation studies; transboundary issues; climate modelling and weather forecast.

Rapid Urban Assessment at the Maputo city planned to combine emissions and pollution concentration data with GIS at city level. A rapid emission inventory for air pollutants including GHGs is being developed on the basis of the APINA Manual. A first National Workshop is being envisaged to implement this project.

Monitoring

- Running of a multi-parameter research station in Inhaca Island, Maputo situated in the pathway of the air masses from the sub-continent, to test the hypothesis of air recirculation in the Southern African region, see Figure Mozambique_4;
- Monitoring of PM_{10} and $PM_{2,5}$ with 6-hour time resolution, meteorological parameters, aerosol optical thickness using a sun photometer;
- Planning to start an Air Quality Monitoring program in Maputo city. The following gases and particles will be monitored: PM_{10}, $PM_{2.5}$, Black Carbon, SO_2, NOx, CO_2, Ozone;

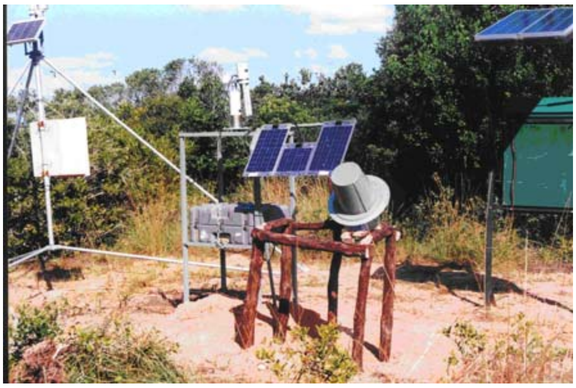

Figure Mozambique_4: The Inhaca Atmospheric Pollution Station

Summary and analysis

Sources in the cities of Mozambique include vehicle fleets, uncontrolled waste burning and forest and savannah fires, industries such as the MOZAL aluminium smelter and power plants. Indoor air pollution due to the use of solid fuels on open stove are an additional source which sometime even contributes to outdoor air pollution. Key pollutants in the cities of Mozambique are PM_{10}, $PM_{2.5}$, Black Carbon, SO_2, NOx, CO_2, and O_3. These pollutants are not monitored because of lack of funding to run a fully fledged monitoring system. Average daylight O_3 concentrations that have been modelled with the CAPIA (Crops Air Pollution Information for Africa) approach show moderate concentrations over large areas of Mozambique and some of its neighbours. Mozambique has promulgated an Environment Act and several decrees relating to phase-out of lead, obligatory inspection of vehicles, and modalities of air pollutant management. An action plan was elaborated to raise public awareness on the benefits of the use of unleaded petrol and the phase-out of leaded petrol. Fuel specifications, emission and air quality standards were promulgated in 1994. The specifications for gasoline, however, have become obsolete with the use of unleaded petrol since April 2006.

Other reported challenges for the implementation of AQM include the lack of expertise and capacity, lack of an effective waste management system in cities which is the cause of uncontrolled waste burning, and shortcomings in law enforcement.

Although progress has been made in phasing out lead, more has to be done in Mozambique towards the promulgation of fuel specifications for unleaded petrol and low-sulphur diesel. Currently, diesel has a sulphur content of 5,500 ppm, eleven times the value of its neighbour South Africa (PCFV, 2007). As sulphur content in diesel is a major cause of sulphates further progress should be made to lower this level. Further tools to curb emissions within a command and control approach would be to set emission standards for its industries and power plants.

The lack of a waste management system with transporting wastes to and incinerating wastes at a central facility, the uncontrolled burning of wastes in the cities of Mozambique will continue. This problem needs urgent attention because the emissions from uncontrolled burning of wastes including household wastes, tyres, electrical devices etc. emit not only the key pollutants but also VOCs, polycyclic aromatic hydrocarbons, and dioxins and furans. Some of these pollutants are carcinogenic and/or highly toxic. In order to protect public health, a viable waste management system could prevent open burning of wastes.

Without knowledge of air pollutant concentrations in the cities of Mozambique, especially Maputo, it is difficult to decide if air quality standards or guidelines are complied with. Therefore, the assessment of the concentrations of key air pollutants such as PM_{10}, SO_2, NO_2, and CO in a pilot project could help provide the necessary information for AQM.

Industrial sources are also a contributor to air pollution in Mozambique. Their contribution is expected to be smaller than that from traffic and uncontrolled waste burning and open fires. Source apportionment could be helpful to decide on control actions for industrial source types. The use of rapid inventory techniques could supplement this technique and provide valuable information.

3.19 Nigeria[19]

Driving forces, pressures and state of air pollution

Driving forces in Nigeria include a rapid growth of the population of 2.38 per cent (CIA, 2007) and growing energy production for transport, industries and households. Pressures include

- Strongly growing vehicle fleet
- Uncontrolled growth of urban transport by two-wheelers
- Bad state of the vehicle fleet of an elevated age
- Insufficient infrastructure
- Doubtful quality of used petroleum products

Nigeria is the 10th largest producer of oil in the world, and third in Africa. There are four refineries in Nigeria, and hydrocarbon production is centred on Eleme, Warri, and Kaduna.

The textile industry is still in early stages of development.

The Delta Steel Plant at Aladja supplies three steel rolling mills at Oshogbo, Katsina and Jos. In 1999 most of the steel mills were inoperative, and the ones that did work had very small production rates (EN, 2006).

The vehicle fleet constitutes the main source of air pollution.

Some of the major infrastructure brought in for research in the university in the early 1990s could not be mainitained at levels which could support sustainable research. In 1998, the Government in partnership with the World Bank purchased some low-cost units of air quality monitoring systems for each of the 36 states of the Federal Republic of Nigeria. Again these were not sustainable, because measures and framework for routine mainitence, spare-parts acquisition as well as funds for field sampling or measurement campaigns were not included as part of the project design. At the end, none of the equipment appeared to have been used to make reasonable measurements, which was needed for enhanced air quality managenent in Nigeria. Lastly, there are many facilities which are not obsolete but which are not optimally functional. The most significant of these are facilities to support elemental and hydrocarbon analysis, including AAS, XRF, GC, GC-MS, ICP-AES, FNAA, etc, which are available in many research institutions. Similarly, set-ups for sampling and consumables for sampling (filters, etc) are not easily replenished which lead to activities stagnation.

The current number of national experts capable of designing and implementing research programmes on AQM is critically low. The challenge is to increase the number by exploring programmes which to attract younger scientists to the field. Unfortunately, with poor funding and non-availability of scholarships, the hope of increasing the tempo of local training activities appear to be low.

Summary of air pollution information

Nature of problem	Industrial and energy production. Vehicles.
Status of monitoring	An operational surveillance system does not exist
Key pollutants	CO_2, CO, NO_X, O_3, SO_2, TSP, PM_{10}
Number of monitoring stations	One station in Lagos which is not operational
Capacity to assess air pollution	Capacity is existent but funds are lacking
Air quality standards	Standards are promulgated but need to be enforced

Impacts

The impact of the emissions quoted above on regional air pollution and air basin physico-chemical processes has not yet been assessed adequately due to the demand in quantity and scope of studies required to adequately isolate the problems. However, during the late 1980s to mid-1990s, various studies (Ogunsola et al, 1993 & 1994; Oluwole et al, 1994; Baumbach et al, 1995; Obioh et al, 1994, and Akeredolu, 1994) have been reported on the atmospheric mixing values of principal air pollutants: total suspended particulate (TSP), lead (Pb), SO_2, NO_x, VOC, CO, and some specific carcinogenic hydrocarbons such as benzene. In recent times, there have been attempt to consolidate and continue on not just urban level monitoring, but also to undertake in-depth assessment of specific urban sources. These are reported by Olisemeke (2002), Olise (2004), Obioh et al (2005), Owoade et al (2006a, 2006b), among others. Major results from the few available studies are that national and international air quality standards in the urban areas are violated. Apart from potential contribution to atmospheric acidification of the region, that atmospheric air quality standards are violated by many pollutants for a substantial part of the year also possess serious dangers to human health and ecology.

More detailed information on acid precipitation, urban temperatures, solar irradiance and greenhouse effect, heavy metals in biological indicators, and human health impacts can be found in Annex Nigeria_1 in Section 8. The Annex also includes the extensive reference list.

[19] Based on Obioh (2006)

Emissions

A comprehensive survey of sources and processes leading to emissions into the atmosphere has been carried out for 1988 and 1990. This has identified about 150 emission relevant processes in all major economic sectors. Although the mean annual emissions of air pollutants in Nigeria are low in comparison with emissions from the major developed countries, Lagos (which for many remained the federal capital and the most important industrial city in Nigeria), the oil producing areas, as well as other major urban centres, are isolated areas where high level of industrial activities may lead to enormous problems of environmental contamination. In 1990 for instance, the gross emissions and those from energy production and consumption were estimated as depicted in Table Nigeria_1.

Table Nigeria_1: GHG and air pollutant emissions 1990

	CO_2	CO	CH_4	NMVOC	NOx	N_2O
Gross emissions [Gg]	$178.3 \cdot 10^3$	$8.4 \cdot 10^3$	$40.3 \cdot 10^3$	580	350	8.1
Emissions from energy production [Gg]	$98 \cdot 10^3$	$5.1 \cdot 10^3$	280.8	437	105	3.5

After 1990 the emissions of carbon dioxide from energy consumption and gas flaring of fossil fuels ranged between 80 and 100 megatons and remained fairly stagnant, as is illustrated in Figure Nigeria_1 (EIA, 2006).

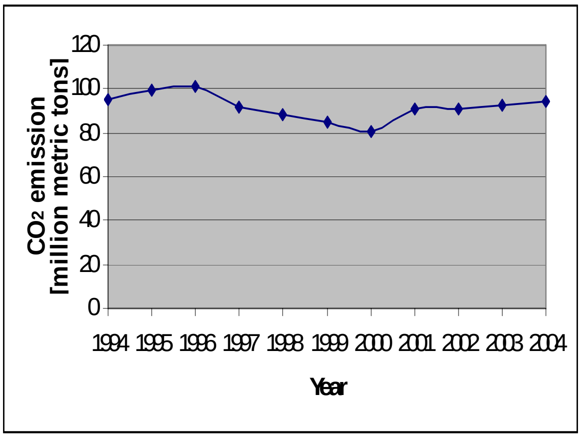

Figure Nigeria_1: CO_2 emissions from energy consumption and flaring

Figure Nigeria_2: Waste deposit in Lagos

Gas flaring and other oil and gas production activities in the Niger delta contributed more than 50% of total CO_2 emissions from energy production and consumption. The emissions from the major urban and industrial centre, Lagos, have been shown to be approximately 10% of total national emissions for most pollutants investigated.

The estimated NO_x specific emissions in the Niger Delta (for instance) range from 0.1 to 6.0 t/km^2/year and up to 10 t/km^2/year for Lagos State. These values are comparable to estimates for the NE USA (0.24 to 24 t/km^2/year) where acid rain is widespread. It is also known that SO_2 and NO_x account for a reasonable fraction of pollutants emitted into the atmosphere in the Niger Delta, Lagos and other major cities where intensive use of fossil fuels are carried out. The ambient concentrations of these pollutants in the areas close to major facilities exceeded FEPA limits. Similar values are expected in major cities where monitoring have so far not been carried out.

Reported challenges

- Lack of Major National Activities on AQM
- Low Capacity Development at Policy Level
- Sustainable Funding/Financial Support for research
- Low Capacity Human and Institutional Development at Research Level
- Sustainability of Facilities to Support Air Quality monitoring and Analyses

National response to air pollution

There are no streamlined national activities on AQM. Since the publication in 1991 of the Guidelines and Standards for Environmental Pollution Control in Nigeria (FEPA, 1991), very little activity has taken place to obtain baseline data on ambient air pollution levels, source data on emission factors and annual/monthly emissions for point and area sources, as well as the trends in air quality to date. These are needed to provide indication whether the problems is on either the increase or decrease and the mitigative measures needed to reduce the potential future impacts. This information base is needed at the policy level. The absence of major national activities on AQM is indicative that the status of the potential impacts is not known and cost-effective approaches to mitigate is not yet part of national planning. This leaves the country with adoption of adhoc measures with all the inherent risks that are associated with such measures.

It has been difficult to obtain the attention of policy makers to see AQM programmes as a major national task that potends great threat to human health, food security and other threats, which the United Nations Milenium Development Goals are expected to address.

Legislation.
Key laws relating to the environment are shown in Table Nigeria_2.

Legis-lation	N°	Content (Date of promulgation)
Decree	58	Federal Environmental Protection Agency (1988)
Standard	?	National guidelines and standards for environmental pollution control
Regulation	S.1.8	National effluents limitations (1991)
Regulation	S.1.9	Pollution abatement in industries and facilities (?)
Regulation	S.1.15	Management of solid and hazardous wastes (?)
Decree	86	Environmental Impact Assessment (1992)
Standard	NIS 116	Standard for Premium Motor Spirit (Petrol) Revised (2003)
Standard	NIS ?	Standard for automotive gas oil (2003)

The Federal Environmental Protection Agency (FEPA) is charged with the responsibility of protecting the environment in Nigeria, FEPA is authorised to, among other things, establish and prescribe national guidelines, criteria and standards for air quality and atmospheric protection, gaseous emissions and effluent limits; to monitor and control hazardous substances, supervise and enforce compliance. FEPA has been given broad enforcement powers, even without warrants, to gain entry, inspect, seize and arrest with stiff penalties of a fine and/or jail term on whosoever does not comply with environmental law (Adegoroye, 1994).

Fuel standards.
Fuel standards have been set by the Standards Organisation for Nigeria for petrol and gas oil. For petrol the specifications are compiled in Table Nigeria_3 and for diesel in Table Nigeria_4 of Section 6. Table Nigeria_4 shows that the actual sulphur content in diesel produced in Nigerian refineries is 1330 ppm, the lowest value reported for African countries.

Emission standards.
No emission standards for mobile and stationary sources were reported.

Projects/Programmes. Despite the high levels of air quality deterioration in Nigeria, the tempo of research has slowed down. Earlier research was carried out under the Environmental Monitoring and Impact Assessment Project funded by the European Community under the EEC/ACP Lome III Agreement. There appears to be no major national level activities on AQM which could be reported. However, some research level activities have been on-going projects within the limits of resources and human capacity available. The following activities are identifed as possibly on-going projects or have the prospect of being implemented in the near future.

- AQM study in Lagos;
- NIMET-ARIAL programme to revamp the Lagos automatic ambient air quality station;
- Calabar air-shed systematic monitoring and assessment project;
- Source-receptor assessment of urban aerosols in Ikeja and environs, Lagos State;
- Development and implementation of urban air-shed dispersion modelling for urban air quality forecasting: Pilot study for Lagos and Abuja.

Details about these projects can be found in Annex Nigeria_2 of Section 8.

The Lagos Metropolitan Area Transport Authority (LAMATA) has commissioned an Air Quality (Vehicle Emission) Monitoring Study which aim set tail pipe emission standards for Lagos,

The projects described above can have an AQ benefit when they lead to the formulation of action plans.

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WHO 2000 Polluted cities: The air children breathe. World Health Organization. Website: http://www.who.int/ceh/publications/11airpollution.pdf

Summary and analysis

The key pollutants in the cities of Nigeria are CO_2, CO, NO_X, O_3, SO_2, TSP, and PM_{10}. Mean annual emissions of air pollutants in Nigeria are reported to be low. The WHO estimates that country-averaged PM_{10} concentrations in Nigeria range between 21 and 25 $\mu g/m^3$ (WHO, 2000). Much higher concentrations may be prevalent in Lagos and other cities. In Lagos the oil producing areas, as well as other major urban centres, have got a high level of emissions from industrial activities apart from traffic emissions. Air quality monitoring is hampered by the breakdown of monitoring devices and the scarcity of spare parts. Actual pollutant levels are, therefore, unknown in the major cities of Nigeria.

There are scant Nigerian health impact assessment studies and the potential impact of air pollution on public health is not known. There are no streamlined national activities on AQM, and cost-effective approaches to mitigate impacts is not yet part of national planning.

Nigeria has promulgated a number of decrees and regulations with respect to environmental management. The FEPA is charged with the implementation of the legislation and has been given broad enforcement powers. The major challenge in Nigeria, as related in the report of Obioh (2006) appears still to be the enforcement of the existing legislation, which is persistent even 12 years after FEPA identified this challenge (Adegoroye, 1994). Obviously, this is an issue that has to be addressed urgently.

Monitoring was performed at one site in the city of Lagos. It can be safely assumed that fine particulate matter is the main causative agent for the reported adverse effects. As the existing monitoring devices are not operational, current air pollutant levels remain basically unknown. Provision of essential spare parts and calibration equipment could help revamp the monitoring station. A set of diffusive monitors could be used to build up a spatially representative monitoring system for gaseous compounds which is cost-effective. Monitoring of fine particulate matter by dustTraks at a number of sites could, therefore, be helpful to assess the exposure of people and estimate the risk of adverse health impacts using established exposure-response relationships. Rapid assessment methods would be needed to estimate approximately the contributions of major sources to air pollution. Such methods are cost-effective and provide initial emission estimates. Once these actions are completed control measures or process changes for industrial and power plants can be devised to reduce missions.

Setting emission standards for mobile sources would fcilitate the control of the quality of imported second hand cars and other vehicles Without an operational inspection and maintenance programme it is not possible to qualify the performance of all vehicles run in Nigeria. Vehicles equipped with catalytic converters loose the cleaning capacity after two years of operation if not maintained.

A major problem in Lagos and other cities of Nigeria is uncontrolled smouldering of waste deposits and a multitude of open air fires used to incinerate wastes. Their emissions are unknown and may be a major contributor to the deterioration of air quality. Raising public awareness and discouraging the practice of open fires could help clean the air in a most cost-effective way.

In the long-term a public mass transport system could be envisaged to satisfy public demand for mobility.

3.20 Rwanda[20]

Driving forces, pressures and state of air pollution

Due to rapid growth of the population of 2.43 per cent (CIA, 2007) and it's striving for economic growth the following pressures exist in Rwanda:

- Strongly growing vehicle fleet
- Uncontrolled growth of urban transport by two-wheelers
- Bad state of the vehicle fleet of an elevated age
- Insufficient infrastructure
- Doubtful quality of used petroleum products

Industries in Rwanda are small-scale and include a cement factory, agricultural products, small-scale beverages, and household products (Wikipedia, 2005).

The vehicle fleet constitutes the main source of air pollution.

There are no emissions or air quality data available in Rwanda. Air quality standards are not yet set. Impacts of air pollution are unknown. Public awareness in Rwanda is low.

National response to air pollution

The Rwanda Energy policy goal is to meet the energy challenges and needs of the Rwandan population for economic and social development in environmentally sound and sustainable manner. About 70% of all petroleum products are consumed within the transport sector. The energy challenge within the transport is to ensure efficient and safe use of petroleum products. The responsible agency for AQM is the Ministry of Environment, supported by other partners. Rwanda has phased-out lead in 2006.

Fuel standards

Standardisation of vehicles and quality control of petroleum products are insufficient. There is a need to adopt, adjust and develop technical and product quality in accordance with internationally accepted standards and norms.

Projects/programs

There are no projects or programmes yet in Rwanda.

Summary of air pollution information

Nature of problem	Energy Production. Vehicles.
Status of monitoring	A surveillance system has to be implemented
Key pollutants	Have not been identified
Number of monitoring stations	0
Capacity to assess air pollution	Capacity is non-existent
Air quality standards	Standards are not promulgated

Reported challenges

- Lack of legislation and regulations
- Identification of important air polluters
- Assessment of urban air pollution
- To establish norms and regulations on fuel quality
- To promulgate emission and air quality standards
- To evaluate the funds needed for purchasing materials and equipments for air quality control
- To build up capacity on AQM

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[20] Based on Gashugi (2006)

Summary and analysis

AQM does practically not exist in Rwanda. Expertise is apparently very limited if it exists at all. In order to increase expertise in AQM, a good starting point would be the setting of fuel specifications for new and imported second-hand vehicles. This includes the identification within a legislative and juridical framework of stakeholders in importation/production, distribution and storage to ensure the quality of petrol; setting specifications for new technologies; addressing regulatory aspects related to the import of vehicles; and raising stakeholder awareness.

Setting fuel specifications for unleaded petrol and diesel in Rwanda will help reduce emissions from petrol- and diesel-driven vehicles.

The installation of a small network of permanent monitoring stations in order to identify key compounds and estimate the concentrations of particulate matter and gaseous compounds could provide information on further steps in AQM. A pilot project consisting of small-scale initial monitoring could be sufficient in order to determine if there is a pollution problem in Rwanda and of which magnitude. Simple and cost-effective monitoring devices exist for assessment of AQ such as dustTraks for PM and diffusive tubes for gaseous compounds. For the analysis of diffusive samples laboratory capacity would be needed, which often can be provided by the provider of the devices if it does not exist in the country. Monitoring of particulate matter and subsequent analysis of its components can serve to apportion the contribution of various types of sources to the total PM concentration which in turn will allow setting priorities on which types of sources should be addressed first in applying control measures.

3.21 Senegal[21]

Driving forces, pressures and state of air pollution

Due to rapid growth of the population of 2.34 per cent (CIA, 2007), increasing urbanisation and economic growth the following pressures exist in Senegal:

- Strongly growing vehicle fleet
- Bad state of the vehicle fleet of an elevated age
- Insufficient infrastructure
- Emission from industries and vehicles

Agro-industry (oil mills, sugar refineries, fish canneries, flour mills, bakeries, beverage and dairy processing, and tobacco manufacturing) plays a key role in industries of Senegal. Especially important are groundnut-processing mills. The textile industry includes four cotton-ginning mills, factories for weaving, dyeing, and printing cloth, and plants that produce mattresses, thread, and hats. Cement, refined petroleum products, fertilizers, and phosphoric acid are produced. Other industrial products include plywood, boats, bicycles, soap, leather goods, paints, acetylene, sulfuric acid, and cigarettes. There is a refinery at Dakar, with production capacity of 27,000 barrels per day (EN, 2006).

The vehicle fleet constitutes the main source of air pollution.

Dakar is the most polluted city of Senegal. Air pollutants originate from automobiles (75 per cent of vehicles licensed in Senegal) and from industries (90 per cent of Senegal's industries are located in Dakar). These facts together with the state of the vehicle fleet, the geographic situation, and the population density determines the exposure of Dakar's population.

The AQM Centre in Dakar will deal with a network of five monitoring stations, four of which are stationary and one mobile.

A recent study (World Bank, 2005), performed in the framework of the project "CAI SSA" show high pollution levels for PM_{10}, $PM_{2.5}$ and CO on streets of "canyon" type with high traffic volume. Under unfavourable meteorological conditions PM10 concentrations exceeded by a factor of 20 a corresponding guideline. This situation is exacerbated in certain periods of temperature inversions.

Summary of air pollution information

Nature of problem	Energy Production. Vehicles.
Status of monitoring	A surveillance system is being implemented
Key pollutants	PM_{10}, $PM_{2.5}$, CO
Number of monitoring stations	0
Capacity to assess air pollution	Capacity is small but being enhanced
Air quality standards	Standards are not yet promulgated

Impacts

A World Bank study estimated the annual costs of air pollution to amount to FCFA 65 billion and stated that 20 per cent of the population are exposed to high concentrations exceeding the short-term standard and low concentrations exceeded the long-term standard for 70 per cent of the exposed population (World Bank, 1999).

Emissions

A study of the World Bank showed that road transport was responsible for 94 per cent of HC emissions, 99 per cent of particle emissions and 46 per cent of CO_2 emissions, much higher than the world mean of CO_2 emissions of about 22 per cent (World Bank, 1999).

Under the component "Air Quality of the "Programme for Improvement of Urban Mobility (PAMU), the Department for Environment and Classified Establishments (DEEC) and the Executive Council of Urban Transport in Dakar (CETUD) have endeavoured to install an AQM Centre in Dakar. Among other issues, this centre will have to develop an emissions inventory for Dakar.

[21] Based on Anonymous_1 (2006)

National response to air pollution

A sectoral policy on the environment was developed in 2002. Its objectives are to enhance planning capacity, co-ordination of actions to preserve the environment in collaboration with all stakeholders, to promote sustainable ways of production and consumption, promote public awareness and behaviour towards a better environmental management and use of resources by means of education, training and information dissemination.

Legislation.
Key regulations are compiled in Table Senegal_1.

Table Senegal_1: Legislation, decrees and rules

Legislation	N°	Content (Date of promulgation)
Act	2001-01	Environment Act (15.01.2001)
Decree	2003-415	Specifications of hydrocarbons in petrol and sulphur in diesel
Rule	NS 05-062	Air pollution of stationary and mobile sources (?)
Rule	NS05-060	Limit values for CO and HC for petrol-driven vehicles and opacity for diesel vehicles (?)

The responsibility for AQM in Senegal is with the Ministry of Environment and Nature Protection (MEPN) through its Department for Environment and Classified Establishments (DEEC), in collaboration with other partners such as the industry, energy and transport sectors. The DEEC is responsible to implement the policy of the Government related to the protection of the public and the environment against all forms of pollution and nuisances. Among other issues it is, therefore, charged with developing legislation and regulations relating to air pollution and implementing appropriate measures for prevention and control of air pollution.

The CETUD and the Centre for AQM in Dakar are responsible for urban transport issues and AQM, respectively.

Action plans.
A National Plan of Action for the Environment was formulated in 1997. It already underlined the importance of air pollution for public health and its consideration in strategies for information dissemination of and education and communication on environmental issues in urban areas. It is planned to implement an operational air quality surveillance network and a Regional Observatory in the framework of the project “Air Quality in Dakar”. The implementation should help to identify national priorities with respect to better air quality and work out proposals for decision makers. The Regional Observatory is some kind of inter-institutional platform which analyses the information received from the AQM Centre of Dakar and the action plans concerning political, juridical and technical aspects. The Regional Observatory, therefore, constitutes an important tool for any integral strategy for better air quality.

Fuel standards
Decree No 2003-415 regulates the quality of fuel and requests the phase out of lead in petrol before end 2005. It also limits the sulphur content of diesel to 0.5 per cent or 5000 ppm. Gasoline specifications and test methods for 87 RON are shown in Table Senegal_2, and for 95 RON in Table Senegal_3, both in Section 6. Table Senegal_4, Section 6 shows specification for paraffin oil. Gas-oil and diesel specifications are compiled in Table Senegal_5 and Table Senegal_6 (Section 6), respectively. Fuel oil of a kinematic viscosity of 180 centi Stokes (cSt) is subject to the specifications shown in Table Senegal_7 (Section 6).

Projects/programs

Under the component "Air Quality of the "Programme for Improvement of Urban Mobility (PAMU), the DEEC and the CETUD have endeavoured to install an AQM Centre in Dakar. That centre will deal with a network of five stations, four of which are stationary and one mobile. The activities, presently limited to the region of Dakar, are implemented and/or being implemented with international technical assistance. These activities include

- Evaluation of the AQM structure in Dakar;
- Support/advice regarding legislation on air quality;
- Installation of the AQM Centre at Dakar ;
- Evaluation of air quality levels
- Emissions inventory;
- Training of Centre personnel.

An important aspect of the project is its sustainability when the technical assistance finishes after four years. It is the aim to unite all means of political support, competent human and sufficient financial resources to make the system operational at the ending of technical assistance. The Nordic Development Fund (NDF) co-finances the project "AQM Centre together with the Government of Senegal at a total cost of 3.2 million USD.

Another ongoing project is entitled "Sensibilisation on the environmental challenges of the inland transport sector". This project implements actions to inform and raise awareness among different stakeholders, particularly civil society, the media and students about the challenges of pollution from transport and related health hazards.

A further project addressing exclusively students with regards to awareness raising has been elaborated and awaits funding.

The successful implementation of the projects described above will have an air quality benefit.

Reported challenges

In the framework of the sectoral policy on the environment, developed in 2002, three objectives comprehend the challenges for clean air, namely

- Enhancement of planning capacity; co-ordination of actions to preserve the environment in a context of high responsibility of stakeholders
- Promotion of sustainable ways of production and consumption
- Promotion of public awareness and behaviour to achieve good environmental management and use of resources through education and training, sensibilisation and information dissemination on environmental issues.
- Promulgation of emission and air quality standards

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Summary and analysis:

In Senegal, there are emissions from small-scale industries and from a fleet of vehicles. Uncontrolled growth of the vehicle fleet, particularly motor bikes, a bad state of the ageing vehicle fleet and doubtful quality of used petroleum products contribute to air pollution. The vehicle fleet is the source of most of air pollution. Senegal has set fuel specifications for petrol, diesel and paraffin oil. A four-year project has been started to evaluate the institutional AQM structure in Dakar, assess air quality levels, and install an AQM centre in Dakar. Monitoring is not in place yet. An air quality surveillance network is being planned. A Regional Observatory as an inter-institutional platform for analysing information obtained from the AQM Centre of Dakar is considered to help developing an integral strategy for better air quality. A national plan of Action was formulated in 1997 and is being implemented.

The installation of the AQM centre in Dakar and the creation of a Regional Observatory will enable Senegal and, in particular, Dakar to address the AQM in a rational and comprehensive way. As a consequence air quality monitoring can be started the results of which will allow to assess the situation and can be used to set air quality standards enforceable in Senegal.

Monitoring should start by using simple easy-to-use devices, e.g. diffusive samplers for gaseous compounds and portable, battery-operated laser photometers with real-time mass concentration readings and data logging capability for particles of respirable size. The envisaged training of the centre personnel in the use of monitoring devices, data collection and evaluation is an important aspect of the centre's work. Data produced should be of known quality; this requires the implementation of a QA/QC plan.

A necessary step in achieving rational AQM is an emissions inventory. This has also been envisaged as one of the tasks of the centre. The application of rapid assessment methods such as those developed by APINA and WHO, are suitable to deliver an initial emissions inventory in the city of Dakar. Training of the personnel is essential for achieving reliable results. When the emissions inventory is complemented by a simple easy-to-use dispersion model, air pollutant concentrations can be estimated all over the city and compared to monitored values. Together with demographic data the simulation will help to evaluate public exposure.

Senegal/Dakar has not yet promulgated AQS. Once air quality monitoring has started and concentration values have been obtained AQS will facilitate the interpretation of monitoring results with respect to their health significance.

Dakar has both vehicular and industrial sources. Enforcement of emission standards for both source types can help reduce air pollution in Dakar, particularly if. emission standards for mobile sources contain specifications for new and second-hand vehicles. In addition, the application of best available control technology avoids the problem of inequities among countries, prevents 'social dumping' and favours economic development.

As Dakar also has emissions from stationary sources the quantification of the contribution from different sources to air pollutant concentrations will help set priorities in AQM and permit decide which sources should be first addressed. Dispersion modelling used to estimate pollutant concentrations which can be compared with actual measurements can test the validity of emission estimates and the applicability of the model.

3.22 Swaziland[22]

Driving forces, pressures and state of air pollution

The population is not growing in Swaziland since the rate is -0.23 per cent (CIA, 2007). Due to industrialisation and urbanisation the following pressures exist in Swaziland:

- Growing vehicle fleet
- Emissions from industries
- Emissions from burning landscapes
- Indoor air pollution from solid fuel use
- Emissions from uncontrolled waste burning

Industries that contribute significantly to air pollution include pulp and paper manufacturing, textile, food processing, sugar mills, sugar cane fields and many small industries. Solid waste disposal sites also contribute to air pollution and odours as a result of continuous burning at these sites. The vehicle fleet also contributes significantly to outdoor air pollution.

Leaded petrol was replaced by the use of LRP, with manganese as a metal additive. However, making the LRP more expensive the one with lead replacement additive discourages the use of LRP. This has resulted in the sharp increase in the consumption of the unleaded petrol. Figure Swaziland_1 shows the consumption of the different types of petrol from August 2005 to April 2006.

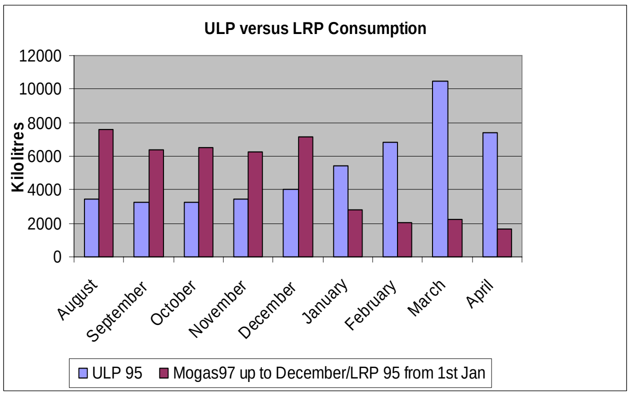

Figure Swaziland_1: Use of petrol types in the period August 2005-April 2006

ULP: Unleaded petrol; Mogas Motor gasoline; LRP 95:

Summary of air pollution information

Nature of problem	Industrial and energy Production, waste burning, Vehicles.
Status of monitoring	A surveillance system does not exist
Key pollutants	Have not been identified
Number of monitoring stations	0
Capacity to assess air pollution	Capacity is non-existent
Air quality standards	Standards are not yet promulgated

National response to air pollution

In 2002, the Environment Management Act was promulgated. Under this Act, a number of regulations have been developed to reinforce the control of air pollution. These are the Waste Regulations (to control the management of wastes in the country), the Environmental Audit, Assessment and Review Regulations to regulate the activities of new and existing industries as well as other developmental projects. In addition to the above, the country is in the process of gazetting air pollution control regulations, including AQS. These regulations specify the roles that should be played by regulatory bodies and other stakeholders like industry in the control of air quality. Towards the end of 2005, the government took a decision of completely phasing out leaded petrol.

The responsibility for AQM is with the Ministry of Environment, in collaboration with other partners

Fuel standards

To decrease sulphur emissions to the atmosphere, from January 2006, the country decided to reduce the content of sulphur in diesel from 3000 ppm to 500 ppm.

Projects/programs

In a bid to reduce emissions from fuel wood, the country, with assistance from donor funding introduced the rural electrification project, which has seen the introduction of electricity to remote rural areas, reducing the consumption of wood as a source of fuel and having an indoor AQ benefit.

[22] Based on Khumalo (2006)

Emissions

Industries that contribute significantly to air pollution include pulp and paper manufacturing, textile, food processing, sugar mills, sugar cane fields and many small industries that collectively contribute significantly.

Emissions from vehicles also contribute significantly to air pollution. Traffic volume has increased sharply as a result of increasing development as well as the sharp increase of importation of used cars from Asian countries. From 2003 data on consumption of fuels by the transport sector, it was recorded that the consumption of leaded gasoline was about 90 million litres as compared to 20 million of unleaded petrol per year, which might indicate a significant contribution of fossil fuel consumption to air emissions.

Solid waste disposal sites also contribute to air pollution as a result of smell and continuous burning in these sites. People still believe that burning of solid waste is a good practice particularly because of the volume reduction. In the past this used to be relatively acceptable as the major composition of solid waste was organic. Presently however waste has become complex even in rural areas. The burning of solid waste results in the emission of noxious gases because of the presence of PVC materials, aerosol cans, batteries, electronic components, unidentified domestic chemicals, home based health care etc. Burning of waste in municipal waste disposal sites by waste salvagers in the process of recovering recyclables is also common. There are only two properly engineered landfills in the country that are run professionally and there is no burning on the sites. One is in the capital city of Mbabane and the other is in a small town of Pigg's Peak. This is primarily because these landfills were developed as part of bigger projects. In Mbabane this was as a result of a World Bank urban development project and in Pigg's Peak the construction of the Maguga Dam located near the town. In all the other urban and industrial areas, solid waste disposed of in unlicensed sites and burning often occurs.

Forest fires are not a common feature in Swaziland however spontaneous burning of landscapes is common in the dry season. This is often very serious as fires are ubiquitous. During the rainy season the atmosphere is usually clear due to wash-out and rain-out of particulate matter. This does not mean, however, that there is no air pollution during the wet season.

Reported challenges:

- Lack of equipment to monitor the air quality
- Assessment of the actual state of the air quality
- Linkage of air quality to human exposure and impacts, assessment of the risks associated with certain activities and of the actions needed to correct the situation
- Finalization the gazetting of air pollution control regulations
- Enhancement of the capacity for AQM
- Revision of the existing institutional setup for effective air pollution control

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Summary and analysis

Both industrial and vehicular sources contribute significantly to outdoor air pollution Waste burning and vegetations fires are other sources, although smaller. Regulations under the Environment Management Act include regulations to control the management of wastes and to audit, assess and review the activities of new and existing plants as well as other developmental projects. Lead has been phased out by end 2005. Some fuel standards for mobile sources exist but no emission standards for all types of sources, vehicular or industrial. The reduction of sulphur content of diesel to 500 ppm is a step in the right direction as it helps to reduce the emission of sulphates. Air quality standards are in the process of being promulgated and should be available by end 2006.

As a monitoring network has not been installed, air pollutant concentrations are unknown. Air pollution control regulations are being gazetted, which contain air quality standards. In order to assess air pollutants and their associated health impacts. Swaziland is to implement an air quality monitoring system which allows monitor key pollutants in e.g. Mbabane. A small network of diffusive monitors will assist in the assessment of key gaseous compounds. Simple particle monitoring devices could help assess particle concentrations. Training provided by external experts could be useful since local monitoring e.g. at universities is not known to have been performed.

3.23 Tanzania[23]

Driving forces, pressures and state of air pollution

Population growth rate is at 1.89 per cent (CIA, 2007). Due to urbanisation, motorisation and economic growth the following pressures exist in Tanzania:

- Emissions from the growing vehicle fleet
- Emissions from open air waste burning
- Emissions from uncontrolled charcoal burning
- Emissions from industries
- Re-suspended dust from unpaved roads (see Figure Tanzania_1)

The extent of the air pollution problem in Tanzania and the city of Dar es Salaam in particular has not yet been studied adequately to be able to track trends and quantify the magnitude of the problem and respective impacts to public health and the environment.

Existing data on the air quality is patchy and inconsistent. Studies in the past include the following:

In **1993**, the National Environment Management Council (NEMC) commissioned the Department of Chemistry University of Dar es Salaam to carry out a study to determine levels of CO, SO_2, NO_2, Lead and PM. Except for CO, levels exceeded WHO guideline values.

In **1994**, a project of the University College of Lands and Architectural Studies (UCLAS), with the support from JICA, found levels of NO_2 and CO at three kerbside sites complied with WHO guideline values

In **1996**, NEMC commissioned the Centre for Energy Environment Science and Technology (CEEST) to carry out an air quality study at four sites in Dar es Salaam, to provide baseline data for CO, SO_2 and SPM. All measured parameters recorded below WHO guideline values.

In **2002**, measurements were taken for SPM, Lead and NO_2 at six areas, of Dar es Salaam. The average concentrations exceeded WHO guidelines.

In **2003,** two separate surveys were carried out at selected 8 bus stations and 8 road junctions. The levels of NO_2, SO_2 and TSP were all above recommended WHO guidelines levels Diesel-driven buses were the main sources of SO_2, NO_2 and TSP, e.g. Figure Tanzania_2 (Jackson, 2004).

These studies indicate that there is degradation of air quality in Dar es Salaam.

Summary of air pollution information

Nature of problem	Energy Production. Vehicles.
Status of monitoring	A surveillance system is being implemented
Key pollutants	PM, CO, NO_2, SO_2, O_3, Pb.
Number of monitoring stations	11
Capacity to assess air pollution	Capacity is existent
Air quality standards	Standards are not yet promulgated, WHO guideline values are used

Sources

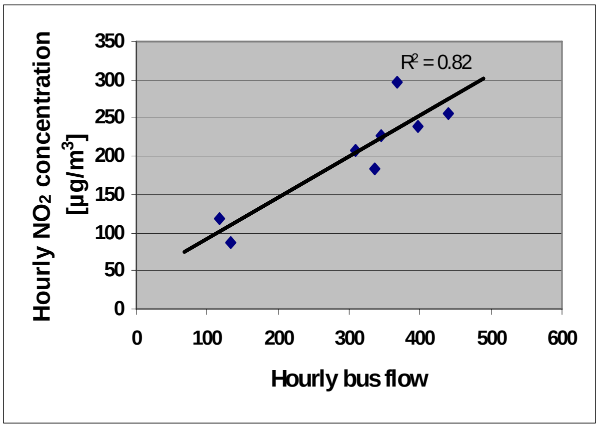
Vehicles are a major source of air pollution. Most of the vehicles which are second-hand imported vehicles are "smoking" due to poor maintenance. Industries include food processing, cement factories, sand and quarry industries, small-scale metal workshops and garages. Urban agriculture is a source of air pollution since people burn residues from agriculture activities as a means of garbage disposal. Burning of solid waste is a common phenomenon in Dar es Salaam. Other wastes are crudely dumped leading to odours and smouldering fires, which emit noxious gases (Kitilla, 2004)-

Figure Tanzania_1: Resuspended dust from unpaved roads in Dar es Salaam

Source: RTI (2006)

[23] Based on Kijazi (2006)

Figure Tanzania_2: The association between hourly bus flow and NO_2 concentration at bus stations in Dar es Salaam



Source: Msafiri (2004)

National response to air pollution

Legislation.

The Environmental Management Act (EMA) came into force in July 2005. EMA provides for stronger emphasis on local government authorities to participate in management of air quality, as quoted in section 132(1) saying; 'the local government authorities shall prescribe rules specifying emissions of carbon monoxide, hydrocarbons, other noxious emissions and standards for exhaust emission applicable in areas of jurisdiction of a local government authority concerned.

The responsibility for AQM is with the Ministry of Environment, Ministry of Health and the National Environment Management Council (NEMC), in collaboration with other partners (Dar es Salaam City Council (DCC), Tanzania Bureau of Standards (TBS), Government Chemist Laboratory Agency (GCLA), University College of Lands and Architectural Studies (UCLAS), Tanzania Meteorological Agency (TMA) and the Tanzania Industrial Research and Development Organization (TIRDO).

Fuel standards

Fuel specifications have been promulgated in Tanzania for leaded gasoline, unleaded gasoline and automotive gas oil. As leaded gasoline is being phased out, only the specifications for unleaded gasoline (TZS 672:2001) and gas oil (TZS 674:2001) are shown in Tables Tanzania_1 and Tanzania_2 of Section 6, respectively.

Projects/programs

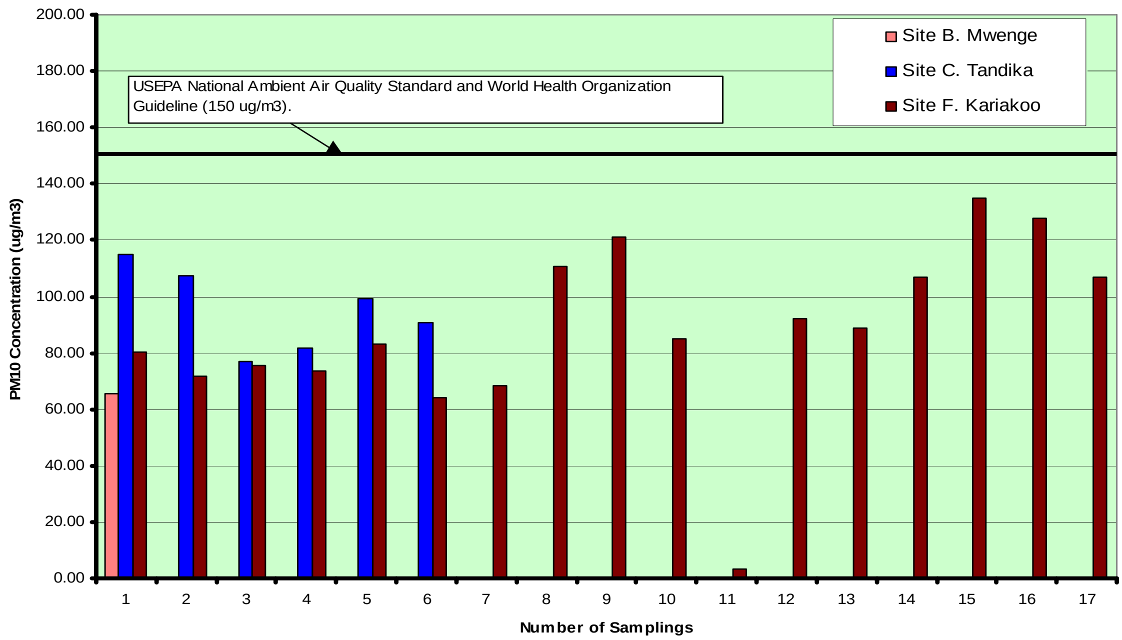
In August 2005, the Air Quality Monitoring Capacity Building Project (AQMCBP) was launched in Tanzania in three municipalities of Dar es Salaam city. Initial results for PM_{10} are shown in Figure Tanzania_3. The WHO 24-hour air quality guideline value of 20 µg/m^3 is exceeded.

The AQMCBP is a multi-stakeholder project that aims at enhancing capacity of participating institutions for monitoring of specific air quality parameters. The objective of the AQMCBP is to build capacity on management of air quality and establish baseline data and information on levels of selected air impurities. The AQMCBP aims at contributing significantly into development of air quality standards in the country/region. The project will focus on surveys related to air pollution and the links to adverse health effects. The project also aims at increasing level of awareness among policy makers, authoritative organizations, stakeholders and general public. The monitoring results will form basis for the development of long-term monitoring program and formation of database to be utilized by different stakeholders. AQMCBP is being implemented by NEMC, coordinated by DoE, and with the first two phases of an ongoing effort expected to last for 12 months beginning January 2006. Under the programme, US EPA provided monitoring equipment, training and mentoring over the course of two years to build the capacity of Tanzanian stakeholders to operate a long-term sustainable monitoring programme for Dar Es Salaam. UNEP provided funding for in-country costs during this period of time. It is now the responsibility of Tanzania Government and other stakeholders to commit funding and staff to ensure the continuation of this monitoring program. US EPA continues to provide long-distance technical support. Stakeholders involved in the project implementation include DCC, TBS, GCLA, TMA and Ministry of Health, research and academic institutions represented by UCLAS and TIRDO. The expected outputs of the project include a comprehensive and consistent database on the quality of air in urban centres in Tanzania.

An extensive description of the AQMCBP can be found in Annex Tanzania_1, Section 8.

If control measures are derived from the project, the successful implementation of the AQMCBP will have an AQ benefit.

Figure Tanzania_3: AQMCBP: Initial results for PM_{10} at two road-sides and a commercial station



Reported challenges

- Inadequate expertise in air quality monitoring,
- Inadequate monitoring facilities
- Inadequate instruments in AQM
- Lack of sufficient regulatory mechanism
- Financial constraints due to the necessity of donor funding

Figure Tanzania_4: Mini-vol samplers for PM_{10} determination

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RTI, 2006 Air sampling in Ghana and Tanzania to lead to public health improvements. Photo: Jeff Nicol Website: http://www.rti.org/page.cfm?nav=365&objectid=8F381C17-B122-4ACF-B86C224F9CBFB770

Summary and analysis

Second hand and poorly maintained vehicles and re-suspended dust from unpaved roads are major sources. Uncontrolled waste burning, agricultural residue burning and smouldering of crudely dumped wastes are also significant sources in Tanzanian municipalities, especially Dar es Salaam. Key pollutants in Dar es Salaam are PM, CO, NO_2, SO_2, O_3 and lead. Several studies performed between 1990 and 2004 indicate that air quality in Dar es Salaam has deteriorated during this period. Until 2005 monitoring was ad hoc and non-systematic. The EMA came into force in July 2005. It regulates the responsibilities of local authorities to prescribe emission standards for stationary and mobile sources. The AQMCBP was recently launched with the objective to enhance the capacity of participating institutions for monitoring specific air quality parameters, survey air quality, establish links to health impacts, assist in standard setting, and raise awareness among stakeholders.

In the past, Tanzania's efforts to address air pollution were limited to a few studies which assessed the state of air quality in an ad hoc manner. The AQMCBP, funded by UNEP and the Government of Tanzania and supported by US EPA is the first systematic attempt in Tanzania to address the challenges of air pollution, particularly in the city of Dar es Salaam, and enhance the capacity in air quality monitoring and impact assessment. Its results will probably enable the city to develop control measures the implementation of which will reduce particulate and gaseous emissions. Such measures could include the enforcement of emission standards for imported second hand vehicles and the prohibition of uncontrolled burning of waste and agricultural residues as the most cost-effective actions. The assessment of the state of air quality can also help to set enforceable air quality standards. The reduction of the age of the vehicle fleet and the introduction of an inspection and maintenance programme will help solve Tanzania's AQ problems.

After the first two phases of the project are completed, additional funding by in-country as well as outside sources will be needed to sustain the project. This additional funding is necessary to provide a long-term assessment of the state of air quality in Tanzania.

3.24 Togo[24]

Driving forces, pressures and state of air pollution

Due to a growth rate of 2.72 per cent (CIA, 2007) of the population, economic growth and increase of energy needs the following pressures exist in Togo in terms of emissions of air pollutants and greenhouse gases:

- Strongly growing vehicle fleet
- Residential and workshop areas
- Manufacturing and construction industries
- Power plants
- Waste deposits
- Agriculture, soil and forests

Industries include mining, a phosphates plant; cement clinker plant, two textile complexes, cotton ginning plant, plastics factory, and a steel rolling mill (EN, 2003). Clinker and refinery products are trafficked through the port of Lomé.

The vehicle fleet constitutes the main source of air pollution, see Figure Togo_1.

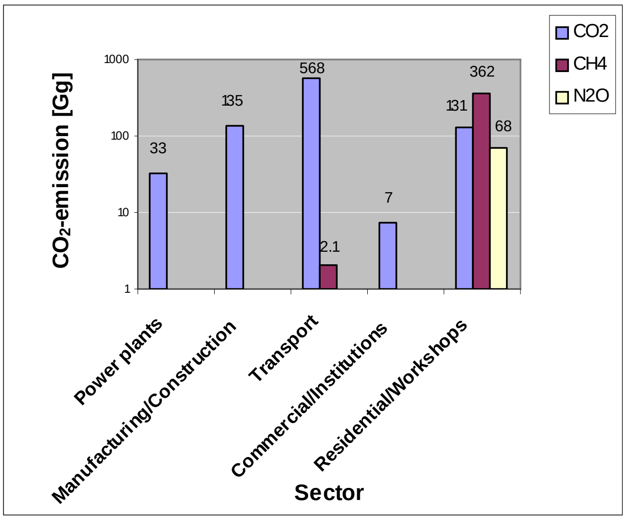

Figure Togo_1: CO2 emissions breakdown by sub-sector of energy sector

Reported challenges

- Financial constraints and logistics and insufficient human capacity and resources have limited the combat against air pollution and delayed the implementation of strategies and projects.
- Lack of fuel standards, emission standards, and air quality standards

Summary of air pollution information

Nature of problem	Energy Production. Vehicles.
Status of monitoring	A surveillance system has to be implemented
Key pollutants	Have not been identified
Number of monitoring stations	0
Capacity to assess air pollution	Capacity is non-existent
Air quality standards	Standards are not promulgated

Lomé harbour

Source:

[24] Based on Volley (2006)

Emissions

In 1995, Togo emitted 25.3 Tg of GHGs. The contribution per sector is shown in Table Togo_1.

Table Togo_1: Emission of GHGs in 1995

Emission (Gg)	CO_2	CH_4	N_2O	Total
CO_2 equivalent potential	**1**	**21**	**310**	
Energy	874.41	364.56	68.20	1,307.17
Industrial processes	403.53	0.00	0.00	403.53
Agriculture	0.00	566.37	2,712.50	3,278.87
Soil and forests	19,964.10	301.56	31.00	20,296.66
Wastes	0.00	3.65	3.10	6.75
Total (CO_2-e)	**21,242.04**	**1,236.14**	**2,814.80**	**25,292.98**

The percentage distribution of GHGs emissions by sources is shown in Figure Togo_2

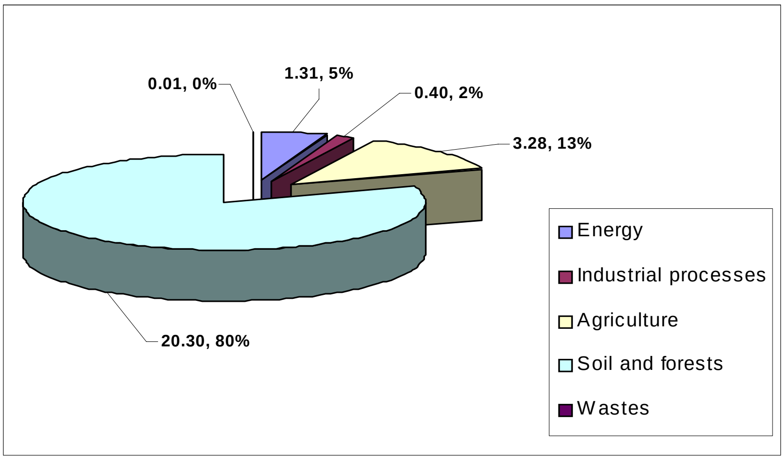

Figure Togo_2: Source apportionment of GHGs
Source: Communication Nationale Initiale du Togo 2001

While natural sources emit the major part of GHG emissions, the contributions of the energy and industrial sectors amount to a few per cent. The partition of the emissions of the energy sector according to its sub-sectors are as follows, see Table Togo_2:

Table Togo_2: GHGs and air pollutant emissions by sub-sector of energy sector

Emission (Gg)	CO_2	CH_4	N_2O	CO	NOx	NMVOC
Energy	**874.41**	**17.36**	**0.22**	**350.68**	**10.44**	**39.29**
Power plants	32.96					
Manufacturing/ Construction	134.69	0.01			0.04	
Transport	568.31	0.10		36.91	4.41	6.94
Commercial/Institutions	7.37					
Residential/Workshops	131.08	17.25	0.22	313.77	5.99	32.35

Source: Communication Nationale Initiale du Togo 2001

National response to air pollution

The Constitution of 14 October 1992 disposes in its Article no. 41 the right of any person to a healthy environment.
Togo has ratified several international conventions regarding the protection of the environment. These include the

- Vienna Convention on the Protection of the Ozone Layer
- United Nations Convention to Combat Desertification
- United Nations Framework Convention on Climate Change
- Climate Change – Kyoto Protocol

There are two policies formulated in Togo:

- Policy on energy development which refers to the energy sub-sectors electricity, hydrocarbons, ligneous fuels and renewable energies. The objective of this policy boils down to the diversification of energy sources, energy distribution and the promotion of new and renewable energies.
- Transport policy which has the objective to improve the efficiency and competitiveness of the sector, the mobility of goods and persons. The goal of this policy is the implementation of an autonomous and sustainable plan of action

Several strategies and plans have been formulated for implementing the conventions and combat air pollution. These include

- The national strategy to implement the climate change convention, which recommends among other issues to reduce the energy demand for solid fuels and the emissions from transport
- The strategy to combat air pollution from vehicles which has the following components: (i) ensure the quality control of fuels; (ii) define the technical characteristics for the import of second-hand vehicles; (iii) define the modalities of control and technical tests; (iv) encourage the use of catalytic converters in second-hand vehicles.

Because of lack of funds and logistics the implementation of these strategies has not yet started. This fact jeopardizes the realisation of Togo's engagement towards implementation of the Millennium Goals and the New Partnership for Africa's Development.

Financial and logistic support would be necessary for the implementation of the strategies mentioned above and consequent improvement of air quality.
The laws and regulations in Togo are compiled in Table Togo_3.

Table Togo_3: Environmental legislation and air quality related Acts and Decrees

Legis-lation	N°	Content (Date of promulgation)
Act	88-14	Environment Act (03.11.1998)
Act	99-03	Hydrocarbon Act relating to the exploitation of mineral resources (18.02.1999)
Decree	010 PM/MEMTPT/MCITDZF/MEFP	Specifications of unleaded "super petrol" (01.06.2005)

The responsibility for AQM in Togo is with several ministries:

- Ministry of Environment and Forests, through the Department of Environment (DoE)
- Ministry for Urban Issues
- Ministry of Technology, Transport, Post and Telecommunication, through the Department of Transport (DoT)
- Ministry of Commerce, Industry and Craft
- Ministry of Mines, Energy and Water
- Ministry of Education and Research
- Ministry of Communication and Public Awareness

National, regional and local private institutions, non-governmental organisations, associations, boards and committees addressing the protection of the environment support these institutions. The DoE is responsible for combating air pollution and nuisances, in particular the regulation and control of emissions. The Ministry for Urban Issues is among other tasks responsible for the definition and application of environmental objectives and the combat against the nuisances in urban milieu. The DoT is responsible for the technical control of vehicles. The Ministry of Commerce, Industry and Craft addresses among other issues questions of the commercialisation of oil products and the formulation of technical specifications of fuels. The Ministry of Mines, Energy and Water is charged with the control of fuel specifications. The Ministry of Education and Research develops through specialised institutions the national capacities for protecting the environment. The Ministry of Communication and Public Awareness plays an important role in the information, sensibilisation and education of the public on adverse effects of air pollutants on the environment and human health.

Project/programmes
A plan of action related to reduce the emission of ozone depleting substances is being implemented.

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Summary and analysis

The energy sector, particularly through the vehicle fleet constitutes the main source of air pollution. Togo has ratified several international conventions regarding the protection of the environment. Its Constitution disposes the right of any person to a healthy environment. An Environment Act was promulgated in 1998 and is supported by the Hydrocarbon Act relating to the exploitation of mineral sources and a Decree with specification of unleaded petrol. Several public institutions and ministries are responsible for air pollution. A policy on energy development and a transport policy have been formulated as have plans and strategies: the national strategy to implement the climate change convention and the strategy to combat air pollution (quality of fuels, modalities for controls and tests of second-hand vehicles, and action plan to phase-out lead). Togo has not yet started to implement the two strategies – climate change and air pollution – due to lack of funding.

With the promulgation of fuel specifications for unleaded petrol Togo made a step forward to initiate sound AQM. Further steps to follow would be to set fuel specifications for diesel and develop and enforce emission standards for imported second-hand vehicles. The fuel specifications for diesel would essentially correspond to those of Nigeria as this country exports fuel to Togo. Standards for imported vehicles could be achieved in a cost-effective way without a large amount of external funding if the importer of vehicles is requested to provide a proof of compliance with the emission standards. . Also the requirement of catalytic converters in second- hand cars can be achieved in a relatively cost-effective way. In contrast, an inspection and maintenance programme as planned in the strategy to combat air pollution requires the installation of testing facilities at costs of several million US$. This can only be achieved with substantial support from donor agencies

A special problem is the delegation of responsibilities for environmental pollution to many Ministries. This can lead to competitive approaches and duplication of work. An institutional restructuring by establishing clear leadership helps avoid this problem.

3.25 Uganda[25]

Driving forces, pressures and state of air pollution

Due to rapid population growth rate of 3.37 per cent (CIA, 2007), industrialisation, economic growth and a high quantity of uncollected waste the following pressures exist in Uganda:

- Emissions from a strongly growing vehicle fleet
- Bad state of the second-hand vehicle fleet of an elevated age
- Insufficient infrastructure of roads with corresponding re-suspended PM
- Emissions from municipal waste (methane, smoke from smouldering or burning waste, smells), for illustration see Figure Uganda_1
- Emissions from construction sites
- Emissions from poorly sited stone quarries
- Dust from cement plants without efficient dust capturing equipment
- Outdoor emissions from indoor air pollution

Figure Uganda_1: Waste deposit

References

Agaba EF 2006 Status of urban air quality in Uganda. Contribution to the Planning and Implementation of the Policy Makers Session of the BAQ 2006 Conference, Nairobi, 26 – 27 July 2006.

CIA 2007 Uganda. The World Fact Book. Central Intelligence Agency, Washington. Website: https://cia.gov/cia//publications/factbook/geos/ug.html

Kamanda PI 2004 Urban air pollution in Uganda. In: Proceedings of Better Air Quality in the Cities of Africa 2004, pp. 68-75.

Summary of air pollution information

Nature of problem	Energy Production. Industrial emissions. Open air burning. Vehicles.
Status of monitoring	A surveillance system has to be implemented
Key pollutants	PM, CH_4, H_2S, NH_3, dioxins and furans, HCs, NO_x, SO_x, re-suspended dust
Number of monitoring stations	0
Capacity to assess air pollution	Capacity is non-existent
Air quality standards	Standards were developed but enforcement is weak

Impacts

The fumes and smoke from plastic burning are known to be responsible for respiratory and circulatory health problems, for example asthmatic attacks besides the pungent and bad smells. This is very evident at the Kitezi Landfill site near Kampala.
An illustration of another impact of the plastic and garbage problem is shown in Figure Uganda_2.

Figure Uganda_2: Blockage of drainage by plastic waste at Kyebando, Nsoba Zone (Kampala)

Therefore, there are many public health concerns especially in regard to poor disposal methods of plastic bags and their persistence in the environment. The contribution of waste-related health effects to the national disease burden and ill health has not been quantified in Uganda. According to the Ministry of Health there are significant adverse public health impacts due to plastic bag burning.

[25] Based on Agaba (2006)

Emissions

Plastics (polyethylene bags) for food packaging and food containers are commonly disposed of by burning. This process emits fumes and smoke which contain very poisonous chemicals (NOx, Dioxins, Hydrocarbons, Furans, SOx, etc). Garbage is dealt with in an ad hoc manner as any framework to its management is lacking. Used plastic are not biodegradable.

Production of carrier bags made from recycled rather than virgin polythene plastics results in the following environmental benefits:

- Production of only a third of sulphur dioxide and a half of the nitrous oxides
- Reduction of water usage by nearly 90%
- Reduction of carbon dioxide generation by 2.5

Reusing plastic is preferable to recycling as it uses less energy and fewer resources. Long life, multi-trip plastics packaging has become more widespread in recent years, replacing less durable and single-trip alternatives, so reducing waste.

Reported challenges

- Development and implementation of a comprehensive, clear and enforceable transport policy, addressing also motor bikes and alternative means of motorized transport, non-motorized transport and road infrastructure
- Development of human resources through curricula in Uganda's universities
- Need of a national policy for the importation of 2nd hand motor vehicles
- Need for a policy on vehicle technologies, fuel specification and emission standards
- Need to strengthen enforcement coupled with public sensitization and awareness activities
- Framework for garbage management
- Regulations for plastic material for food packaging and containers
- Replacement of plastics for general use/packaging by paper and other bio-degradable materials
- Raising public awareness on potential dangers of plastics
- Survey on production, importation and consumption of plastic packaging materials
- Research to address the safety aspects of re-use, misuse and overuse of plastic packaging materials and articles

National response to air pollution

Uganda is party to the Climate Convention, Kyoto Protocol, Desertification Convention, and Montreal Protocol for Ozone Layer Protection (CIA, 2006). The Constitution guarantees every citizen a clean and healthy environment as does the National Environment Act in Article 153.

The responsibility for AQM is with the Ministry of Environment, in collaboration with other partners.

Action plans.
Action plans have not been developed yet in Uganda. There is need to scale up public awareness and sensitizations on the above mentioned potential dangers of plastics especially if misused. A survey is needed in Uganda to generate reliable data on the production, importation and consumption of plastic packaging materials both in terms of quality and quantity. This will also enable the authorities to check for compliance with the set standards on plastic food packaging and contact materials.

Fuel standards
Existing fuel specifications are planned to be revised. There are plans to adopt the revised specifications for Eastern Africa.

Emission standards
The National Environment Management Authority (NEMA) has developed standards for motor vehicle emissions for different categories of vehicles. However enforcement of these standards is currently weak. There is need to strengthen enforcement coupled with public sensitization and awareness activities.

Air quality standards.
NEMA has developed air quality standards which are in the final stage of becoming law in support of the National Environment Act.

Projects/programs
On-going projects include

- Re – introduction of bus transport in urban centres. This was launched by Kampala City Council in May 2006
- Efforts are being made to establish an Industrial Zone outside the City Centre.

Summary and analysis

The major sources of air pollutants in Uganda include imported second-hand vehicles and boiler emissions from industries. Imported vehicles are mostly an increasing number of second hand motor vehicles. Industrial boilers mainly use furnace oil and biomass as energy sources (Kamanda, 2004). Other sources include open air burning of wastes in city skips, waste dumpsites and industrial premises. Odours are a nuisance associated with tobacco processing plants, sewage treatment plants and food cottage industries. Agro-based industries (dry coffee processing) using rudimentary dry processing and only obsolete abatement equipment are emitting particulate matter all over the country. A recent problem is a growth in production and use of polythene bags/packaging materials, with corresponding emissions of hazardous organic pollutants. There is no plastic recycling plant in Uganda. Health effects have not been quantified but the Ministry of Health believes that there are significant adverse health impacts due to plastic bag burning.

Motor bikes are a significant source of air pollution in urban areas. The National Environment Management Authority (NEMA) has developed National Environmental Air Quality Standards & Guidelines for Uganda. These include among others standards for motor vehicle emissions for different categories of vehicles. However enforcement of these standards is currently weak. Road network infrastructure is poor and unpaved roads are a source of dust. Alternative means of transport are weakly developed. Key pollutants in the cities of Uganda are primary PM, NO_x, SO_x, re-suspended dust, dioxins and furans, and hydrocarbons.

In Uganda, AQM is in its very infancy. On-going projects refer to phasing out lead and the use of unleaded fuels. Uganda does not yet dispose of a monitoring network to monitor urban air quality at industrial, commercial, residential and kerbside sites. Air quality standards have been proposed but are not yet promulgated. Baseline measurements of pollutant concentrations of compounds emitted from point sources showed non-compliance with the proposed standards (Kamanda, 2004).

With the promulgation of fuel specifications and emission standards for motor vehicles Uganda made a step forward to initiate AQM. Strengthening enforcement procedures will help make these standards operational and reduce emissions. Enforcing emission standards for imported second-hand vehicles will also support this process. An inspection and maintenance (I/M) programme in the framework of a strategy to combat air pollution requires the installation of testing facilities at costs of several million US$. This can only be achieved in Uganda with substantial support from donor agencies

Without knowledge of air pollutant concentrations in the cities of Uganda, especially Kampala, it is difficult to promulgate enforceable air quality standards. By assessing key air pollutants such as PM_{10}, SO_2, NO_2, and CO in a pilot project could overcome this deficiency

The plastic bag problem is important with respect to emissions into the air from plastic burning and smouldering in waste deposits. Emissions include PM, VOCs, PAHs, dioxins and furans. An efficient garbage management system agreed upon by all stakeholders will readily resolve this challenge. It is not recommendable to start an extensive and expensive monitoring campaign to assess the concentrations and the potential health impacts of these compounds, in particular dioxins and furans.

3.26 Zambia[26]

Driving forces, pressures and state of air pollution

Population growth rate in Zambia is 2.11 per cent (CIA, 2007). Due to industrialisation, motorisation and economic growth the following pressures exist in Zambia:

- Emissions from the copper smelters, cobalt plant, foundries and refineries
- Emissions from mining and quarrying
- Emissions from breweries and other industries such as fertiliser plant, lime manufacture, cement plant, tanneries
- Emissions from domestic waste burning
- Emissions from tailing dumps
- Emissions from forest fires
- Increasing emissions from motor vehicles

Air pollution problems appear to exist in Lusaka due to increasing motorisation and in the cities of the Copper Belt. Generally, the quality of ambient air countrywide is currently not comprehensively known, especially for particulate matter. Significant ambient air pollution, particularly of SO_2, at Nkana-Kitwe emanates from stack emissions and open air burning of saw dust with less significant sources being domestic rubbish open air burning, locomotive engines and vehicle emissions. Tailings dumps are also a source of air pollutants such as dust.

The Environmental Council of Zambia *(ECZ)* with the help of the Norwegian Institute for Air Research *(NILU)* did carry out some ambient air quality screening surveys in *1998* and *1999* at several sites in the city of Kitwe (Namayanga, 2004a).

A network of ambient air monitoring stations in the country was set up temporarily and preliminary results were obtained with passive samplers for SO_2 and NO_2, see Annex Zambia_1, Section 8. At few locations the SO_2 concentrations were greatly exceeding Zambian and WHO guideline values, see Figure Zambia_1. For NO_2 guideline values were not exceeded. After 1999 the project was discontinued.

Since *ECZ* encouraged the private sector to consider self-monitoring through its environmental licensing system, the mining companies in Kitwe have been undertaking ambient air quality measurements since mid 1994 at 13 stations. At several stations SO_2 concentrations are very high, exceeding Zambian and WHO guideline values. Some results of these monitoring campaigns are compiled in Annex Zambia_2 in Section 8 (Namayanga 2004b).

Summary of air pollution information

Nature of problem	Energy Production. Vehicles.
Status of monitoring	Initial monitoring was performed in the late nineties
Key pollutants	SO_2, NO_2, PM, black smoke, dust, CO, CO_2 and odours.
Number of monitoring stations	0
Capacity to assess air pollution	Capacity is existent at industrial plants
Air quality standards	Standards are promulgated

Impacts

SO_2 concentrations in the ambient air on the Copper Belt Province were found to be a major environmental concern due to the high industrial activity. *WHO's* air quality guidelines were exceeded in Kitwe downwind of the smelters and converters. These concentrations can have very serious impacts on both the population and vegetation downwind of the sources of air pollution.

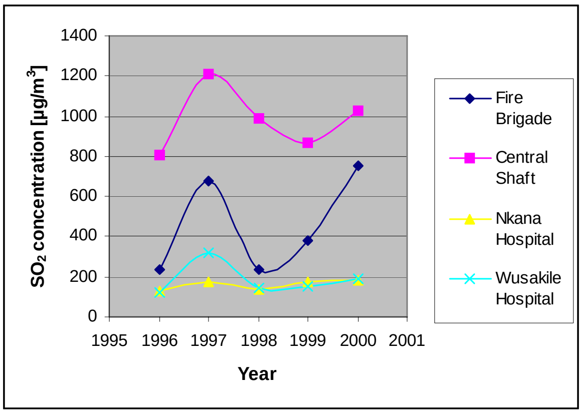

Figure Zambia_1: SO_2 concentrations at four monitoring sites in Kitwe

[26] Based on Namayanga (2004a;b); Simukanga (1999)

Emissions

Annual emissions from the Nkana copper mine were estimated in 1997 to amount to 50,000 metric tons of sulphur or about 45 per cent of the total S-emissions. About 60,000 metric tons of S are emitted by the Mulufira mine operations. Emissions in Kitwe amount to ca. *20 387* tons of SO_2 and *1 729* tons of dust per month (Namayanga, 2004b).

Particulate matter emissions from Chilanga Cement from the gases coming out of the kilns per day are in the range 100-500 mg/Nm^3. Amounts of dust released per day from some mines are: Nkana approximately 40 tons per day and for Mufulira approximately 14 tons per day.

Reported challenges

- Serious localised episodes of very poor ambient air quality
- At nearly all sources, emissions are directly discharged into the atmosphere
- Fugitive emissions although tremendously reduced since the recent privatisation of the mines, are still problematic
- High age of the equipment in industries
- Lack of proper maintenance of industrial facilities
- Lack of studies on air quality in Zambia

National response to air pollution

Zambia is party to the Conventions on Climate, Desertification, and the Montreal Protocol. The Kyoto Protocol has been signed by Zambia but not ratified (CIA, 2006). The Zambian law as it stands today does not legally bind for maintenance, monitoring and sustenance of air quality. The goal of the legislation is, however, to provide the protection of the environment and the control of pollution.

The overarching policy for Zambia's environmental legislation mainly stems from the 1994 National Environmental Action Plan *(NEAP),* implemented by the Ministry of Tourism, Environment and Natural Resources *(MTENR)* and the Environmental Council of Zambia *(ECZ).* The *NEAP* outlines the framework for all aspects of the "national environmental policy", embodying three core principles: (i) the right of citizens to a clean and healthy environment, (ii) integrated local community and private sector participation in natural resources management, and (iii) obligatory environmental impact assessment *(EIA)* for major projects in all sectors. The *NEAP* further aims at facilitating wider involvement of the private sector in environmental management while recognising that Government must develop a greater capacity for monitoring, regulation and enforcement.

Legislation.
Zambia has enacted the Environment Protection and Pollution Control Act (EPPC) on 23rd July 1990. The responsibility for clean air is delegated to the ECZ, which is supported by an Advisory Committee. The Council is to establish ambient air quality and emission standards; specify methods for measuring air contaminants and establish laboratories for analytical services; and identify areas of research on human health effects, effects on the environment and flora and fauna. The *EPPC* Act, together with its Statutory Instrument *(SI) No. 141* of *1996* only gives ambient air quality guidelines, however. Where the *ECZ's* regulations do not state a guideline, other pieces of regulations tend to fill in the gaps. An example is the Mines and Minerals (Environmental) Regulations of *1995*. Ambient air monitoring is, however, not a requirement of the law.

Action plans.
The *NEAP* outlines the framework for all aspects of the "national environmental policy", embodying three core principles: (i) the right of citizens to a clean and healthy environment, (ii) integrated local community and private sector participation in natural resources management, and (iii) obligatory *EIA* for major projects in all sectors.

Fuel standards
Fuel specifications for unleaded petrol and gas oil (diesel) have been en set and are shown in Tables Zambia_1 and Zambia_2, se Section 6.

Emission standards
Zambia has set long-term emission standards for industrial sources in the Copper Belt (Namayanga, 2004a).

National response to air pollution (continued)

Air quality standards.
Zambia has promulgated air quality guideline values, which are laid down in Table Zambia_3, see Section 6.

Projects/programs
On-going projects include

- Cleaner Production (CP)
- Licensing and Permitting
- Stack Sampling
- Monitoring and Inspections
- Self-Monitoring of Industry

These projects are co-ordinated and controlled by the ECZ and can have an AQ benefit. The objective of the CP is to encourage industry to limit or even avoid emission of pollutants right at their sources. The major action is to provide training of companies to reduce emissions. The licensing & permitting programme offers incentives to industries to meet the set long-term emission limits for stationary sources. It is complementary to the CP. The system issues a permit or licence with conditions attached to each. A permit lasts for 6-12 months for a company not complying with the limits and 36 months for an industry that complies. Annual stack sampling at large stationary sources is used by the ECZ as a compliance verification tool. Once a company or industry is licensed, information on associated and available data is stored in a Licensing Information System. The *ECZ* Inspectorate carries out routine monitoring and inspections to enforce provisions of the law.

Licences and permits issued by the ECZ are accompanied by provisions which compel industry to conduct monitoring of discharged pollutants, perform the analysis of samples and submit a report to the ECZ. The ECZ reviews and may reject or accept the report. If the report is rejected, the ECZ may decide to conduct an independent monitoring or supervise the monitoring by the facility.

Kitwe

The city of Kitwe is one of the ten towns that constitute the Copper Belt Province of Zambia and the third largest town in the country. Other cities with important mining are Konkola Nchanga, Chambishi, Mufulira, Chibuluma, and Luansha. Kitwe is located at ca. *1 300 m* above sea level and home to over *38, 000* people. Mining is still the main economic activity although agriculture is now being promoted to diversify the economic base. Kitwe houses a copper smelter, a cobalt plant, foundries, breweries and other industries. Fortunately, Kitwe's altitude and climate offer favourable conditions for rapid air pollutants dispersal. Prevailing winds blow from Northeast to the Southeast and average wind speeds are below 1.5 m/s with occasional high speed gusts of more than 20 m/s (Namayanga, 2004b).

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The smelter complex in Kitwe

Summary and analysis

Most air quality problems in Zambia exist in the capital, Lusaka, and the Copper Belt Province around the city of Kitwe. Air quality monitoring of SO_2 and NO_2 using diffusive monitors was performed in the late 1990s by NILU but discontinued. Automatic continuous monitoring equipment is currently only owned and used by Konkola Copper Mines (KCM) Plc, which manages the copper smelter and refinery in Kitwe. Some stack emission measurements are conducted by the ECZ, the mining companies themselves and private contractors (Namayanga, 2004b).

SO_2 concentrations are of major concern in the Copper Belt since copper smelters, cobalt plant and foundries are still operating on obsolete technologies without efficient stack-gas-cleaning facilities. Mining, quarrying, lime manufacture and a cement plant are other sources which also may cause PM air concentrations although monitoring of this compound has not been performed. Monitored NO_2 concentrations comply with Zambian guideline values and are not considered to be of concern.

Emissions from industries such as breweries and fertilizer plants, domestic waste burning, tailing dumps, forest fires and increasing vehicular emissions may also contribute to air pollution in the Copper Belt area but their contribution is unknown.

Zambia has promulgated the EPPC Act and other legal instruments such as the Mines and Minerals (Environmental Regulations). While the Statutory Instrument gives air quality guidelines which are internationally comparable, outdoor air quality monitoring is not required in the law. With respect to vehicular emissions Zambia has set fuel specifications for petrol and diesel.

Several projects and tools have been initiated by the ECZ. These include cleaner production to encourage industry to limit the emission of pollutants, an effective licensing scheme to obligate industry to meet long-term emission limits. At large stationary sources the ECZ is stack sampling once a year to test compliance of industrial sources with long-term emission standards; monitoring data are stored in a Licensing Information System. Licensing condition include the requirement to industries to perform monitoring of air pollutants.

Integrate AQM is lacking in Zambia. Air pollution monitoring in Zambia is limited to patchy measurements in the Copper Belt Province. While it is known that SO_2 concentrations are high in the vicinity of the smelters not much action has been taken to implement control measures. The impacts of SO_2 on human health and the environment has been suggested but not quantitatively assessed. PM concentrations are also unknown. Monitoring routinely PM and SO_2 and assessing health and environmental impacts would overcome this problem. In view of the complex emission situation in Kitwe and other cities of the Copper belt, source apportionment could help quantitatively assess the contributions of the different types of sources. A rapid assessment of the emissions using e.g. the WHO or APINA emission inventory manuals would allow specify emissions of individual plants in a cost-effective manner. These assessments could be used as input to the World Bank SIM/AIR model in order to roughly estimate potential health impacts and their costs.

The licensing and permitting programme is a good approach to ensure the compliance of industries and other facilities with long-term emission standards and to encourage them to perform monitoring. However, in the privatization process for Zambian industries concessions were made to investors, greatly limiting their environmental obligations and liabilities. New mining companies are at liberty to emit air pollutants at the same level as at the time of purchase. Nonetheless, the private sector, NGOs such as “Citizens for a Better Environment”, the general public and the ECZ have made some progress to better AQM.

3.27 Zimbabwe[27]

Driving forces, pressures and state of air pollution

Population growth rate is at 0.62 per cent (CIA 2007). Due to urbanisation, industrialisation, motorisation and economic growth the following pressures exist in Zimbabwe (Chibanda, 2004):

- Emissions from fuel burning appliances, thermal power plants
- Emissions from iron and steel smelting, gold mining and roasting, chrome smelting, steel and wire production, wire and rope industry, asbestos processing
- Emissions from cement works, stone quarries, sand blasting, brake lining works, milling
- Emissions from metallurgical plants, rubber manufacturing, battery manufacturing, chrome plating, chemical manufacturing, foundries, tanneries, etc.
- Emissions from bonfires and Veld fires
- Emission from industrial waste dumps
- Emissions from fertiliser manufacturing, woodwork, tobacco processing
- Increasing emissions from an ageing fleet of poorly maintained motor vehicles
- Indoor air pollution from cooking and heating with solid fuels

Major centres of air pollution are the cities of Harare and Kwekwe. In both cities air pollution monitoring has been performed in the past, in Kwekwe in individual scientific studies relating mostly to indoor air pollution and in Harare routinely since 1995.

The city of Harare has the capacity to sample and measure ambient SO_2, Suspended Particulate Matter (SPM) and NO_2 three times a week on a 72-48-48 hour basis. Currently there are eight sampling sites situated within the following areas:

(i) high density residential areas
(ii) low density residential areas
(iii) areas of light industry
(iv) areas of heavy industry

Both active and passive sampling methods are used. The method for analysis for SO_2 uses titration whereas for SPM and NO_2 analysers are used. A densitometer is used to determine the density of the deposited particulates on the filter paper used. NO_2 is measured as its nitrite (NO_3) component using a UV Spectrophotometer. Challenges exist with respect to the completeness, operation and calibration of the equipment and the purity of chemical reagents.

All the data obtained from the samples is documented and

Summary of air pollution information

Nature of problem	Energy Production. Vehicles.
Status of monitoring	Initial monitoring was performed in the late nineties
Monitored pollutants	SO_2, NO_2, PM, CO, VOCs.
Number of monitoring stations	8 sampling sites
Capacity to assess air pollution	Capacity is existent
Air quality standards	Standards are not yet promulgated

Impacts

Most studies in Zimbabwe examined the influence of the domestic environment on adverse health effects in women and children (Charakupa-Chingono, 2006). One study was designed to monitor the concentrations of air pollution in the vicinity of industrial areas in Kwekwe during 27 April to 28 May 2001 (Zoergel, 2005). While SO_2 and NO_2 complied with international short-time guideline values, levels of PM_{10} measured at the Mbizo suburbs of Kwekwe varied between 27 and 207 $\mu g/m^3$, exceeding the WHO 24-hour guideline value by up to five times. Although no effort was made to link measured concentrations with health impacts, the measured concentrations are likely to induce adverse health impacts (Zoergel, 2005). Some anecdotal evidence exists in Kwekwe since the 1950s (Charakupa-Chingono, 2006)

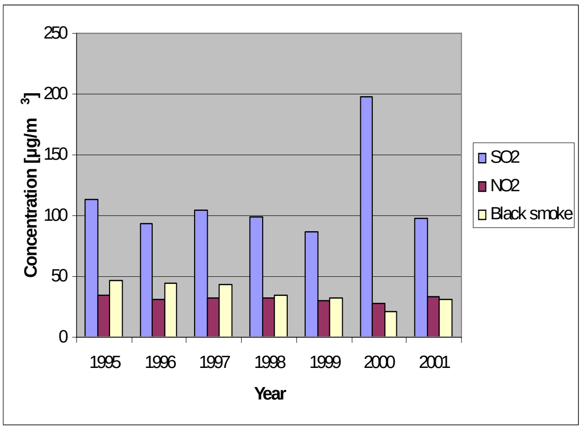

Figure Zimbabwe_1: SO_2, NO_2 and black smoke concentrations in Harare, 1995-2001
Source: City Health Department Annual Reports 1995-2001

[27] Based on Nengomasha (2006)

National response to air pollution

Legislation.
Zimbabwe is party to the Climate Change Convention and the Montreal Protocol on Ozone Depleting Substances (CIA, 2006).

Until 2003 the management of air pollution in Zimbabwe was regulated by the Atmospheric Pollution Prevention Act (APPA) of 1971 as amended by Act 20:03 of 1996. In addition, the Atmospheric Pollution Prevention Regulations for smoke control (1999), control of emissions (2000), dust control areas (1981) and the Atmospheric Pollution Prevention Notice for gas control and specified processes (1974) were promulgated. This legislation was based on the best practicable technology concept and did not have human health as one of its components. Since 2003 the APPA was repealed by the Environmental Management Act (EMA). The EMA provides for the sustainable management of natural resources and protection of the environment, the prevention of pollution and environmental degradation, and the preparation of a National Environmental Plan and other plans for the management and protection of the environment. It also provides for the conducting of Environmental Impact Assessments (which include possible impacts on health) for all development projects (WHO, 2004). The EMA is, however, not yet enforced since the structure of the Environmental Management Agency and it *modus operandi* are still being formulated. Therefore, Act 20:03 of 1996 is being still enforced because at present there is no alternative (Charakupa-Chingono, 2006).

The responsibility for air pollution management in Zimbabwe rests with the Ministry of Health and Child Welfare. Within the Ministry, the Air Pollution Control Board is appointed by the Health Secretary and advises on air pollution control policies, particularly relating to industrial pollution.

In Harare, air pollution management is the responsibility of the Air Pollution Control Unit (APCU) of the City Health Department. The management of air quality in the city is carried out in a two pronged approach: Industrial surveillance and the measurement of SO_2, SPM and NO_2. One of the ways of controlling and reducing the concentration of ambient air pollution is done at the planning stages of, the companies that intend to install either fuel burning appliances or chimneys or both. Appliances for installation here refer to boilers, furnaces, incinerators and foundries. APCU scrutinizes the information given by the company with respect to legally requested control systems and chimney heights. The final approval notice is served to the Company on condition that the chimney of the recommended appropriate height will be installed as well as the assent to comply with any other air pollution legislation. Compliance during subsequent operations is investigated through random inspections. Reports on the monthly average concentrations of the 3 pollutants are made to the Ministry tri-annually. If necessary, activities of some companies are reported.

As far as possible, all the activities of the APCU are documented especially information about visits made to companies, occurrences of passing or casual observations on emission of pollution, monthly station average concentrations of pollutants and any other data incidental to the activities of the APCU.

The monitoring and control of other sources of air pollution like burning of refuse lies with local/area inspectors. Control of air pollution does not only occur at industrial sites but in residential locations as well.

Emissions

The inspection by APCU takes the form of random checks on the activities of companies especially the known pollution sources. Should a company be found violating any of the air pollution laws/regulations, an inspection is carried out at the Company to verify the nature, the cause and the degree of pollution. In Harare the general causes of pollution are dark smoke, metal fumes, dust and gases.

The main aim of these inspections is to seek for solutions to the causes of pollution, a task that involves the participation of the relevant departments or sections of a particular company.

As a follow-up to these industrial visits and inspections, intimation notices are usually served where necessary and to this end, the Air Pollution Control Unit has files for all known sources and names of companies that pollute.

This is a form of pro-active approach by the Unit but there too is a reactive approach where the Unit responses to air pollution complaint by individuals, companies or any interested party.

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Reported challenges for Harare

- Need for further training on air pollution monitoring, AQM and EIA for staff of APCU.
- Need to improve and supplement equipment and reagents used at the APCU.
- Enhancement of the capacity to monitor a wider set of pollutants, especially heavy metals and other gases.
- Need for calibration equipment
- Improvement of NO_2 monitoring

Summary and analysis

A multitude of sources emits air pollutants in urban areas of Zimbabwe, especially in Harare and Kwekwe. These include industrial sources and power plants and an increasing vehicle fleet which is ageing and not well maintained. All three types of sources are likely to contribute significantly to air pollution concentrations.

Zimbabwe has promulgated the APCU and Regulations for smoke and emission control. Recently the EMA was promulgated which provides for pollution control and environmental impact assessment. The EMA is not yet fully operational and the repealed APPA is still being enforced for lack of an alternative.

AQM in the city of Harare is carried out in a two pronged approach: Industrial surveillance and the measurement of SO_2, SPM and NO_2. Some monitoring capacity exists in both Harare and Kwekwe. Challenges include however the need for training, equipment and chemical analysis capacity.

AQM in Zimbabwe focuses mostly on industrial sources although the contribution from the vehicle fleet is likely to be significant, too. A stronger emphasis of vehicle emissions and corresponding measures such as the reduction of sulphur in diesel would help reduce exposure of the population. Setting fuel specifications for gasoline and diesel and enforce them for imported second hand vehicles are cost-effective actions to reduce vehicular air pollution.

Revamping the monitoring system in Harare and starting monitoring in Kwekwe using cost-effective monitoring devices would help assess population exposure in these cities and to initiate the process of setting enforceable air quality standards. Air quality monitoring could be complemented by the development of initial emission inventories through use of rapid assessment methods such as those developed by WHO, APINA and World Bank.

Section 4. Country summaries and analyses

4.1 Country summaries

Section 3 presented the SSA countries' efforts to tackle the problem of air pollution in their cities. The section bases essentially on the country contributions made to the *Better Air Quality in Sub-Saharan Africa 2006* conference. As the individual contributions range in size from one page to about 25 pages, it was attempted to collect information from other sources within the given time frame. The material compiled in this report, therefore, is only a starting point for benchmarking the capabilities of the SSA countries with regards to air pollution management in a similar way as has recently been performed for 20 Asian cities (Schwela et al., 2006).

All countries considered in this review are parties to international conventions which bear relevance to air pollution. The status of participation is compiled in Table 4.1 (CIA, 2007). Thus, all countries have signed and ratified the Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention to Combat Desertification (UNCCD), and the Vienna Convention for the Protection of the Ozone Layer & the Montreal Protocol on Substances that Deplete the Ozone Layer. Only three countries – Congo-Brazzaville, Swaziland, and Zimbabwe - do not participate in the Kyoto Protocol to the UNFCCC. Four countries – Congo-Brazzaville, Gabon, Togo and Zimbabwe - are not parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. 13 out of 28 countries have not signed the International Convention for the Prevention of Pollution from Ships, see Table 4.1.

Table 4.2 present a synopsis of an estimate of the countries' capabilities in AQM. Topics considered in assessing the AQM capability are the existence of inspection & maintenance facilities for mobile sources, assessment of emission in inventories, routine monitoring, health impact assessment, and ongoing projects. All countries except three have identified key air pollutants which in almost all cases are PM, SO_2, NO_2, CO, and HCs. Burundi has named pesticides, persistent organic pollutants, and lead as key pollutants, while Guinea considers formaldehyde and benzene as important in addition to PM_{10}, $PM_{2.5}$, NO_2, and SO_2. Mozambique considers Black Carbon as one of the key pollutants, Uganda considers dioxins and furans, and Zambia also thinks odours important. VOCs are considered among key pollutants in Mali and Zimbabwe. O_3 is among key compounds in seven countries – Benin, Botswana, Ethiopia, Ghana, Mozambique, Nigeria, and Tanzania. Inspection & maintenance facilities are installed or being installed in four countries – Cameroon, Ghana, Madagascar, and South Africa. More or less complete emissions inventories have been established in seven countries – Botswana, Burkina Faso, Mali, Nigeria, South Africa, Togo, and Zambia. These inventories are partially very elementary, old and not quality assured. Ethiopia applies source apportionment techniques, Mozambique is developing an initial emissions inventory, and Swaziland has got only qualitative estimates.

Table 4.1: Participation of countries in International Conventions and Treaties relevant for air pollution

Country	Biodiversity	Climate Convention	Kyoto Protocol	Desertification	Hazardous Wastes	Ozone Layer Protection	Ship Pollution
Benin	X	X	X	X	X	X	X
Botswana	X	X	X	X	X	X	
Burkina Faso	X	X	X	X	X	X	
Burundi	X	X	X	X	X	X	
Cameroon	X	X	X	X	X	X	
Congo-Brazzaville	X	X		X		X	X
Congo-Kinshasa	X	X	X	X	X	X	
Ethiopia	X	X	X	X	X	X	
Gabon	X	X	X	X		X	X
Ghana	X	X	X	X	X	X	X
Guinea	X	X	X	X	X	X	X
Kenya	X	X	X	X	X	X	X
Liberia	X	X	X	X	X	X	X
Madagascar	X	X	X	X	X	X	X
Malawi	X	X	X	X	X	X	X
Mali	X	X	X	X	X	X	
Mauritius	X	X	X	X	X	X	X
Mozambique	X	X	X	X	X	X	X
Nigeria	X	X	X	X	X	X	X
Rwanda	X	X	X	X	X	X	
Senegal	X	X	X	X	X	X	X
South Africa	X	X	X	X	X	X	X
Swaziland	X	X		X	X	X	
Tanzania	X	X	X	X	X	X	
Togo	X	X	X	X		X	X
Uganda	X	X	X	X	X	X	
Zambia	X	X	X	X	X	X	
Zimbabwe	X	X		X		X	

Source: CIA (2007)

Table 4.2: Synopsis of country AQM capability

Country	Key pollutants	Sulphur content of diesel [ppm]†	Inspection & maintenance for mobile sources	Emissions inventory	Routine monitoring	Health impact assessment	Projects or plans with AQ benefit ongoing	Estimated stage of air quality management
Benin	SO_2, NO_x, NO_2, O_3, CO, HCs, PM.	5,000	No	No	No	Two studies	Yes	Early*
Botswana	SO_2,NOx, NO_2, O_3, CO, HCs	500	No	Yes, but incomplete	Yes	Few qualitative studies	No	Intermediate**
Burkina Faso	PM, SO_2, HCs, NOx, SO_2	5,000	No	Yes, but elementary	No	No	Yes	Early*
Burundi	Pesticides, Persistent Organic Pollutants, Pb	5,000	No	No	No	No	No	Absent[#]
Cameroon	PM, CO, HCs, NOx, SO_2.	5,000	Yes	No	No	No	No	Initial[†]
Congo-Brazzaville	PM, CO, HCs, NO_x	10,000	No	No	No	No	No	Absent[#]
Congo-Kinshasa	PM, SO_2, NO_2, CO, HCs	3,500	No	No	No	No	Yes	Initial[†]
Ethiopia	PM_{10}, CO, SO_2, O_3	10,000	No	No, but source apportionment for PM_{10}	No, only campaign	No	No	Early*
Gabon	PM, CO, HCs, NOx, SO_2	8,000	No	No	No	No	No	Absent[#]
Ghana	SO_2, NO_2, O_3, CO, PM_{10}, manganese	5,000	In progress	No	Yes	Three studies	Yes	Advanced[+]
Guinea	PM_{10}, $PM_{2.5}$, NO_2, SO_2, formaldehyde, benzene	5,000	No	No	No	No	No	Absent[#]
Kenya	PM, CO, HCs, NOx, SO_2	10,000	No	No	No	No	Yes	Initial[†]
Liberia	PM, CO, NOx, SO_2.	5,000	No	No	No	No	No	Absent[#]
Madagascar	PM, CO, HCs, NOx, SO_2	5,000	Yes, mobile sources	No	Yes	No	Yes	Intermediate**
Malawi	PM, SO_2, CO, NOx, HCs	5,000	No	No	No	No	No	Absent[#]
Mali	PM, NOx, CO, HC, VOC, SO_2, Pb	5,000	No	Yes, for transport	No	No	No	Initial[†]
Mauritius	PM, NOx, CO, SO_2	2,500	No	No	No	No	Yes	Initial[†]

Table 4.2 continued: Synopsis of country AQM capability

Country	Key pollutants	Sulphur content of diesel [ppm]	Inspection & maintenance for mobile sources	Emissions inventory	Routine monitoring	Health impact assessment	Projects or plans with AQ benefit ongoing	Stage of air quality management
Mozambique	PM_{10}, $PM_{2.5}$, Black Carbon, SO_2, NOx, CO_2, O_3.	5,500	No	Being developed	No	No	Yes	Early*
Nigeria	CO_2, CO, NO_X, O_3, SO_2, TSP, PM_{10}	5,000	No	Yes, of 1990	No, one non operational station	No	Yes	Early*
Rwanda	Not identified	5,000	No	No	No	No	No	Absent[#]
Senegal	PM_{10}, $PM_{2.5}$, CO	5,000	No	No	Being initialised	No	Yes	Initial[†]
South Africa	PM_{10}, $PM_{2.5}$, NOx, SO_2, O_3, CO,Pb	500	Yes	Yes	Yes	Yes	Yes	Comprehensive[++]
Swaziland	Not identified	500	No	Qualitative	No	No	Yes	Early*
Tanzania	PM, CO, NO_2, SO_2, O_3, Pb	5,000	No	No	Yes	No	Yes	Early*
Togo	Not identified	5,000	No	Yes, initial	No	No	No	Initial[†]
Uganda	PM, CH_4, H_2S, NH_3, dioxins and furans, HCs, NO_x, SO_x, re-suspended dust	5,000	No	No	No	No	Yes	Initial[†]
Zambia	SO_2, NO_2, PM, black smoke, dust, CO, CO_2 and odours	7,500	No	Yes, initial, in copper belt	Yes	No	Yes	Intermediate**
Zimbabwe	SO_2, NO_2, PM, CO, VOCs	5,000	Yes, for stationary sources	No	Yes	Anecdotal evidence	No	Intermediate**

† Source: PCFV (2007); [#] Absent = None of the topics addressed; [†] Initial Any one topic addressed; * Early = Any two topics addressed; ** Intermediate = Any three topics addressed; [+] Advanced = Any four topics addressed; [++] Comprehensive = All topics addressed.

Eight countries – Botswana, Ethiopia, Ghana, Madagascar, South Africa, Tanzania, Zambia, and Zimbabwe - are routinely monitoring. Nigeria and Zambia dispose of non operational stations; in Zambia, however, the smelter industries perform some monitoring. In Senegal, air pollutant monitoring is being initialised. Health impact studies exist in a few countries – Benin, Botswana, Ghana, and Tanzania. Anecdotal evidence on health impacts exists in Zimbabwe. In more than half of the countries listed in Table 4.2 projects are ongoing which will have an AQ benefit.

On the basis of these results it was attempted to characterise the capability of countries with respect to AQM. Six categories were defined: Absent, Initial stage, Early stage; intermediate stage; advanced stage, and comprehensive stage, see legend to Table 4.2. As a result, AQM can be considered comprehensive only in South Africa and advanced in Ghana; the AQM capability of Botswana, Madagascar, Zambia and Zimbabwe can be judged as being at an intermediate stage of AQM. Seven countries are at an early stage of AQM: Benin, Burkina Faso, Ethiopia, Mozambique, Nigeria, Swaziland and Tanzania. In eight countries – Cameroon, Congo-Kinshasa, Kenya, Mali, Mauritius, Senegal, Togo and Uganda – AQM is at an initial (very early) stage. AQM is practically absent in seven countries – Burundi, Congo-Brazzaville, Gabon, Guinea, Liberia, Malawi and Rwanda.

By June 2006 all countries had phased out lead in gasoline (PCFV, 2007). For the whole of Africa, the status of the use of unleaded gasoline is depicted in Figure 4.1. Only four countries – Algeria, Mauritania, Morocco, and Tunisia are using leaded fuel for vehicles.

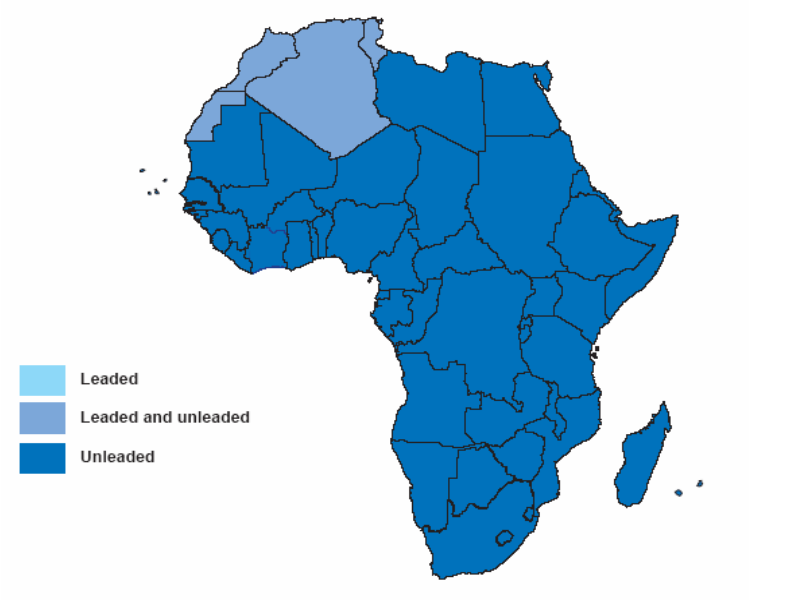

Figure 4.1: Status of leaded gasoline phase-out in SSA (June 2006)
Source: PCFV (2007)

Three countries – Botswana, South Africa and Swaziland – limit the sulphur content of diesel to 500 ppm. In Mauritius and Congo-Kinshasa diesel has a sulphur content of 2,500 and 3,000 ppm, respectively. All other countries use diesel with 5000 ppm sulphur except Mozambique (5,500), Zambia (7,500) and three countries – Congo-Brazzaville, Ethiopia, and Kenya - which still have 10,000 ppm in diesel fuel.

In detail the country situation is summarized as follows.

Benin. A major air pollution problem exists in the city of Cotonou where two initial studies have found high concentrations of CO, PM and HCs. The Benin authorities assume that vehicles are practically the only source and other sources do not contribute significantly. This may not be the case due to transboundary contributions from its neighbour countries and to sources such as uncontrolled open fires, waste deposits, industry and commerce, unpaved roads etc.

Dispersion modelling is apparently not used in Benin as a tool for estimating concentrations for existing or planned sources or helping to provide information on source apportionment.

Without routine monitoring, it cannot be ensured that the action taken to reduce emissions from mobile sources leads to a substantial reduction of air pollutant concentrations in the cities of Benin. The only impact study mentioned in the report (Worou, 2006) does not elucidate how the causal association between the enhanced frequency of respiratory infections and urban air pollution was assessed and which pollutants were responsible.

Botswana. The government of Botswana has developed a National Conservation Strategy, which promotes environmental conservation and sustainable development in the country, and an Act on Environmental Impact Assessment. The National Conservation Strategy does not yet cover explicitly the conservation of clean air. Botswana's legislation specific to air pollution is very old and only covers industrial sources. At the industrial monitoring stations, only PM_{10} and SO_2 do not always comply with monthly standards. Botswana standards are lenient to the 24-hour WHO guidelines of 50 $\mu g/m^3$ for PM_{10} and 20 $\mu g/m^3$ for SO_2. Botswana's other air quality objectives are comparable to those of the WHO and the US EPA developed to protect human health.

Burkina Faso. Air quality in Burkina Faso, especially the city of Ouagadougou is determined by a growing fleet of vehicles, particularly two-wheelers of an old age and a bad state on maintenance of vehicles. Fuels are often the adulterated. From simulated concentrations it can be assumed that AQS at kerbside location will be exceeded. A "Clean Air" action plan is designed to counteract this development by a set of measures including the phase-out of old vehicles, introduction of catalytic converters in new cars, enforcement of strict regulations for two-wheelers, improvement of public transport, the road network and the traffic flow, and the implementation of a transport plan. This action plan is a significant progress in combating air pollution in Ouagadougou and can be deemed to decisively reduce emissions from the transport sector.

Routine monitoring is not yet performed in the cities of Burkina Faso. Conclusions are drawn of the basis of simulation models. Unless based on reliable emission estimates and validated through quality assured monitoring campaigns or routine monitoring, simulation models may give misleading results, which can lead to non-efficient control measures.

Burundi. This country is in a very early stage of AQM. Practically, only the phase-out of lead has been initiated. An Environment Act exists. Public awareness and media involvement is very limited.

Cameroon has developed a Framework Environment Act which has incorporated air pollution as an important issue for which the situation should be carefully assessed. Surveillance centres for the control of vehicle emissions have been established which are able to survey the emissions of petrol-driven cars and test compliance with fuel specifications. Similar surveillance for diesel vehicles is not possible due to lack of corresponding gas oil specifications. The contribution of industrial sources, power plants, area sources such as waste deposits and open fires and that of transboundary dispersion of air pollutants cannot be assessed. Emission estimates only exist for greenhouse gases.

Republic of the Congo (Congo-Brazzaville). AQM is not yet considered as an issue that has to consider the emissions from all types of sources in order to decide on the priorities for cost-efficient control measures. The distribution of the responsibility for AQM to different ministries apart from the Ministry for Environment is a major obstacle for integrated AQM. Legislation is dissipated in the sectors of environment, energy and transport and in part overlapping. Congo Brazzaville has formulated a National Plan for Environmental Action which is to implement appropriate instruments in the industrial sector. The Ministry of Transport is aware of the environmental dimension of its policy and attempts to follow an integrated ansatz for transport. The emissions from a strongly growing and ageing fleet of second-hand vehicles are a major challenge in the cities of the Congo-Brazzaville. Industries and the vehicle fleet constitute the main consumers of energy and the main sources of air pollution. Industrial emissions and emissions from gas flaring constitute localised problems.

Democratic Republic of the Congo (Congo-Kinshasa). A framework law on AQM does not exist. There are no regulations about fuel specifications, emission or air quality standards. A monitoring network is not in place. A strongly growing vehicle fleet and obsolete industrial facilities and extremely polluting processes are responsible for air pollution. In addition, emissions from waste deposits and uncontrolled waste burning contribute significantly. Congo-Kinshasa stopped the importation of leaded gasoline in February 2005. On-going projects include the development of an Environment Act, an awareness campaign for the use of catalytic converters, and reduction of sulphur in diesel.

The capacity and capability to assess and manage air pollution in the DRC-Kinshasa is undeveloped.

Ethiopia. The major environmental laws are the Pollution Control Proclamation which addresses important issues in AQM, and the Environmental Impact Assessment Proclamation, which serves to predict and mitigate adverse environmental impacts of planned projects. Both Proclamations were promulgated in 2002. AQS have not yet been set. The Ethiopian Environmental Protection Authority is in charge of the implementation of the laws including the setting of standards. Sources of air pollution are the vehicle fleet and industrial plants such as cement plants, breweries and waste incinerators, power plants, and mineral mining and processing The vehicle fleet is badly maintained and ageing.

AQM in Ethiopia is limited to Addis Ababa where air pollution has been assessed in a short-term screening study. In this initial study levels of PM_{10}, CO, SO_2 and O_3 were found low to moderated, complied with US EPA standards and turned out to be much smaller relative to other African cities such as Cairo or Johannesburg. Diurnal behaviour of CO and O_3 concentrations correspond to those found in other cities with peaks during the morning rush hours. As the study started after the phase-out of leaded fuels in vehicles only traces of lead were found, supporting the conclusion that lead phase-out in Ethiopia was successful. Motor vehicle exhaust, residential wood burning, and dust from roads are the probable major sources of PM_{10}. These sources emit elemental carbon, organic carbon, sulphates and nitrates which constitute 52 per cent of the total PM10 mass concentration. Geologic material contributes 48 per cent of the measured PM_{10}, indicating the influence of substantial natural PM sources such as deserted areas and eroded soils.

Due to lack of funding actions plans or projects relating to AQM are not being performed in Ethiopia.

Gabon. The Environment Act was promulgated in 1993 and describes general criteria to regulate air pollution. .No surveillance network exists for air quality due to lack of monitoring devices, experience and funding. Emissions from stationary and mobile sources are not known except for carbon dioxide. Health and environmental impacts assessments are not performed.

The planned project POLAIR aims to evaluate the socio-economic, institutional and juridical impacts of rational air pollution management at the local and sub-regional levels. The plan includes already main ingredients of AQM such as an emission inventory and a monitoring network. This project, if implemented, can provide a good starting point for rational AQM in urban areas of Gabon.

Ghana. Environmental legislation including fuel specifications for petrol and diesel is promulgated and enforced. Ghana is also in the process of enacting AQS. Emission standards are still lacking. Vehicle exhaust emissions, open burning of waste and other materials, road dust, emissions from industrial sources, residential cooking, commercial activities and wind-blown dust are major contributors to air pollution.

Several projects are being implemented in Ghana:

- Capacity enhancement to assess the nature and severity of the air pollution problems in Accra
- Emission testing to enhance public participation in control measures, develop emission standards and regulations, and reduce vehicular emissions
- Introduction of a mass transport system
- Follow-up of the lead study to assess reduction of lead blood levels in vulnerable persons
- Reducing industrial wastes and pollutants
- Decongesting the roads
- Assessing health impacts associated with vehicular exhaust emissions.

The USAID, US EPA, and UNEP in July 2004 selected the city of Accra, Ghana as one of two cities in Africa to benefit from an air quality monitoring capacity building project. The project seeks to accurately characterise the severity and nature of air pollution problems in Accra and to make recommendations for the development of a broad base AQM strategy for Ghana. The main objectives of the project are to:

- Build and establish local capacity in air quality monitoring
- Collect and analyse ambient air quality data on key pollutants
- Provide policy makers with a ‘snapshot’ of the air quality situation in Accra and provide a basis to further develop an AQM strategy and
- Provide recommendations on next steps in developing a broad base AQM strategy for Ghana.

This project and other projects already initiated by Ghana EPA present a good entry into AQM in Ghana.

Guinea. AQM is, practically not existing in Guinea. Expertise is limited to conduct some small-scale monitoring with the support of US EPA.A routine monitoring system for particulate and gaseous compounds does not yet exist. Guinea did not yet promulgate legislation related to AQM. Projects to develop action plans for AQM are envisaged but their implementation needs the assistance of international programmes and agencies with respect to expert advice and funding.

Kenya. AQM is not yet performed in Kenya. The capacity and capability to assess and manage air pollution in Kenya is being developed. Fuel specifications for unleaded petrol, diesel, kerosene and fuel oil exist. Emission standards have not yet been promulgated. AQS are being developed through a participatory approach. Emissions especially in Nairobi and Mombassa originate mostly from an ageing fleet of not well maintained vehicles and open air burning of household wastes, wood and charcoal. Emissions from industries such as agro-processing manufacturers, power plants and a refinery are of less importance. The National Environment Management Authority (NEMA) is charged with the role of formulating and enforcing air quality regulations and standards. Progress has, however, been slow due to lack of funding. A continuous monitoring programme does not exist. Monitoring of particulate matter is performed sporadically and on an ad hoc basis. Other sources of monitoring data include the Global Atmospheric Watch programme of WMO measuring background CO_2, and some studies of KEMRI and KENGO on PM, SO_x and NO_x. The Ministry of Transport recently launched monitoring of emission from PSV vehicles.

Liberia. As a consequence of the war AQM has not been developed. However, the Government is aware of the challenge of air pollution. Emissions are mainly from a rapidly growing fleet of old vehicles in a state of poor maintenance and from uncontrolled power plants.

Madagascar. Madagascar has got an Environmental Act and promulgated several decrees relating to technical specifications of fuels and emission standards for mobile sources. The vehicle fleet constitutes the major source of air pollution. A national action plan is being elaborated and priorities set for the improvement of air quality. A study on exhaust gas control equipment in the test centre of Antananarivo was completed and delivered statistical information on the ability of vehicles to conform to emission standards. Several projects are envisaged relating to cost-benefit analysis, surveillance of air quality, emissions estimation, estimation of public health impacts, and improvement of traffic flow. A workshop was held in Antananarivo in 2005 dealing with the improvement of air quality in Antananarivo and the implementation of complete phase-out of lead in petrol.

Malawi. Air pollution and climate change issues are currently relatively small environmental concerns. As a consequence AQM has not developed in Malawi. However, air pollution and climate change can easily become serious problems if they go unchecked. The Government is aware of the challenge of air pollution. Emissions are mainly from a growing fleet of old vehicles in a state of poor maintenance and from uncontrolled power plants.

Mali. Political will to improve the environment has recently been developed; as is shown in the promulgation of environmental legislation and the recent setting of fuel specifications for unleaded petrol. Emission and air pollutant standards are not yet promulgated although proposals by the DNACPN were presented for deliberation of the Committee for Chemistry and Environment. Industrial sources in the vicinity to urban areas and the strongly growing vehicle fleet are major polluters in Mali. The ageing vehicle fleet consumes 60 per cent of conventional energy and constitutes a major source of air pollution. Polluting industrial facilities are located near urban areas, especially in the city of Bamako, which is directly exposed to air pollution originating in the east of the city and dispersing in the main wind direction east-west. A network of air pollutant stations does not exist. No data exist for the concentrations of hazardous pollutant in Mali or the district of Bamako.

Mauritius. Mauritius has promulgated an Environment Act and a regulation on road traffic control of vehicle emissions which provides among other issues for vehicle emission standards. Emission standards, based on the best available technology locally, are set for stationary sources of all industries, power plants and industrial boilers. The major air pollution problem in cities of Mauritius is caused by vehicle emissions which are strongly increasing. Vehicles are old and not well maintained. Diesel driven trucks are major polluters. Industry emissions are expected to be relatively low since heavy industry is absent in Mauritius. Most emissions from stationary sources are caused by power plants and industrial boilers.

The Government's strategy is to encourage the use of cleaner production technologies by enterprises. Unleaded petrol was introduced in 2002. After the introduction of unleaded petrol lead concentrations in the ambient air decreased from an average of 0.1 $\mu g/m^3$ to trace levels. AQS proposed by the Technical Committee are being under consideration by the government. An integrated approach has been proposed towards tackling air pollution, comprising prevention, enforcement, monitoring and education.

Mozambique. Mozambique has promulgated an Environment Act and several decrees relating to phase-out of lead, obligatory inspection of vehicles, and modalities of air pollutant management. Fuel specifications, emission and AQS were promulgated in 1994. The specifications for gasoline have become obsolete with the complete phase-out of unleaded petrol since April 2006. Sources in the cities of Mozambique include vehicle fleets, uncontrolled waste burning and forest and savannah fires, industries such as the MOZAL aluminium smelter and power plants. Indoor air pollution due to the use of solid fuels on open stove are an additional source which sometime even contributes to outdoor air pollution. Air pollutants are not monitored because of lack of funding to run a fully fledged monitoring system. Average daylight O_3 concentrations that have been modelled with the CAPIA (Crops Air Pollution Information for Africa) approach show moderate concentrations over large areas of Mozambique and some of its neighbours.

Other reported challenges for the implementation of AQM include the lack of expertise and capacity, lack of an effective waste management system in cities which is the cause of uncontrolled waste burning, and shortcomings in law enforcement.

Nigeria. Nigeria has promulgated a number of decrees and regulations with respect to environmental management. The Federal Environmental Protection Agency (FEPA) is charged with the implementation of the legislation and has beeen given broad enforcement powers. Mean annual emissions of air pollutants in Nigeria are reported to be low. Air pollution concentrations are presently not monitored in Nigerian cities, including Lagos where the only existing station discontinued monitoring years ago for lack of spare parts. Much higher concentrations may be prevalent in Lagos and other cities. In Lagos and oil producing areas, as well as other major urban centres, have got a high level of emissions from industrial activities apart from traffic emissions. A major problem in Lagos and other cities of Nigeria are uncontrolled smouldering waste deposits and a multitude of open air fires used to incinerate wastes. Their emissions are unknown and may be a major contributor to the deterioration of air quality. Actual pollutant levels are unknown in the major cities of Nigeria.

There are scant Nigerian health impact assessment studies and the potential impact of air pollution on public health is not known. There are no streamlined national activities on AQM, and cost-effective approaches to mitigate impacts is not yet part of national planning.

Recently, the Lagos Metropolitan Area Transport Authority (LAMATA) has commissioned an Air Quality (Vehicle Emission) Monitoring study which amongst other issues aims set tail pipe emission standards for the city of Lagos.

The major challenge in Nigeria appears still to be the enforcement of the existing legislation, which is persistent even 12 years after FEPA identified this challenge.

Rwanda. AQM does practically not exist in Rwanda. Expertise is apparently very limited if it exists at all.

Senegal. A national plan of Action was formulated in 1997 and is being implemented. Air pollution in the cities of Senegal is due to emissions from small-scale industries and from a fleet of vehicles. Uncontrolled growth of the vehicle fleet, particularly motor bikes, a bad state of the ageing vehicle fleet and doubtful quality of used petroleum products contribute to air pollution. The vehicle fleet is the source of most of air pollution. Senegal has set fuel specifications for petrol, diesel and paraffin oil. A four-year project has been started to evaluate the institutional AQM structure in Dakar, assess air quality levels, and install an AQM centre in Dakar. Monitoring is not in place yet. An air quality surveillance network is being planned. A Regional Observatory as an inter-institutional platform for analysing information obtained from the AQM Centre of Dakar is considered to help developing an integral strategy for better air quality.

The installation of the AQM centre in Dakar and the creation of a Regional Observatory will enable Senegal and, in particular, Dakar to address the AQM in a rational and comprehensive way. As a consequence air quality monitoring can be started the results of which will allow to assess the situation and can be used to set AQS enforceable in Senegal.

Swaziland. Regulations under the Environment Management Act include regulations to control the management of wastes and regulations to audit, assess and review the activities of new and existing industries as well as other developmental projects. Lead has been phased out by end 2005. Some fuel standards for mobile sources exist but no emission standards for all types of sources, vehicular or industrial. Both industrial and vehicular sources contribute significantly to outdoor air pollution Waste burning and vegetations fires are other sources, although smaller. Air pollution control regulations including AQS are being gazetted.

As a monitoring network has not been installed, air pollutant concentrations are unknown.

Tanzania. The Environmental Management Act (EMA) came into force in July 2005. It regulates the responsibilities of local authorities to prescribe emission standards for stationary and mobile sources. AQS have also been enacted. Second hand and poorly maintained vehicles and re-suspended dust from unpaved roads are major sources in Dar es Salaam. Uncontrolled waste burning, agricultural residue burning and smouldering of crudely dumped wastes are also significant sources in Tanzanian municipalities, especially Dar es Salaam. Several studies performed between 1990 and 2004 indicate that air quality in Dar es Salaam has deteriorated during this period. Until 2005 monitoring was ad hoc and non-systematic.

The Air Quality Monitoring Capacity Building Project (AQMCBP) was recently launched with the objective to enhance the capacity of participating institutions for monitoring specific air quality parameters, survey air quality, establish links to health impacts, and raise awareness among stakeholders.

In the past, Tanzania's efforts to address air pollution were limited to a few studies which assessed the state of air quality in an ad hoc manner. The AQMCBP, supported by USAID, US EPA, UNEP and the Government of Tanzania is the first systematic attempt in Tanzania to address the challenges of air pollution, particularly in the city of Dar es Salaam, and enhance the capacity in air quality monitoring and impact assessment. US EPA, funded by USAID, provided monitoring equipment, training and mentoring over the course of two years to build the capacity of Tanzanian stakeholders to operate a long-term, sustainable a monitoring program for the city of Dar Es Salaam. UNEP provided funding for in-country costs during this period of time. It is now the responsibility of Tanzania Government and other stakeholders to commit funding and staff to ensure the continuation of this monitoring programme. US EPA continues to provide long-distance technical support

Togo. Togo's Constitution disposes the right of any person to a healthy environment. An Environment Act was promulgated in 1998 and is supported by the Hydrocarbon Act relating to the exploitation of mineral sources and a Decree with specification of unleaded petrol. Several public institutions and ministries are responsible for air pollution. The energy sector, particularly through the vehicle fleet constitutes the main source of air pollution. A policy on energy development and a transport policy have been formulated as have plans and strategies: the national strategy to implement the climate change convention and the strategy to combat air pollution (quality of fuels, modalities for controls and tests of 2nd hand vehicles. Togo has not yet started to implement these two strategies – climate and air pollution due to lack of funding.

A special challenge is the delegation of responsibilities for environmental pollution to many Ministries. This can lead to competitive approaches and duplication of work. An institutional restructuring and establishment of a clear leadership could resolve this problem.

Uganda. The National Environment Management Authority (NEMA) has developed National Environmental Air Quality Standards & Guidelines for Uganda. These include among others standards for motor vehicle emissions for different categories of vehicles. Fuel specifications are planned to be revised and then adopted in Eastern Africa. However enforcement of these standards is currently weak. The major sources of air pollutants include imported second-hand vehicles, re-suspended dust from unpaved roads and a poor infrastructure, and boiler emissions from industries. Imported vehicles are mostly an increasing number of second hand motor vehicles. Motor bikes are a significant source of air pollution in urban areas. Industrial boilers mainly use furnace oil and biomass as energy sources (Kamanda, 2004). Other sources include open air burning of wastes in city skips, waste dumpsites and industrial premises. Odours are a nuisance associated with tobacco processing plants, sewage treatment plants and food cottage industries. Agro-based industries (dry coffee processing) using rudimentary dry processing and only obsolete abatement equipment are emitting particulate matter all over the country. A recent problem is a growth in production and use of polythene bags/packaging materials, with corresponding emissions of SO_2, NO_x, and CO_2. There is no plastic recycling plant in Uganda. Health effects have not been quantified but the Ministry of Health believes that there are significant adverse health impacts due to plastic bag burning.

In Uganda, AQM is in its very infancy. Uganda does not yet dispose of a monitoring network to monitor urban air quality at industrial, commercial, residential and kerbside sites. AQS have been proposed but are not yet promulgated. Baseline measurements of pollutant concentrations of compounds emitted from point sources showed non-compliance with the proposed standards (Kamanda, 2004).

The plastic bag problem is important with respect to emissions into the air from plastic burning and smouldering in waste deposits. Emissions include PM, VOCs, PAHs, dioxins and furans. A framework for garbage management bringing all stakeholders together will readily resolve this challenge. It is not recommendable to start an extensive and expensive monitoring campaign to assess the concentrations and the potential health impacts of these compounds, in particular dioxins and furans.

Zambia. Zambia has promulgated the Environment Protection and Pollution Control (EPPC) Act and other legal instruments such as the Mines and Minerals (Environmental Regulations. While the Statutory Instrument gives air quality guidelines which are internationally comparable, outdoor air quality monitoring is not required in the law. With respect to vehicular emissions Zambia has set fuel specifications for petrol and diesel.

Most serious air quality problems exist in the Copper Belt Province around the city of Kitwe. Air quality monitoring of SO_2 and NO_2 using diffusive monitors was performed in the late 1990s by NILU but discontinued. Automatic continuous monitoring equipment is currently only owned and used by Konkola Copper Mines (KCM) Plc, which manages the copper smelter and refinery in Kitwe. Some stack emission measurements are conducted by the ECZ, the mining companies themselves and private contractors.

SO_2 concentrations are of major concern in the Copper Belt since copper smelters, cobalt plant and foundries are still operating on obsolete technologies without efficient stack-gas-cleaning facilities. Mining, quarrying, lime manufacture and a cement plant are other sources which also may cause PM air concentrations although monitoring of this compound has not been performed. Monitored NO_2 concentrations comply with Zambian guideline values and are not considered to be of concern.

Emissions from industries such as breweries and fertilizer plants, domestic waste burning, tailing dumps, forest fires and increasing vehicular emissions may also contribute to air pollution in the Copper Belt area but their contribution is unknown.

Several project and tools have been initiated by the ECZ. These include cleaner production to encourage industry to limit the emission of pollutants, an effective licensing scheme to obligate industry to meet long-term emission limits. At large stationary sources the ECZ stack sampling once a year to test compliance of industrial sources with long-term emission standards; monitoring data are stored in a Licensing Information System. Licensing condition include the requirement to industries to perform monitoring of air pollutants.

The licensing and permitting programme is a good approach to ensure the compliance of industries and other facilities with long-term emission standards and to encourage them to perform monitoring. However, in the privatization process for Zambian industries concessions were made to investors, greatly limiting their environmental obligations and liabilities. New mining companies are at liberty to emit air pollutants at the same level as at the time of purchase. Nonetheless, the private sector, NGOs such as “Citizens for a Better Environment”, the general public and the ECZ have made some progress to better AQM.

Zimbabwe. Zimbabwe has promulgated an Air Pollution Prevention Act (APPA) and Regulations for smoke and emission control. Recently an Environmental Management Act was promulgated which provides for pollution control and environmental impact assessment and repealed the APPA. The Environmental Management Act is not yet fully operational and the repealed APPA is still being enforced for lack of an alternative.

A multitude of sources emits air pollutants in urban areas of Harare and Kwekwe. These include industrial sources and power plants and an increasing vehicle fleet which is ageing and not well maintained. All three types of sources are likely to contribute significantly to air pollution concentrations. AQM in the city of Harare is carried out in a two pronged approach: Industrial surveillance and the measurement of SO_2, SPM and NO_2. Some monitoring capacity exists in both Harare and Kwekwe. Challenges include however the need for training, equipment and chemical analysis capacity.

4.2 Analysis

AQM is based on the precautionary, polluters pay and prevention principles. It searches to protect human health and the environment and ensures a cost-effective approach using best available control technologies. A framework for AQM is depicted in Figure 4.2.

Rational AQM includes several approaches: Command and control, application of economic instruments, co-regulation and stakeholder voluntary initiatives, and self regulation. Education and information of the population is also an integral part of AQM.

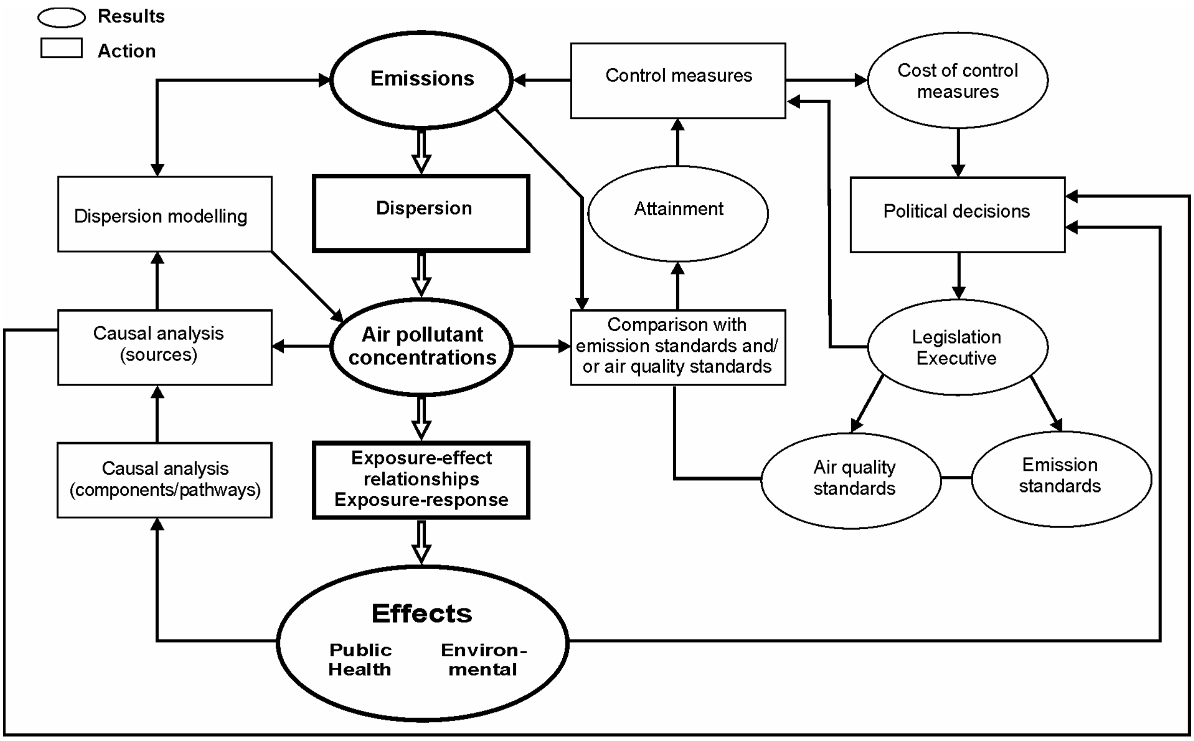

Figure 4.2: A framework for air quality management
Source: Schwela et al. (2006)

Tools for rational and systematic AQM include emission inventories, dispersion models, monitoring networks, epidemiological study approaches, and environmental study approaches. For staring AQM action plans rapid assessment methods are most suitable. Rapid inventory assessment methods allow develop initial emission inventories (WHO, 1993; APINA, 2006). A number of easy-to-handle dispersion models are available on the internet at the US EPA website. Hybrid monitoring networks are minimal sets of monitors with one or few automatic analyzers and a larger number of diffusive tubes for gaseous compounds. For particulate matter simple and easy-to-manage devices are available such as dustTraks and minivols. Rapid epidemiological assessment methods help estimate health effects due to exposure to air pollution by using known exposure-response relationships. A simple tool incorporating emissions, estimated concentrations, estimated health impacts and control actions is e.g. the World Bank SIM/Air programme which allows optimize the costs of health impacts due to air pollution with the costs of source controls.

The promulgation of emission and air quality standards and their enforcement is necessary in order to effectively control sources and interpret monitoring results with respect to their threats to public health and the environment.

4.2.1 Policies and legislation

Policies on environmental protection have been developed in all countries with the exception of Congo-Kinshasa, Guinea, Liberia, Malawi and Rwanda They take the form of an Environment Act which also covers air pollution. The Environment Act is complemented by regulations and rules which specify fuel parameters, emission standards and AQS. While 15 countries have set fuel specifications for gasoline and 13 for diesel, only 8 countries have promulgated emission standards for vehicles and 6 have set AQS. In the five countries that have not passed an Environment Act, regulations on fuel parameters for petrol and diesel do also not exist.

Most SSA countries address AQM in an ad hoc fashion. This procedure bears the risk of making wrong decisions. Only Madagascar appears to develop a full-fledged AQM system addressing revision of legislation, emissions, dispersion, air pollutant concentrations, control measures, impacts and cost-benefit analysis, and Ghana and Tanzania are on the way to develop an AQM system.

Benin’s legislation refers only to mobile sources which are apparently considered the most significant source. Thus, industrial sources, uncontrolled fires, waste deposits and transboundary air pollution are disregarded. Botswana’s air pollution legislation is very old and covers only industrial sources. Updating this legislation would make the AQM approach more realistic.

In Congo Brazzaville, the legislation relating to air pollution is diluted in many partly overlapping texts among the different sectors of the environment, energy and transport. This makes an integrated approach to AQM difficult.

In view of the substantial PM concentrations and their potential health impacts the promulgation of legislation regulating AQM is very urgent. Kenya is in a similar situation since a comprehensive urban AQM programme is lacking. Togo’s two policies on energy development and transport and the strategy to combat air pollution have the character of ad hoc measures rather than being integrated policies. In addition, the implementation of these strategies has not yet started due to lack of funding and logistics.

Zambia’s legislation has the goal to control pollution but does not legally bind for maintenance, monitoring and sustenance of air quality. In consequence, monitoring is not performed by the government but rather delegated to industry with respect to their sources. This, in turn implies that exposures related to vehicular emissions are only controlled via fuel specifications and emission standards if promulgated.

4.2.2 Governance

The political will to implement and enforce strict regulations has developed differently, as e.g. in Burundi where only a NGO has been instrumental in the past to promote air quality management measures. The major challenge in Nigeria appears still to be the enforcement of existing legislation, which is persistent even 12 years after FEPA identified this challenge. Reasons for lack of political will include limited degree of public awareness about adverse impacts of air pollution on human health and the environment. In other countries such as Liberia and Malawi the development of AQM has been hampered by the lack of funding.

Challenges in the majority of the 27 African countries include the lack of monitoring equipment; prevalence of ad hoc awareness raising; and poor participation of stakeholders including the public and the media. Further challenges are the high costs of awareness raising programmes; the design and implementation of AQM strategies, which are often based on poor knowledge and inadequate regulatory, institutional, planning, technical, social, and financial capacities for AQM. E.g. in all African countries industrial facilities are obsolete and poorly maintained. Growing vehicle fleets are mostly consisting of aged cars, trucks and buses.

Institutional set-up is often characterised by responsibilities shared by several ministries without a lead agency for the implementation of environmental goals, policies and strategies. Roles and responsibilities are often not well defined, documented, communicated and enforced. Human resources and specialized skills are lacking in many countries as are technological and financial resources.

A revision of the institutional set-up in countries and introducing transparency in institutional mechanisms will enhance the capability to implement AQM policies, enforce laws and regulations and review their effectiveness. Establishing a lead agency for the implementation of environmental goals, policies and strategies can assist in consolidating responsibilities, ensure integrated approaches, and can avoid duplication of work. The implementation of AQM needs the provision of human resources, specialized skills, technology and financial resources.

Awareness of the impacts of air pollution on human health and the environment, risk perception and risk communication are poorly developed in most African countries. This is particular true for the health impacts of indoor air pollution. Awareness raising is essential in order to strengthen the participation of all stakeholders such as the public, academia, industry, NGOs in AQM and particularly in projects on health impacts due to air pollution. As the need for training in African counties is noted for almost all countries under consideration specialized programmes and training modules are necessary to enhance capacity in AQM. In the design and implementation of these tasks all stakeholders should be involved. The capacity for regular public information on the importance of air quality and AQM necessity should be enhanced as well. All stakeholders should have a well-defined role in AQM and receive relevant information regularly.

4.2.3 Emissions

Fuel specifications. In order to increase expertise in AQM, a good starting point would be the setting of fuel specifications for new and imported second-hand vehicles. This includes the identification within a legislative and juridical framework of stakeholders in importation/production, distribution and storage to ensure the quality of petrol; setting specifications for new technologies; addressing regulatory aspects related to the import of vehicles; and raising stakeholder awareness.

Lead has been phased out in all SSA countries and, therefore, is not any more a major problem if no other lead sources such as lead smelters exist. Sulphur content in diesel is a major source of fine particles (sulphates). Diesel sulphur levels in SSA countries vary between 500 ppm (Botswana, South Africa, and Swaziland) and 10,000 ppm (Congo-Brazzaville, Ethiopia and Kenya) with most other countries having levels of 5,000 ppm, see Table 4.2. Three countries (Gabon, Mozambique, and Zambia) have sulphur content levels above 5,000 ppm but below 10,000 ppm and two countries limit the sulphur content to 3,500 ppm (Congo-Kinshasa) and 2,500 ppm (Mauritius). In order to reduce the emission of sulphates from diesel vehicles, the EU and the USA have recently reduced sulphur content levels to 50 ppm. Compared to this limit, diesel sulphur contents in SSA countries are high. Sulphur content in fuels need to be reduced in order to reduce the emission of sulphates. Changes in sulphur content in diesel would make necessary to adapt fuel specifications as does the phase-out of lead in gasoline with respect to the corresponding fuel specifications.

With the promulgation of fuel specifications for unleaded petrol, Togo and Uganda made a step forward to initiate sound AQM. Further steps to follow would be to set fuel specifications for diesel and develop and enforce emission standards for imported second-hand vehicles. The fuel specifications for diesel would essentially correspond to those of Nigeria as this country exports fuel to Togo.

Inspection and maintenance. Most countries do not dispose of facilities for vehicle inspection and maintenance (I&M). An exception is Cameroon. Inspection and maintenance of vehicles, even of new ones with catalytic converters is an issue to be considered but does not appear to be part of Cameroon's project and action plan as it is formulated. Lack of maintenance makes catalytic converters inefficient after a couple of years.

Emission standards. Emission standards both for mobile and stationary sources are not set in the majority of SSA countries cp. Table 6.1 in Section 6. In consequence, and as I&M facilities for vehicles are lacking it is not possible to control the performance of second hand cars and other vehicles imported in SSA countries. Standards for imported vehicles can be achieved in a cost-effective way if the importer of vehicles is requested to provide a proof of compliance with emission standards. The requirement of catalytic converters in second- hand cars can also be fulfilled in a relatively cost-effective way. However, vehicles equipped with catalytic converters loose the cleaning capacity after two years of operation if not maintained. This requests the installation of I&M facililties which can only be realised in SSa countries with substantial support from donor agencies.

Five countries have set or proposed emission standards for mobile sources, either petrol- or diesel-driven or both: Botswana, Burkina Faso, Kenya, Madagascar, and Uganda. These standards relate to emissions of CO, CO_2, NO_x, HCs and VOCs. Emission standards for stationary source exist or are being set in four countries: Botswana, Burkina Faso, Kenya and Mauritius. Mauritius has developed a most comprehensive set of emission standards for several source types and a number of pollutants, as is shown in Annex Mauritius_2, Section 6.

Emissions inventories. Emission inventories do not exist in any of the 27 countries. Therefore quality assured emission data are not available and dispersion modelling cannot be applied. Quantification of the contribution from different sources will help to set priorities in AQM which permit to decide which sources should be first addressed. Dispersion modelling can be used to estimate pollutant concentrations and by comparison with actual measurement test the validity of the emission estimates.

Most SSA countries even do not dispose of emission estimates. Some emission estimates exist in Botswana, Burkina Faso, Mali, Mozambique, Nigeria, Togo, and Zambia. However, these are crude, incomplete and the quality of these data is uncertain. Rapid inventory assessment systems such as such as the APINA procedure (APINA, 2006) or the rapid assessment system of the World Health Organization (WHO, 1993) would be useful with respect to this, e.g. in the case of Selebi Phikwe, Botswana.

In countries like Botswana (Selebi-Phikwe), Mali (Bamako), Senegal (Dakar) and Zambia (Kitwe) and to a smaller extent, Mozambique (Maputo), industrial sources are a key contributor to air pollution in some parts of the country. An initial source apportionment would be helpful to decide which source types should be addressed first with respect to implementing control actions. Source apportionment has been performed in only two countries and limited to GHGs: Congo Brazzaville and Togo.

Waste Management. Some countries such as Mozambique and Uganda lack a waste management system with transporting wastes to and incinerating wastes at a central facility. As a consequence, uncontrolled burning of wastes in cities is common practice. This problem needs urgent attention because emissions from uncontrolled burning of wastes including household wastes, tyres, electrical devices etc. emit not only the key pollutants but also VOCs, PAHs, dioxins and furans. Some of these pollutants are carcinogenic and/or highly toxic. In order to protect public health, open burning of wastes should be prohibited. A corresponding law can, however, only be enforced if a viable waste management system is operational.

4.2.4 Air quality monitoring

Routine air quality monitoring is not performed in the majority of SSA countries considered in this report. Monitoring stations exist in seven of the 27 countries – Botswana, Ghana, Madagascar, Nigeria, Tanzania, Zambia, and Zimbabwe. Monitoring stations are being installed in Senegal (Dakar). In those countries where monitoring stations are operational, these are located in the capital cities or in the cities with heavy industry. Examples include Botswana (Gaborone, Selebi Phikwe), Ghana (Accra), Madagascar (Antananarivo), Tanzania (Dar es Salaam) and Zimbabwe (Harare). Nigeria (Lagos) and Zambia (Lusaka) dispose of monitoring stations which are non-operational since several years. In Zambia, monitoring is performed by industry; in other SSA countries the Environmental Protection Agency or the Ministry of Environment is responsible for monitoring.

Some countries such as Congo-Brazzaville have already envisaged the implementation of a monitoring network. The monitoring capability of the 19 countries not monitoring could be enhanced by installing a small hybrid network of monitoring stations with a station of automatic samplers, dustTrak or minivol samplers and diffusive samplers for the gaseous compounds. While automatic samplers provide time series of monitoring data, diffusive samplers are very useful for providing spatially representative data at a lower time resolution. Such a hybrid network could deliver information on the air quality situation in a cost-effective manner. An important part of the network would be a quality control/quality assurance plan which ensures that data are of known quality. Installation of a monitoring network involves the consideration of the supply of spare parts in order to make the network sustainable. Nigeria and Zambia are examples where this was not the case in the past. Regarding the compounds to be monitored, PM is of particular concern with respects to health impacts.

Air pollutant concentration monitoring is used to test compliance with AQS. AQS have been set or proposed in eight of the 27 countries – i.e. Botswana, Burkina Faso, Ghana, Kenya, Mauritius, Nigeria, Tanzania, Uganda, and Zambia. In Burkina Faso, Kenya, Mauritius, Nigeria and Uganda enforcement is not possible for lack of monitoring results. Countries which are monitoring but do not have promulgated AQS such as Ethiopia use US EPA standards or WHO guideline values for the compliance test.

Routine monitoring will also allow set enforceable AQS. WHO's guidelines for air quality may help set standards and averaging times (WHO 2006; 2000). The current guideline values for key air pollutants have been compiled in Table 4.3. The criteria for the derivation of air quality

Table 4.3: WHO air quality guidelines for a number of compounds.

Compound	Averaging time	Guideline value [μg/m^3]	Reference
PM_{10}	1 year	20	WHO (2006)
	24 hours	50	
$PM_{2.5}$	1 year	10	
	24 hours	25	
SO_2	24 hours	20	WHO (2006)
	15 min	500	WHO (2000)
NO_2	1 year	40	WHO (2000)
	24 hours	200	
O_3	8 hours	100	WHO (2006)
CO	8 hours	10,000	WHO (2000)
	1 hour	30,000	
	30 min	60,000	
	15 min	100,000	
Pb	1 year	0.5	WHO (2000)
Mn	1 year	0.15	
Cd	1 year	0.05	
Hg	1 year	1	
Volatile Organic Compounds			
Formaldehyde	30 min	100	WHO (2000)
Ethyl benzene	1 year	22,000	
Styrene	1 week	260	
	30 min	70	
Toluene	1 week	260	
	30 min	1,000	
Xylenes	1 year	870	
	24 hours	4,800	
Diesel exhaust	1 year	5.6	
Carcinogenic compounds		**Unit risk**	
Benzene	Lifetime	(4.4-7.5) x 10^{-6}	WHO (2000)
Benzo[a]pyrene		8.7 x 10^{-2}	
Diesel exhaust		(1.6-7.1) x 10^{-5}	

guidelines set by WHO are also valid for setting standards. Experience from developed countries may be used to collect information on the number of standards-exceeding values not leading to adverse health or environmental effects. A participatory approach in setting standards which involves stakeholders (e.g. industry, local authorities, non-governmental organizations, media and the general public) assures –as far as possible – social equity or fairness to the parties involved. The provision of sufficient information and transparency in standard setting procedures ensures that stakeholders understand the environmental, health and socio-economic impacts of such standards.

4.2.5 Modelling

Air quality modelling is hardly applied in the 27 countries. This is due to the lack of quality assured emission data and source apportionment experience. Dispersion models are useful in determining the spatial and time distribution of pollutants from different sources in an urban area. Dispersion models allow estimate concentrations from existing and planned sources and the contribution from transboundary air pollution in a particular country. Dispersion modelling also helps determine the most appropriate sites for monitoring.

4.2.6 Impacts

Information on the impacts of air pollution on human health and the environment is rare in the 26 countries. 14 countries (Burundi, Cameroon, Congo Brazzaville, Kenya, Liberia, Madagascar, Mauritius, Mozambique, Congo Kinshasa, Rwanda, Swaziland, Tanzania, Togo and Zimbabwe) do not have any reports on health and environmental impacts. In Burkina Faso and Senegal estimates on the costs of air pollution in terms of percent reduction of the gross domestic product have been performed. Guinea, Mali, Uganda and Zambia suggest on the basis of qualitative and anecdotal observations that respiratory symptoms and other public health impacts may be due to air pollution. Some studies have been performed in Benin, Botswana, Ghana, and Nigeria. The most comprehensive ones are studies of blood lead levels in Ghana before and after the phase-out of lead, a study on the linkage of air pollution and health impacts. In Nigeria, studies are being planned on acidification, urban temperature, solar irradiance, greenhouse gas effects and human health in Nigeria. In Botswana small scale studies performed in the city of Selebi Phikwe investigated impacts of SO_2 on the population and the environment.

The POLAIR project of Gabon plans to estimate human health impacts caused by air pollution through epidemiological studies. In view of this situation, there is a lack of short- and long-term studies of health, environmental and economic impacts due to air pollution in practically all 26 African countries. This shortcoming is also reflected by the absence of air quality monitoring capability of 21 countries. Insufficient institutional capability and the lack of national health surveillance systems may also be causes of the scarcity of health and environmental studies. Without a health surveillance system, it is impossible to assess the contribution of air pollution to morbidity and mortality. The system can be expanded to report morbidity and mortality cases associated with air pollution on a regular basis. The use of rapid assessment techniques for epidemiological studies and evaluation of the data of the surveillance system is recommended as a starting point for estimates on the impacts of air pollution on human health and their social costs. Social costs of air pollution can be used in cost-benefit analysis comparing costs of control and costs of avoided health and environmental impacts.

4.2.7 Finances

In view of the necessity of financial sustainability of AQM challenges in African countries include a low priority for AQM funding, under-funding of AQM and lack of transparency on the use of resources. There is also a lack of sufficient funding for capacity building and awareness raising; poor knowledge of existing market mechanisms; and a lack of adherence to the 'polluter pays' principle. As health and a sound environment are basic human rights often laid down in the Constitutions of African countries governments have the responsibility to reduce emissions of air pollutants and improve air quality. This includes the awareness among decision makers on the need to financing AQM to improve the health of their populations and the environment. In this respect it would be helpful if governments would share information on AQM with the private sector and give incentives to all stakeholders to find ways for fund-raising. The support of international development agencies is crucial to enhance the capacity of countries in reducing air pollution and to provide incentives for sound AQM.

4.2.8 Country-approaches of general interest

There are a few approaches which deserve further interest as they may be replicable in other countries.

Burkina Faso: "CLEAN AIR" project for Ouagadougou

Ghana: Air quality monitoring capacity building project

Mauritius: Promulgation procedure for air quality standards

Tanzania: Air Quality Monitoring Capacity Building Project

Zambia: Licensing and permitting programme

These approaches are described in more detail in Section 5.

Section 5. Presentation of some Best Practices in the SSA Region

The Best Practices compiled in this Section refer to

- Fuel specifications
- Emission standards
- Air quality standards
- Action plan
- Monitoring network
- Follow up to the leaded gasoline phase-out. Monitoring blood lead levels in high risk groups

They are selected under the viewpoint of easy transferability from the country where they are applied to other countries.

5.1 Fuel specifications

In 14 of the SSA countries considered in this report, fuel specifications have been formulated for fuels to be imported, produced, stored and distributed. The countries with most comprehensive fuel specifications are presented in Table 5.1 (Sexsmith, 2005). It should be noted that the fuel specifications presented in this table and the tables of Section 5 correspond to the situation of 2004 and early 2005. At this time, Sub Saharan African countries were in the process of phasing out lead in gasoline and generally reviewing their fuel specifications.

Table 5.1: Countries with fuel specifications for petrol and gas oil (diesel)

Country	Petrol RON	Table # in section 5	Diesel Cetane	Table # in section 5
Benin	91	Benin_2		Benin_2
Cameroon	91	Cameroon_2		
Ethiopia	90	Ethiopia_1	48	Ethiopia_2
Ghana	91	Ghana_1	45	Ghana_3
	93	Ghana_2		
Kenya	87	Kenya_1		
	93	Kenya_2		
Madagascar	87	Madagascar_2	48	Madagascar_5
	91	Madagascar_3		
	95	Madagascar_4		
Mali	91	Mali_2		
Mauritius	95	Mauritius_3	49	Mauritius_4
Mozambique	93	Mozambique_1	45	Mozambique_2
Nigeria	??	Nigeria_3	47	Nigeria_4
Senegal	87	Senegal_2	45	Senegal_5
	95	Senegal_3	40	Senegal_6
Tanzania	95	Tanzania_1	48	Tanzania_2
Uganda	??			
Zambia	91	Zambia_1	46	Zambia_2

?? No information provided

Any holder of an import license, a storage license or a distribution license has to comply with the specifications laid down in the tables. In addition, Senegal has set specifications for paraffin oil and fuel oil of kinematic viscosity of 180 centi Stokes.

Leaded gasoline has been phased out in SSA since January 2006 but countries have not yet set specifications for the content of fuels for sulphur, aromatics and olefins. Refineries in SSA are confronted with the challenge of reducing sulphur contents in diesel and gasoline. The World Bank will initiate a study with the objective to facilitate setting up regional harmonised specifications. This study will also consider the costs of required fuel upgrades in comparison to other alternatives such as vehicle maintenance or measures to improve traffic flow.

5.2 Emission standards

Burkina Faso has set emission standards for emissions of CO, NOx, HC and VOC for mobile sources (Table Burkina_Faso_2 and Table Burkina_Faso_3 in Section 3). It has also promulgated emission standards for power plants, industrial plants, cement factories and brick kilns (Table Burkina_Faso_4). Another example for control of diesel- and petrol-driven vehicles are the emission standards of Madagascar (Table Madagascar_4 and Table Madagascar_5).

In Mauritius emission standards are set for stationary sources of all industries, power plants and industrial boilers (see Mauritius in Section 3). They are based on the best available technology locally available. Emission standards are set for

- PM_{10} emitted from all industries and power plants,
- SO_2 emitted from thermal power stations (new and existing) and industrial boilers,
- NOx applicable to all industries and power plants
- CO emitted from all types of plants
- VOCs emitted from all types of plants.

These emission standards follow essentially World Bank recommendations.

Mauritius has also regulated stack design and operation of boilers with respect to efficient combustion and compliance with emission standards. Mauritius' legislation also deals with cleaner production and efficient use of energy.

5.3 Air quality standards

According to the reports provided, AQS have been promulgated or are being considered in Botswana, Burkina Faso (Table Burkina_Faso_5 in Section 3), Ghana, Mali, Mauritius (see Table Mauritius_1 in Section 3), Nigeria, Tanzania and Uganda. The most comprehensive set of proposed AQS appears to exist in Mauritius. AQS should be promulgated in all SSA countries and subsequently enforced, eventually in a stepwise process.

5.4 Action plan

The Air Quality Monitoring Capacity Building Project (AQMCBP) that was launched in Tanzania in August 2005 in three municipalities of Dar es Salaam city is an approach to AQM that could be applied in other countries.

AQMCBP is a multi-stakeholder project that aims at enhancing capacity of participating institutions for monitoring of specific air quality parameters. AQMCBP aims at contributing significantly into development of AQS in a country/region. The project focuses on surveys related to air pollution and its links to adverse health effects. The project also aims at increasing level of awareness among policy makers, authoritative organizations, stakeholders and general public. The monitoring results will form basis for the development of long term monitoring program and formation of database to be utilized by different stakeholders. The objective of AQMCBP is to build capacity on management of air quality and establish baseline data and information on levels of selected air impurities. The expected outputs of the project include a comprehensive and consistent database on the quality of air in urban centres. The project is also expected to provide information that would assist in standards formulation process.

The main components of AQMCBP include capacity building; with sub-activities including; training of the teams involved in routine monitoring activities, establishing and upkeep of sampling sites (need to conform to international sampling protocols), and conducting air monitoring and sampling activities. Laboratory works also form significant part of the projects activities as sampling equipment and filters requires conditioning before and after each round of sampling activity.

Although the project suffers from some inherent shortcomings the ansatz to address AQM is sound and well transferable to other countries, which all encounter similar challenges. An extensive description of the AQMCBP can be found in the Annex Tanzania.

5.5 Monitoring network

The USAID, US EPA, and UNEP in July 2004 selected the city of Accra, Ghana as one of two cities in Africa to benefit from an air quality monitoring capacity building project. The project seeks to accurately characterise the severity and nature of air pollution problems in Accra and to make recommendations for the development of a broad base AQM strategy for Ghana. The main objectives of the project are to:

- Build and establish local capacity in air quality monitoring
- Collect and analyse ambient air quality data on key pollutants
- Provide policy makers with a ‘snapshot’ of the air quality situation in Accra and provide a basis to further develop an AQM strategy and
- Provide recommendations on next steps in developing a broad base AQM strategy for Ghana.

To achieve the above objectives, the following tasks were set out and implemented:

- An inception meeting with relevant stakeholders was convened with responsibility for decision-making on all aspects of the project.
- A Quality Assurance Project Plan (QAPP) for the implementation of the project was drafted.
- Air quality sampling sites in accordance with the air quality-monitoring plan were established
- A workshop to disseminate the outcomes of the air quality-monitoring programme was organised.

As part of the project implementation plan, a number of monitoring sites have so far been established in representative residential, commercial, industrial and roadside sites

Key pollutants such as particulate matter (PM_{10}), sulphur dioxide, nitrogen dioxide, carbon monoxide, ozone and lead and manganese in particulate are being monitored at these sites.

Sampling is conducted in accordance with a 6- day routine schedule. Data collection is performed in accordance with the standard operating procedures (SOPs).
Results of the air quality monitoring show that vehicular exhaust emissions, open burning of waste and other materials, road dust, emissions from industrial sources, residential cooking, commercial activities and wind-blown dust are all major contributors to the air quality measured at the permanent and roadside sites. The results also revealed that roadside locations and commercial areas have high particulate concentration, which is likely to affect the health of the populace.

Other countries should consider start similar projects.

5.6 Follow up to the leaded gasoline phase-out. Monitoring blood lead levels in high risk groups

As a party to the World Bank Clean Air Initiative in Sub-Saharan African Cities (CAI-Asia), Ghana successfully phased-out leaded gasoline in December 2003. As part of the phase-out programme, the EPA carried out sampling and analysis of lead levels in soil, air and blood of high-risk groups during one year. The Agency and the Ghana Health Service are currently conducting a follow-up study to monitor trends in blood lead levels of high-risk groups after the phase-out of leaded gasoline. The results of this study can be compared to the results of the previous one. The comparison will probably show a significant decrease in average blood lead levels if no other lead sources such as tap water and leaded paints have contributed to blood lead levels of high risk groups.

Section 6. Presentation of information per thematic issue

This section compiles the data available in SSA countries on fuel specifications for petrol and diesel, emission standards for mobile and stationary sources, and AQS as they have been reported in the reports received by World Bank, UNEP and APINA. The countries are listed in Table 6.1 showing their reporting with respect to fuel specifications, emission standards and AQS.

According to this table,

- 16 countries have reported on fuel specifications for petrol
- 14 countries have reported on fuel specifications for diesel
- 0 countries have reported on fuel specifications for fuels used in stationary sources
- 5 countries have reported on emission standards for petrol driven vehicles
- 4 countries have reported on emission standards for diesel driven vehicles
- 5 countries have reported on emission standards for stationary sources
- 9 countries have reported on air quality standards

The tables on fuel specifications and emission standards are compiled on the following pages (Sexsmith, 2005; Worou, 2006; Farota, 2006). They show quite substantial differences in the specifications with respect to lead and sulphur contents. E.g. the lead content ranges between not detectable for Benin and 0.4 g/L for Mozambique (presumably since beginning of 2006 lower specifications were developed in this country due to phase-out of lead) with most countries having petrol with a residual lead content of 0.013 g/L. The sulphur content of petrol varies between 40 ppm for Ethiopia and 2000 ppm for Madagascar. Harmonization of these parameters as well as of the distillation values and other parameters would be useful. Diesel specifications are also quite divergent among countries. E.g. the sulphur content of diesel varies between the lowest values of 1,300 ppm and 1,500 ppm for Nigeria and Senegal, respectively and 10,000 ppm for Ethiopia. Harmonisation in terms of all specifications for diesel would also be useful.

Table 6.1: Country reporting of fuel specifications, emission standards, and air quality standards

Country	Fuel specification petrol	Fuel specification diesel	Fuel specification stationary	Emission standards petrol-driven vehicles	Emission standards diesel-driven vehicles	Emission standards stationary	Air quality standards
Benin	X						
Botswana				X	X	X	X
Burkina Faso	X	X		X		X	X
Burundi							
Cameroon	X						
Congo Brazzaville	X	X					
Congo-Kinshasa							
Ethiopia							
Gabon	X**	X					
Ghana	X	X					X
Guinea							
Kenya	X	X		X	X	X	X
Liberia							
Madagascar	X	X		X	X		
Malawi							
Mali	X						
Mauritius	X	X				X	X**
Mozambique	X	X					
Nigeria	X	X				X	X
Rwanda							
Senegal	X	X					
Swaziland		X					
Tanzania	X	X					X
Togo	X	X					
Uganda				X	X		X
Zambia	X	X					X
Zimbabwe							

** Proposed

6.1 Fuel specifications for mobile sources

6.1.1 Fuel specifications for petrol

Table Benin_2: Fuel specifications and test methods for petrol 91 RON

Characteristic variable	Unit	Specified values		Methods		
		MIN	MAX	AFNOR	ASTM	OTHERS
Research octane number (RON)		91	-		D-2699	NF EN ISO 25163
Lead content	g/L	0	0	NFM07-043; NFM07-014	D-3341; D-5059	NF EN ISO-3830
Sulphur content	% wt.		0,15	NFT60-142; NFM07-059	D-2785	
Olefins content	% vol.	tbd			D-1319	
Aromatics content	% vol.	tbd			D-1319	
Masse density	Kg/L	0,730	0,790		D-1298	NF EN ISO 12188
Distillation				NFM07-002	D-86	NF EN ISO-3405
10 % evaporated at	°C	45	75			
50 % evaporated at	°C	88	125			
90 % evaporated at	°C	120	180			
Final distillation point	°C	175	215			
Residue	% vol.		1.5			
Reid Vapour Pressure	g/cm²	585	650	NFM07-007	D-323 D-5191	
Gasoline existent gum	mg/100 ml		4	NFM07-004	D-381	
Corrosiveness to copper			1a or 1b	NFM07-015	D-130	NF EN ISO-2160
Induction period	min	240		NFM07-012	D-525	
Appearance		Clear and limpid				Visual
Colour		Pale yellow				Visual
Odour		Marketable				

Table Cameroon_2: Fuel specifications and test methods for "super" fuel

Characteristic variable	Unit	Specified values		Methods		
		MIN	MAX	AFNOR	ASTM	Other
Research octane number		91	-	M07 026	D 2699	
Lead content	g/L	0	0.013		D-3341	
Sulphur content	% wt.		0,05		D-3227	
Olefins content	% vol.		10		D-1319	
Masse density	Kg/L				D-1298; D-4052;	NF EN ISO12188
Distillation				M07-002	D-86	
10 % evaporated at	°C					
50 % evaporated at	°C					
90 % evaporated at	°C					
Final distillation point	°C					
Residue	% vol.					
Reid Vapour Pressure	g/cm²		650	M07-007	D-323	
Gasoline existent gum	mg/100 ml		4	M07-004	D-381	
Induction period	min	240		M07-012	D-525	
Colour		Pale yellow				Visual
Odour		Marketable				

Table Ethiopia_1: Specifications and test methods for unleaded gasoline

Characteristic variable	Unit	Specified values		Methods
		MIN	MAX	ASTM
Research octane number		90	-	D-2699
Lead content	g/L	0	0.007	D-3237
Sulphur content	% wt.		0,004	D-5453
Masse density	Kg/L	0,722		D-4052
Distillation				D-86
10 % evaporated at	°C		55	
50 % evaporated at	°C		94.5	
90 % evaporated at	°C		159	
Final distillation point	°C		184	
20% minus 10% recovery	°C		8	
Residue	% vol.		1	
Reid Vapour Pressure	g/cm²		610	D-323
Gasoline existent gum	mg/100 ml		2	D-381
Corrosiveness to copper			1	D-130
Induction period	min	480		D-525
Doctor test			Negative	D-4952
Colour			Pale yellow	Visual

Table Cameroon_2: Fuel specifications and test methods for "super" fuel

Characteristic variable	Unit	Specified values		Methods		
		MIN	MAX	AFNOR	ASTM	Other
Research octane number		91	-	M07 026	D 2699	
Lead content	g/L	0	0.013		D-3341	
Sulphur content	% wt.		0,05		D-3227	
Olefins content	% vol.		10		D-1319	
Masse density	Kg/L				D-1298; D-4052;	NF EN ISO12188
Distillation				M07-002	D-86	
10 % evaporated at	°C					
50 % evaporated at	°C					
90 % evaporated at	°C					
Final distillation point	°C					
Residue	% vol.					
Reid Vapour Pressure	g/cm²		650	M07-007	D-323	
Gasoline existent gum	mg/100 ml		4	M07-004	D-381	
Induction period	min	240		M07-012	D-525	
Colour		Pale yellow				Visual
Odour		Marketable				

Table Ghana_1: Fuel specifications and test procedures for domestic unleaded gasoline

Characteristic variable	Unit	Specified values		Methods
		MIN	MAX	ASTM
Research octane number		91	-	D-2699
Lead content	g/L	0	0.013	D-3237
Sulphur content	% weight		0,10	D-1266
Manganese content	g/L		0.018	D-3831
Dye content	% weight		0.0008	
Masse density	Kg/L	0,725	0,790	D-1298; D-4052
Distillation				D-86
10 % recovered at	°C		70	
50 % recovered at	°C		115	
90 % recovered at	°C		180	
Final distillation point	°C		204	
Residue	%Vol		2	
Reid Vapour Pressure	g/cm^2		670	D-323
Gasoline existent gum	mg/100 ml		5	D-381
Corrosiveness to copper (3 h at 40 °C)			1	D-130
Induction period at 100 °C	min	240		D-525
Water and sediment	% vol.		0.01	D-2709
Colour			Red	Visual

Table Ghana_2: Fuel specifications and test methods for imported unleaded gasoline

Characteristic variable	Unit	Specified values		Methods	
		MIN	MAX	ASTM	Other
Research octane number		93	-	D-2699	
Lead content	g/L	0	0.013	D-3237	
Sulphur content	% weight		0,10	D-2785	
Manganese content	g/L	Nil	D-3831		
Benzene	% vol.		Report	D-4420	
Aromatics	% vol.		Report	D-1319	
Masse density	Kg/L	0,725	0,790	D-1298; D-4052	
Distillation				D-86	
10 % recovered at	°C		70		
50 % recovered at	°C		115		
90 % recovered at	°C		180		
Final distillation point	°C		205		
Residue	% vol.		2		
REID Vapour Pressure	g/cm^2		670	D-323	
Gasoline existent gum	mg/100 ml		5	D-381	
Corrosiveness to copper (3 hr at 40 °C)			1	D-130	
Induction period at 100 °C	min	240		D-525	
Alcohol/MTBE or Ethers			0		EN 13132
Colour		Not dyed		Visual	
Oxygenates					
o Ethers C_5+			0		EN 13132
o Alcohol C_1-C_4			0		EN 13132

Table Madagascar_2: Generally applicable requirements and test methods for "tourism" grade unleaded motor petrol (RON 87)

Characteristic variable	Unit	Specified values		Method[1]	
		MIN	MAX	ASTM	Others
Research octane number (RON)		87	-	D-2699	
Lead content	g/L	0	0.3	D-3341	
Sulphur content	% weight		0.20	D-2785	
Masse density at 15 ^{0}C	Kg/L	0.700	0,750	D-1298	
Distillation				D-86	
10 % evaporated at	°C		85		
50 % evaporated at	°C		115		
90 % evaporated at	°C		205		
Evaporated at 100 ^{0}C	% vol.	40	70		
Final distillation point	°C		215		
Residue	% vol.		2		
Reid vapour pressure at 37.8 ^{0}C	bar		0.800	D-323	
Gasoline existent gum	mg/100 ml		4	D-381	
Corrosiveness to copper (3 h at 50 ^{0}C)			1		
Sulphur compounds – Doctor test		negative	D-4952		
Appearance		Free from water and suspended matter			Visual
Colour		Red[2]			

[1]This method or any other equivalent international method utilized by petroleum industry
[2]Neutral colour at the time of import

Table Madagascar_3: Fuel specifications and test procedures for petrol 91 RON

Characteristic parameters	Unit	Specifications		Method[1]	
				ASTM	Others
		Min	Max		
Research octane number		91.0			D-2699
Lead content	g Pb/L		0.013	D-3341	
Sulphur content	% wt.		0.20	D-2785	
Benzene content	% vol.		2.5	D-3606	
Aromatics content	% vol.		42.0	D-1319	
Olefins content	% vol.		18.0	D-1319	
Phosphorous content		Nil			
Mass density at 15^{0}C	kg/L	0.705	0.790	D-1298	
Distillation				D-86	
T 10 – 10% evaporated	^{0}C		75		
Final distillation point	^{0}C		215		
Residue	% vol.		2		
Gasoline existent gum	mg/100 ml		5	D-381	
Corrosiveness to copper (3h at 50^{0}C)			1	D-130	
Reid-vapour pressure at 37.8 ^{0}C	kPa	45	75	D-323	
Sulphur compounds "Doctor Test"		negative		D-4952	
Colour		Red[2]		Visual	
Odour		Marketable			
Oxygen compounds:					NF EN 1601
- Methanol (with stabilisators)			3		
- Ethanol (also with stabilisators			5		
- Iso-propylalcohol			10		
- Iso-butylalcohol			10		
- Iso-ter-butylacohol			7		
- Ethers (5 C-atoms or more per molecule)			15		
Additives		Additives to improve the quality of petrol 91 can only be added in small quantities in agreement with the Ministry of Energy			

[1]The methods quoted or any other equivalent international method utilized by petroleum industry
[2]Neutral colour at the time of import

Table Madagascar_4: Fuel specifications and test procedures for petrol 95 RON

Characteristic parameters	Unit	Specifications		Method[1]	
		Min	Max		ASTM
Research octane number		95.0		D-2699	
Lead content	g Pb/L		0.013	D-3341	
Sulphur content	% wt.		0.20	D-1266	
Phosphorous content		Nil			
Benzene content	% vol.		2.5	D-3606	
Aromatics content	% vol.		42.0	D-1319	
Olefins content	% vol.		18.0	D-1319	
Mass density at 15^{0}C	kg/L	0.720	0.775	D-1298	
Distillation				D-86	
Volume of evaporated distillate at 100 ^{0}C	% vol.	46.0	71.0		
Final distillation point	^{0}C		215		
Residue	% vol.		2		
Reid vapour pressure at 37.8 ^{0}C	kPa	45	90	D-323	
Gasoline existent gum [mg/100 ml]			5	D-381	
Corrosiveness to copper (3h at 50^{0}C)			1	D-130	
Sulphur compounds “Doctor Test”		negative		D-4952	
Colour		Green[2]			Visual
Odour		Marketable			
Oxygen compounds:					NF EN 1601
- Methanol (with stabilisators)			3		
- Ethanol (also with stabilisators			5		
- Iso-propylalcohol			10		
- Iso-butylalcohol			10		
- Iso-ter-butylalcohol			7		
- Ethers (5 C-atoms or more per molecule)			15		
Additives		Additives to improve the quality of petrol 95 can only be added in agreement with the Ministry of Energy			

[1]This method or any other equivalent international method utilized by petroleum industry
[2]Neutral colour at the time of import

Table Mali_2: Fuel specifications and test methods for petrol

Characteristic variable	Unit	Specified values		Methods		
		MIN	MAX	AFNOR	ASTM	OTHERS
Research octane rating (RON)		91	-	NF EN ISO 25163	D-2699	
Lead content	g/L	0	0.013	NFM07-043; NFM07-014	D-3341; D-5059	
Sulphur content	% wt.		0,05	NFT60-142; NFM07-059	D-2785	
Masse density	Kg/L	0,720	0,790	NF EN ISO 12185	D-1298	
Distillation				NFM07-002	D-86	
10 % evaporated at	°C		70	//	//	
50 % evaporated at	°C		125	//	//	
90 % evaporated at	°C		180	//	//	
Final distillation point	°C		215	//	//	
Residue	% vol.		2	//	//	
REID Vapour Pressure (at 37.8^{0}C)	g/cm^2	5	635	NFM07-007	D-323; D-5191	
Gasoline existent gum	mg/100 ml		5	NFM07-004	D-381	
Corrosiveness to copper (3 h at 50 ^{0}C)			1b	NFM07-015	D-130	NF EN ISO-150-260
Induction period (Stability to oxidation)	min	240		NFM07-012	D-525	NF EN ISO M07-012
Colour		Pale yellow or limpid				Visual

Table Mauritius_3: Fuel specifications and test methods for unleaded petrol 95 RON

Characteristic variable	Unit	Specified values		Methods	
		MIN	MAX	ASTM	Other
Research octane number		95	-	D-2699	
Lead content[2]	g/L	0	0.003	D-3237; D-3348	
Sulphur content	% wt.		0.10	D-3120	
Mercaptan sulphur content	% wt.		0.0015	D-3227	
Benzene	% vol.		5	D-4815	
Masse density	Kg/L	0,710	0.785	D-1298	
Distillation				D-86	
10 % evaporated at	°C		65		
50 % evaporated at	°C	77	115		
90 % evaporated at	°C		185		
Final distillation point	°C		215		
Residue	%vol.		2.0		
Reid Vapour Pressure at 37.8 °C	kPa (Psi)	45	75	D-323	
Gasoline existent gum (2.5 h at 100 %	mg/100 ml		4	D-381	
Gasoline potential gum (2.5 hrs at 100 ^{0}C)	mg/100 ml		4	D-873	
Corrosiveness to copper (3 h at 50 °C)			1	D-130	
Induction period	min	360		D-525	
Doctor test	% wt.	Negative		D-4952;	IP 30
Appearance[1]	Clear and bright				
Colour		Green	Visual		
Odour		Marketable			

[1]Clear and free from visible water, sediments and suspended matter
[2]Suppliers specifications is applicable ex-refinery gate

Table Mozambique_1: Fuel specifications and methods for gasoline RON 93

Characteristic variable	Unit	Specified values		Methods
		MIN	MAX	ASTM
Research octane number (RON)		93		D-2699
Lead content	g/L	0	0.40	D-3341
Sulphur content	% wt.		0,15	D-1266
Mercaptan sulphur	% wt.		0.0015	D-1219
Masse density	Kg/L	0,715		D-1298
Distillation				D-86
10 % evaporated at	°C		82	
50 % evaporated at	°C		110	
90 % evaporated at	°C		180	
Final distillation point	°C		210	
Residue	% vol.		2	
Loss	% vol.	Report		
REID Vapour Pressure at 37.8 ^{0}C	kPa		0.75	D-323
Gasoline existent gum	mg/100 ml		4	D-381
Corrosiveness to copper (3 h at 50 ^{0}C			1	D-130
Induction period	min	240		D-525
Doctor test		Negative		D-4952
Colour		Orange		Visual

Table Nigeria_3: Specifications of gasoline

Characteristic variable	Unit	Specified values		Test Methods
		MIN	MAX	
Research octane number		??		
Lead content	g/L	Nil		Appendix I
Sulphur content	% wt.		0,10	Appendix E
Specific gravity at 15 ^{0}C	Kg/L	0,725	0,790	Appendix B
Distillation evaporated at				Appendix C
70 ^{0}C	% vol.	10	45	//
100 ^{0}C	% vol.	36	70	//
180 ^{0}C	% vol.	90		//
Final distillation point	°C		205	//
Residue	% vol.		2	//
Reid Vapour Pressure	kPa	62.0 (9 Psi)	Appen dix H	
Gasoline existent gum	mg/100 ml		4	Appendix F
Corrosiveness to copper (3 h at 50 ^{0}C)			1	Appendix D
Oxidation stability	^{0}C	360		Appendix G
Flash point	^{0}C			Appendix J
Appearance		Clear and bright		Visual
Free water		Nil		Visual
Sediments		Nil		Visual
Colour		Report		Visual

Table Senegal_2: Specifications of petrol 87 RON

Characteristic variable	Unit	Specified values		Methods	
		MIN	MAX	AFNOR	Others
Research octane number (RON)		87		NF M 07 026	
Lead content	g/L		0.15	NF M07-014	
Sulphur content	% weight		0,15	NF T 60142	
Masse density at 15 °C	Kg/L	0,715	0,770	NF T 60101	
Distillation				NF M07-002	
10 % evaporated at	°C		75		
50 % evaporated at	°C		125		
90 % evaporated at	°C		180		
Final distillation point	°C		210		
Residue	% vol.		2		
Reid Vapour Pressure at 37.8 °C	g/cm²		630	NF M07-007	
Gasoline existent gum	mg/100 ml	3		NF M07-004	
Corrosiveness to copper			1b	NF M07-015	
Induction period	min	240		NF M07-012	
Colour		Red			Visual
Odour		Marketable			

Table Senegal_3: Fuel specifications and test methods for petrol 95 RON

Characteristic variable	Unit	Specified values		Methods	
		MIN	MAX	AFNOR	Others
Research octane number (RON)		95	-	NF M 07 026	
Lead content	g/L		0.15	NF M07-014	
Sulphur content	% weight		0,15	NF T 60142	
Masse density at 15 °C	Kg/L	0,715	0,770	NF T 60101	
Distillation				NF M07-002	
10 % evaporated at	°C		75		
50 % evaporated at	°C		125		
90 % evaporated at	°C		180		
Final distillation point	°C		210		
Residue	% vol.		2		
Reid Vapour Pressure at 37.8 °C	g/cm²		630	NF M07-007	
Gasoline existent gum	mg/100 ml		3	NF M07-004	
Corrosiveness to copper			1b	NF M07-015	
Induction period	min	240		NF M07-012	
Colour		None			Visual
Odour		Marketable			

Table Tanzania_1: Specifications of gasoline RON 95

Characteristic variable	Unit	Specified values		Methods		
		MIN	MAX	ASTM	EN/ISO	Other
Research octane number (RON)		95		D-2699		D-2699
Motor octane number (MON)		85		D-2700	5163	
Lead content	g/L	0	0.013	D-3348		
Sulphur content	% wt.		0.05	D-1266	ISO 8754	
Benzene content	% vol.		5.0		EN 238: 1998	
Masse density	Kg/L	0,725	0.780			TZS 679: 2001
Distillation				D-86		
10 % evaporated at	°C		71			
50 % evaporated at	°C	77	115			
90 % evaporated at	°C		180			
Final distillation point	°C		205			
Residue	% vol.		2.0			
Gasoline existent gum (solvent washed)	mg/100 ml		4	D-381		
Corrosiveness to copper	1	1-strip		D 130	ISO 2160:1998;	TZS 680:2001
(3 h at 50 ^{0}C)						
Oxidation stability		360				TZS 643: 2001
Colour		As per government requirement				Visual

Table Zambia_1: Specifications and test methods for gasoline RON 91

Characteristic variable	Unit	Specified values		Methods
		MIN	MAX	ASTM*
Research octane number (RON)[1]		91		D-2699
Motor octane number (MON)[1]		81		D-2700
Motor octane number (MON) for blends containing more than 2% vol. alcohol[1]		83		D-2700
Lead content	g/L	0	0.02	D-3116; D-5059; D-3237; D-3348
Sulphur content	% wt.		0,10	D-1266; D-3120; IP 243
Benzene content	% vol.	Report		D-4815
Aromatics content	% vol.	Report		D-4815
Oxygen content[5]	% wt.		3.7	D-4815
Masse density at 20 °C[2]	Kg/L	0,710	0.785	D-1298; D-4052
Distillation				D-86
10 % vol. evaporated at	°C		65	
50 % vol. evaporated at	°C	77	115	
90 % vol. evaporated at	°C		185	
Final distillation point	°C		215	
Residue	% vol.		2.0	
Evaporated to 70 °C (E70)	% vol.	Report		
Reid Vapour Pressure (RVP)	kPa	45	62	See 6.1
Flexible Volatility Index (FVI = RVP + 0.7 E70)	kPa			See 6.2
FVI (summer[3])		89		
FVI (winter[3])		94		
Gasoline existent gum	mg/100 ml		4	D-381
Potential gum (2.5 hr at 100 °C)			4	D-873
Corrosiveness to copper (3 h at 50 ^{0}C)			1	D -130
Induction period	min	360		D-525
Total acidity[4]	mg KOH/g		0.03	D-3242
Colour		Yellow		Visual

*ASTM if not specified otherwise
[1]For octane rating only one of the three parameters needs to be satisfied
[2]ASTM D-1250/IP 200 (Standard guide for petroleum measurement tables) should be used for correlation of densities at 15°C and 20°C, respectively
[3]Summer = 1 September to 30 April; Winter = 1 May to 31 August
[4]Applicable to fuels only containing oxygenates
[5]Any alcohol blended into the fuel shall contain a minimum of 85% wt. ethanol with the balance i-propanol and n-propanol, and only trace quantities of other alcohols. 3.7% wt. = approximately 20% vol. MTBE = approximately 9.5% vol. ethanol = approximately ?% wt. MMT. Ethers containing five or more carbon atoms per molecule may be included up to a maximum concentration as indicated in the standard. The oxygen content of the blend will be determined by method ASTM D-4815 (MTBE) and such other methods that may be developed for other C_5 esters.

6.1.2 Fuel specifications for gas oil (diesel), paraffin oil and fuel oil 180 cSt

Table Ethiopia_2: Fuel specifications and test methods for diesel

Characteristic parameters	Unit	Specifications		Methods
		Min	Max	ASTM
Cetane number (calculated)		48		D-976
Sulphur content	% wt.		1	D-1552
Mass density at 15^{0}C	Kg/L	0.830	0.870	D-4052
Distillation 90% vol.	^{0}C		362	D-86
Ramsbottom carbon residue 10% distillation residue	% wt.		0.2	D-524
Water	% vol.		0.05	D-95
Sediments	% wt.		0.03	D-473
Ash	% wt.		0.01	D-482
Flash Point, Persky-Martens, closed cup	^{0}C	66		D-93
Cloud Point	^{0}C	5.0		D-2500
Kinematic viscosity at 37.8 ^{0}C	cSt	2.0	5.5	D-445
Corrosiveness to copper (3h at 100^{0}C)			2	D-130
Colour			3	D-1500

Table Ghana_3: Fuel specifications and test procedures for automotive gas oil (diesel)

Characteristic parameters	Unit	Specifications		ASTM Test method
		Min	Max	
Cetane number		45		IP 380
Sulphur content	% wt		0.5	D 1552
Mass density at 15^{0}C	kg/L	0.830	0.870	D 4052; D-1298
Evaporated at 360 ^{0}C	% vol.	85		D 86
Conradson carbon residue 10% distillation residue	% wt		0.20	D 189
Water by distillation	% vol.		0.05	D-95
Water by sediment	% vol.		0.10	D-473
Ash	% wt		0.1	D 482
Flash point, Persky Masters	^{0}C	55		D-8693
Pour point	^{0}C		15	D-97
Kinematic viscosity at 37.8 ^{0}C	cSt		6.5	D 445
Total acidity	mg KOH/g		1	D-974
Colour			3	D 1500

Table Madagascar_5: Fuel specifications and-test procedures for "gas oil (diesel)

Characteristic parameters		Specifications		Method[1]
		Min	Max	
Cetane number		48		D-976
Sulphur	% wt		0.5	D-1552
Mass density at 15⁰C	Kg/L	0.810	0.890	D-1298
Distillation at 360 ⁰C	% vol.	90		D-86
Final distillation point	⁰C		385	
Conradson carbon residue	% wt		0.15	D-189
Water	% vol.		0.05	D-95
Sediments	% wt		0.01	D-473
Ash	% wt		0.01	D482
Flash/no flash closed cup equilibrium	⁰C	55		D-93
Flow point			0	D-97
Viscosity at 100 ⁰F	cSt	1.6	5.5	D-445
Corrosiveness to copper (2h at 100⁰C)			1	D-130
Strong acidity	mg KOH/g	Nil		D-974
Total acidity	mg KOH/g		0.5	D-974
Colour			3	Visual

[1]The methods quoted-or any other equivalent international method-utilized-by petroleum industry

Table Mauritius_4: Fuel specifications and test procedures for gas oil

Characteristic parameters	Unit	Specifications		Methods	
		Min	Max	ASTM	Other
Cetane number		49		D-613	
Sulphur	% wt		0.25	D-2622	
Mass density at 15^{0}C	Kg/L	0.820	0.860	D-1298	
Distillation					
50% recovered at	^{0}C		290	D-86	
90% recovered	^{0}C		366		
Distillation 95%	^{0}C		385		
Ramsbottom carbon residue 10% distillation residue	% wt.		0.20	D-524	
Water	% vol.		0.05	D-95	
Sediments	% wt		0.01	D-473	
Ash	% wt.		0.01	D-482	
Flash/no flash closed cup equilibrium	^{0}C	66		D-93	
Pour point	^{0}F		55	D-97	
Cloud point	^{0}F	60		D-2500	
Corrosiveness to copper (3h at 100^{0}C)			1	D-130	
Kinematic viscosity at 40 ^{0}C	cSt	2	4.5	D-445	
Conductivity at 20 ^{0}C	Ps/m	75	350	D-2624	
CFPP	^{0}C				IP 309
Strong acidity	mg KOH/g	NIL		D-974	
Total acidity	mg KOH/g		0.25		
Colour			2.50	D-1500	
Odour		Marketable			
Appearance		Clear and bright			Visual

Table Mozambique_2: Fuel specifications and test procedures for diesel

Characteristic parameters	**Unit**	**Specifications**		**Methods**
		Min	**Max**	**ASTM***
Cetane number		45		D-976
Sulphur	% wt.		0.55	D-1552
Mass density at 15^{0}C	Kg/L	0.820	0.869	D-1298
A.P.I. gravity		Report		IP 250-Tab. E
Distillation				D-86
50% recovered at	^{0}C	240		
90% recovered at	^{0}C		362	
Ramsbottoms carbon residue on 10%	% wt.		0.2	D-524
Water by distillation	% vol.		0.05	D-95
Sediment by extraction	% wt		0.01	D-473
Ash	% wt		0.01	D-482
Flash/no flash closed cup equilibrium	^{0}C	60		D-93
Pour point	^{0}C		5.0	D-97
Kinematic viscosity at 40 ^{0}C	cSt	1.6	5.3	D-445
Corrosiveness to copper (3h at 100^{0}C)			1	D-130
Neutralization value				D-974
Strong acidity	mg KOH/g		Nil	
Total acidity	mg KOH/g		0.5	
Colour			2	D-1500
Appearance		Bright and clear		Visual

*ASTM if not specified otherwise

Table Nigeria_4: Fuel specifications and test procedures for diesel

Characteristic parameters	Unit	Specifications		Actual values*	Methods		
		Min	Max		ASTM	IP	Other
Diesel index		47		50		21	
Sulphur content	% wt		0.3**	0.133			x-ray
Mass density at 15^{0}C	Kg/L	0.820		0.871	D-1298	160	
Distillation recovered at 357 ^{0}C	% vol.	90		> 90	D-86	123	
Final distillation point	^{0}C		385	358			
Conradson carbon residue	% wt		0.15	< 0.01	D-189		
Water by distillation	% vol.		0.05	< 0.05	D-95	74	
Ash content	% wt		0.01	< 0.01	D-482		
Flash/no flash closed cup equilibrium	^{0}C	65		100	D-93	34	
Cloud point	^{0}C		4.0	3	D-2500	219	
Corrosiveness to copper (3h at 100^{0}C)			1	1a	D-130	154	
Kinematic viscosity at 38 ^{0}C	cSt	1.6	5.5	5.1	D-445	71	
Strong acidity	mg KOH/g	Nil		Nil	D-974	139	
Total acidity [mg KOH/g]	mg KOH/g		0.5	0.02			
Colour			3	1.5	D-1500		

*Data from NNPC. **Communication by SON

Table Senegal_4: Fuel specifications and test methods for paraffin oil

Characteristic variable	Unit	Specified values		Methods
		MIN	MAX	AFNOR
Sulphur content	% wt		0,15	NF T 60142
Masse density at 15 °C	Kg/L		0,820	NF M 60-101
Smoke point	°C	21		NF M 07-028
Distillation				NF M07-002
% evaporated at 200 °C	%	20		//
Final distillation point	°C		300	//
Flash point (open cup) Abel	°C	38		NF M07-011
Corrosiveness to copper			1b	NF M07-015
Odour		Marketable		

Table Senegal_5: Fuel specifications and test procedures for gas oil (diesel)

Characteristic parameters		Specifications		Methods	
				AFNOR	ISO
		Min	Max		
Cetane number		45			ISO 4264
Sulphur content	% wt.		0.5	NF M 07-053	
Mass density at 15^{0}C	Kg/L	0.820	0.880	NF T 60101	
Distillation 90% evaporated at	^{0}C		362	NF M 07-002	
Final distillation point		Report			
Conradson carbon residue 10%	% wt.		0.15		
Water content	% vol.		0.05	NF T 60113	
Sediments	% wt.		0.01	NF M 07-010	
Ash	% wt		0.01	NF M 07-045	
Cloud point	^{0}C		7		ISO 3015
Freezing point	^{0}C	5		NF T 60105	
Flash point PMcc	^{0}C	61		NF M 07-019	
Corosiveness to copper			1	NF M 07-015	
Kinematic viscosity at 37.8 ^{0}C	cSt	1.6	5.9	NF T 60100	
Total acidity	mg KOH/g		1		
Strong acidity	mg KOH/g	Nil			
Colour			3	NF T 60140	

Table Senegal_6: Fuel specifications and test procedures for diesel oil

Characteristic parameters		Specifications		Methods	
				AFNOR	Others
		Min	Max		
Cetane number		40			ISO 4264
Sulphur content	% wt.		0.5	NF NF M 07-053	
Mass density at 15^{0}C	Kg/L	0.820		NF T 60-101	
Distillation 90%	^{0}C	362		NF M 07-002	
Final distillation point	^{0}C	Report			
Conradson carbon residue 10%	% wt.		0.15		ISO 10370
Water content	% vol.		0.05	NF T 60-113	
Sediments	% wt.		0.01	NF M 07-010	
Ash	% wt.		0.01	NF M 07-045	
Freezing point	^{0}C		10	NF T 60-105	
Flash point PMcc	^{0}C	66		NF M 07-019	
Kinematic viscosity at 37.8 ^{0}C	cSt		7.5	NF T 60-100	
Total acidity	mg KOH/g		1.0	NF M 60-112	
Colour		Red			Visual

*AFNOR if not indicated otherwise

Table Senegal_7: Fuel specifications and test procedures for fuel oil 180 cSt at 50 ^{0}C

Characteristic parameters	Unit	Specifications		Methods	
				AFNOR	Others
		Min	Max		
Sulphur content	% wt.		3.5	M 07-053	
Mass density at 15^{0}C	Kg/L		0.995		T 60-101
Water content	% vol.		0.01		T 60-113
Sediments	% wt.		0.01	M 07-010	
Ash	% wt.		1	M 07-045	
Freezing point	^{0}C		21		T 60-105
Flash point PMcc	^{0}C	66		M 07-019	
Kinematic viscosity at 50 ^{0}C	cSt		180		T 60-100

Table Tanzania_2: Fuel specifications and test procedures for automotive gas oil (diesel)

Characteristic parameters	Unit	Specifications		Methods	
		Min	Max	ASTM	Other
Cetane number (calculated)		48		D-613	
Sulphur	% wt.		0.5	D-2622	
Mass density at 15^0C	kg/L	0.820	0.870	D-1298	
Distillation recovery	% vol.	1.00		D-86	
Distillation recovery at 357 ^{0}C	% vol.	90		D-8	
Total volume recovery at 240-310 ^{0}C	% vol.	90			
Ramsbottoms carbon residue on 10%	% wt.		0.15	D-189	
Water by distillation	% vol.		0.05	D-95	
Sediment by extraction	% wt.		0.01	D-473	
Ash	% wt.		0.01	D-482	
Flash/no flash closed cup equilibrium	^{0}C	65.5		D-93	
Cloud point	^{0}C		4.5	D-2500	
Corrosiveness to copper (3h at 100^0C)			1	D-130	
Kinematic viscosity at 40 ^{0}C	cSt	1.6	4.5	D-445	
Oxidation stability	mg/100 ml		2.0	D-2274	
Appearance		Clear			Visual
Colour			3.5	D-1500	

Table Zambia_2: Specifications and test methods for Automotive Gas oil (Diesel Fuel)

Characteristic parameters	Unit	Specifications		Methods
		Min	Max	ASTM*
Cetane number		46		D-613
Cetane number (calculated)		50		D-976
Sulphur	% wt.		0.75	D-1552; D-2622
Mass density at 15⁰C	Kg/L	0.820	0.870	D-1298
Distillation recovery				D-86
Distillation recovery at 360 ⁰C	% vol.	90		
From 240-310⁰C	% vol.	50		
Ramsbottoms carbon residue on 10%	% wt		0.15	D-524
Water by distillation	% vol.		0.05	D-95
Sediment by extraction	% wt.		0.01	D-1796
Ash	% wt		0.01	D-482
Flash/no flash closed cup equilibrium	⁰C	60		D-93
Cloud point	⁰C		4.5	D-2500
Kinematic viscosity at 40 ⁰C	cSt	2.00	5.50	D-445
Corrosiveness to copper (3h at 100⁰C)			1	D-130
Total acidity	mg KOH/g		1.00	D-664
Appearance		Clear		Visual
Colour			3.5	D-1500

*If not specified otherwise

The requirements for Low Sulphur Gas oil are specified as for Automotive Gas oil except for the calculated cetane number of minimal 40 and the maximal sulphur content of 0.5% (5000 ppm).

6.2 Emission standards for mobile sources

Tables for emission standards for mobile sources are quoted below for Burkina Faso and Madagascar.

Table Burkina_Faso_2: Emissions standards for mobile sources

Age [yrs]	Emission standards [g/km]			
	CO	**NOx**	**HC**	**VOC**
0-5	2	0.25	0.12	0.15
6-10	3	0.37	0.12	0.19
11-15	4	0.4	0.2	0.2
16-20	4.5	0.6	0.3	0.3
> 20	5	0.8	0.5	0.5

Table Burkina_Faso_3: Emission standards for mopeds (< 50 cm^3) and motorcycles (> 50 cm^3)

Engine type	Emission standards [g/km]			
	CO	**NOx**	**HC**	**VOC**
2-stroke	7	8	5	0.1
4-stroke	12	3.5	3	0.3

Table Madagascar_4: Emission standards for diesel-driven vehicles

Category of vehicles	Arithmetic mean of absorption coefficients [m^{-1}]
Individual	≤ 2.50
Busses and caravans	≤ 2.50
Industrial and commercial	≤ 2.50
Tractors for agriculture	≤ 2.50
Special and public construction	≤ 2.50

Table Madagascar_5: Emission standards for petrol-driven vehicles

Compound	Lower limit	Upper limit	Unit
HC	0	2000	ppmv
CO	0	15	% vol
Corrected CO	0	15	% vol
CO_2	0	20	% vol
O_2	0	4	% vol
λ coefficient* (leaded petrol)	0.8	1.2	none

*λ coefficient: carburettor rating; equals 1 for perfect carburetion. The analyser of exhaust gasses combines the values of CO, CO_2, HC, and O_2 to derive λ

6.3 Emission standards for stationary sources

Only Burkina Faso has reported emission standards for stationary sources.

Table Burkina_Faso_4: Emission standards for stationary sources

Source type	Pollutant	Standard [unit]
Power plant	PM	90 mg/MJ
	NOx	330 ppm
Industrial plant	VOC	6 µg/Nm^3
	PM	100 mg/m^3
Cement plant; brick kiln	PM	55 g/ton clinker

6.4 Ambient air quality standards

Ambient AQS are reported for Botswana, Burkina Faso, Mauritius and Zambia. Numerically the reported standards differ somewhat among countries. Their magnitude roughly corresponds to AQS used in developed countries. Most adopted standards are much more lenient than corresponding WHO guideline values.

Table Botswana_2: Air quality standards

Pollutant	**Standard [µg/m^3]**	**Averaging time**
PM	100	1 year
	200	1 month
SO_2	80	1 year
	160	1 month
	300	24 hours
CO	10,000	8 hours
	40,000	1 hour
NO_2	100	1 year
	200	1 month
	400	1 hour
O_3	157	8 hours
	235	1 hour

Table Burkina_Faso_5: Air quality standards

Pollutant	Standard [µg/m^3]	Averaging time
CO	30,000	1 hr
SO_2	200-300	1 hr
NO_2	170	1 hr
	100	1 hr
PM	200-300	24 hrs
Pb	2	1 yr
O_3	150-300	1 hr

Table Mauritius_1: Air quality standards (proposed)

Criteria Pollutant	Limit * ($\mu g/m^3$)	Frequency of monitoring	Statistical Details
TSP	50	Annual	An annual average for 104 measurements taken twice a week for a period of 24 hours at uniform intervals
	150	24-hour	24-hourly values should be met 98% of the time in a year and it should not exceed 2 consecutive days.
PM_{10}	100	24-hour	24-hourly values should be met 98% of the time in a year and it should not exceed 2 consecutive days.
SO_2	50	Annual	An annual average for 104 measurements taken twice a week for a period of 24 hours at uniform intervals
	150	24-hour	24-hourly values should be met 98% of the time in a year and it should not exceed 2 consecutive days.
	350	1-hour	The maximum value should never be exceeded
	500	10-minutes	The maximum value should never be exceeded
NO_2	40	Annual	An annual average for 104 measurements taken twice a week for a period of 24 hours at uniform intervals
	200	1-hour	The maximum value should never be exceeded
CO	10 000	8-hour	8-hourly values should be met 98% of the time in a year and it should not exceed 2 consecutive days.
	25 000	1-hour	The maximum value should never be exceeded
Pb	1.5	3-month	An average of at least 3 measurements per week over a period of 3 months.
O_3	100	1-hour	The maximum value should never be exceeded

* Standards refer to values of temperature of 20 °C and atmospheric pressure of 101.3 KPa

Table Zambia_3: Zambian ambient air quality guideline values

Parameter		**Reference Time**	**Guideline Limit [µg/m^3]**
Sulphur dioxide *(SO_2)*		10 minutes	500
		1 hour	350
Sulphur dioxide *(SO_2)* in combination with Total Suspended Particles *(TSP)**[1] and PM_{10}	SO_2	24 hours	125
		6 months	50
	TSP	24 hours	120
		6 months	50
	PM_{10}	24 hours	70
Respirable Particulate Matter *(PM_{10})**[2]		24 hours	70
Oxides of Nitrogen *(NO_x)* as nitrogen dioxide *(NO_2)*		1 hour	400
		24 hours	150
Carbon monoxide *(CO)*		15 minutes	100
		30 minutes	60
		1 hour	30
		8 hours	10
Lead *(Pb)*		3 months	1.5
		12 months	1.0
Dust fall		30 days	7.5 tonnes/km^2

Source: Statutory Instrument (SI) No. 141, 1996, 1st schedule, Regulation 3.

A guideline value for hydrogen sulphide (H_2S) has been set as a maximal permitted amount of 14 mg/m^3 (Mines and Minerals (Environmental) Regulations, 6th schedule, Regulation 25.).

Section 7. Conclusion

Despite some progress being made to address air pollution in Sub Saharan African countries, air pollution continues to pose a threat to human health, environment and quality of life in cities. The concoction of increasing migration, motorization and uncontrolled urban growth has all contributed to the intensification of air pollution, which currently poses a significant challenge to all Sub Saharan African cities.

This report assesses the current status and challenges in urban air pollution in 26 African countries, based on country reports collected by the World Bank, UNEP and the APINA network. The results show that air pollution management is in its early stages in all countries that have contributed reports and many ingredients of AQM are not yet in place. Air quality monitoring is patchy in most Sub Saharan cities and monitoring networks if they exist show often breakdowns after a short time of running. Emissions inventories of key pollutants are lacking as are studies on the adverse impacts of air pollution on human health. However, a highlight and basis for hope for future AQM is the successful phasing-out of lead in gasoline in most SSA countries which has been or is being completed. Some countries have developed examples of best practices in specifying fuel standards and developing emission and AQS. A few action plans have the potential of providing guidance for action plans to a larger number of countries outside the country for which they were developed. Most countries have promulgated Environmental Act legislation and all are concerned about the potential threats of air pollution to their populations.

Much has, however to be done to strengthen and enforce existing legislation, making monitoring networks operational to deliver data of known quality and developing initial emission inventories which permit to implement control measures in Sub Saharan African cities.

With the phase-out of lead in gasoline in all SSA countries and the promulgation of fuel specifications for unleaded petrol in the majority of SSA countries a major step forward to towards quality management has been performed. Further cost-effective steps would be to set fuel specifications for diesel and reduce sulphur in diesel, a major source of fine particles (sulphates), to lower values than the present range of 1,300 -10,000 ppm.

Some countries such as Benin, Burkina Faso, Burundi, Cameroon, Congo Brazzaville, Congo Kinshasa, Gabon, Guinea, Kenya, Liberia, Mali, Mauritius, Rwanda, Swaziland, Togo and Uganda are in an early stage of AQM. Practically, the phase-out of lead has been performed and some of these countries have set fuel specifications. An Environment Act exists but public awareness and media and other stakeholder involvement is limited. First steps towards rational AQM would be to strengthen the political will of the government to address air pollution, to raise public awareness about adverse impacts of air pollution on human health and the environment. A cost-effective measure to reduce air pollution would be the reduction of sulphur in diesel. Another action would be to develop and implement initial monitoring stations using cost-efficient sampling methods. By installing a small monitoring network, the contribution of industrial sources, power plants, area sources and that of transboundary dispersion of air pollutants could be assessed. In order to be able to interpret monitoring data in terms of their potential impact on human health and the environment, AQS should be promulgated, which are reasonably enforceable. WHO air quality guidelines may be used in setting standards and averaging times since the criteria for the derivation of air quality guidelines set by WHO are also valid for setting standards. Experience from developed countries may be used to collect information on the number of standards-exceeding values not leading to adverse health or environmental effects. A participatory approach in setting standards which involves stakeholders (e.g. industry, local authorities, non-governmental organizations, media and the general public) assures –as far as possible – social equity or fairness to the parties involved. The provision of sufficient information and transparency in standard setting procedures ensures that stakeholders understand the environmental, health and socio-economic impacts of such standards.

Other SSA countries with more developed AQM capability such as Ghana, Madagascar, Mozambique, Nigeria, Tanzania and Zimbabwe should enhance their ability by extending and/or revamping their monitoring facilities, develop initial emissions inventories using rapid assessment methods and start the use of dispersion modelling. The knowledge of the contribution from different sources will help to set priorities in AQM and permit to decide which sources should be first addressed. Dispersion modelling could be used to estimate pollutant concentrations and by comparison with actual measurement test the validity of the emission estimates.

If not already promulgated, emission and AQS should be set. Regulations on emission standards for mobile and stationary sources, AQS, viable dispersion models and reliable monitoring procedures will ensure rational and sound AQM. This includes, where appropriate, the adoption of emission standards based on developed countries' experiences. Best available control technology avoids the problem of inequities among countries and prevents 'social dumping'.

Countries with even more experience – Botswana, Ethiopia, Ghana, Madagascar and Zambia - should stride towards the adoption of Clean Air Implementation Plans (CAIPs) in their cities, tailored for developing countries, as an instrument in achieving policy goals in a structured and transparent manner.

For all SSA countries training in all aspects of AQM is absolutely necessary in order to achieve the goal of cleaner air.

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8.2 List of Acronyms and Abbreviations

APCU	Air Pollution Control Unit (Harare)
APINA	Air Pollution Information Network Africa
APPA	Air Pollution Prevention Act
APPA	Atmospheric Pollution Prevention Act (Zimbabwe)
AQ	Air Quality
AQM	Air Quality Management
AQMCBP	Air Quality Monitoring Capacity Building Project
CAI-SSA	Clean Air Initiative in Sub-Saharan African Cities
Cd	Cadmium
CETUD	Executive Council of Urban Transport in Dakar
CO	Carbon Monoxide
CO_2	Carbon dioxide
CP	Cleaner Production
cSt	centi Stokes
DCC	Dar es Salaam City Council
DCC	Dar es Salaam City Council
DEEC	Department for Environment and Classified Establishments (Senegal)
DNACPN	National Agency for Sanitation and Pollution Control (Mali)
DoE	Department of Environment
DoT	Department of Transport
ECZ	Environmental Council of Zambia
EEPA	Ethiopian Environmental Protection Authority
EIA	Environmental Impact Assessment
EMA	Environmental Management Act
EPA	Environmental Protection Agency
EPPC	Environment Protection and Pollution Control
FEPA	Federal Environmental Protection Agency (of Nigeria)
GAW	Global Atmospheric Watch
GCLA	Government Chemist Laboratory Agency
GDP	Gross Domestic Product
GHG	GreenHouse Gas
HCs	HydroCarbons
Hg	Mercury
HQ	Headquarters
INSTN	Institute National de la Science et Technologie Nucléaire (Madagascar)
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
KEBS	Kenya Bureau of Standards
KEMRI	Kenya Medical Research Institute
KENGO	Kenya Energy and Environment Organizations
LAC	Latin America and the Caribbean
Mn	Manganese
MoH	Ministry of Health
MoU	Memorandum of Understanding
NEAP	National Environmental Action Plan
NEMA	National Environment Management Authority (of Kenya)
NEMC	National Environment Management Council (Tanzania)
NEMC	National Environment Management Council
NGO	Non Governmental Organizations
NILU	Norwegian Institute for Air Research
NISNT	National Institute of Science and Nuclear Technology (of Madagascar)
NO	Nitrogen monoxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
O_3	Ozone

Pb	Lead
PM_{10}	Particulate Matter with an average aerodynamic diameter of 10 µm
$PM_{2.5}$	Particulate Matter with an average aerodynamic diameter of 2.5 µm
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RON	Research Octane Number
RTI	Research Triangle Institute
SEI	Stockholm Environment Institute
SO_2	Sulphur Dioxide
SOP	Standard Operating Procedure
SSA	Sub-Saharan Africa
TBS	Tanzania Bureau of Standards
TIRDO	Tanzania Industrial Research and Development Organization
TMA	Tanzania Meteorological Agency
TMA	Tanzania Meteorological Agency
ToT	Training of Trainers
UCLAS	University College of Lands and Architectural Studies
UFP	Ultrafine particle (defined as a particle with mean aerodynamic diameter at 0.1 µm
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
US-EPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds
WHO	World Health Organization
WRI	World Resources Institute

8.3 Annex Ethiopia_1: Monitoring PM_{10}, CO and lead

During the monitoring campaign in Addis Ababa a peak is seen in the early morning hours for PM_{10} and CO. CO also show a smaller peak in the evening hours. Lead concentrations are very small.

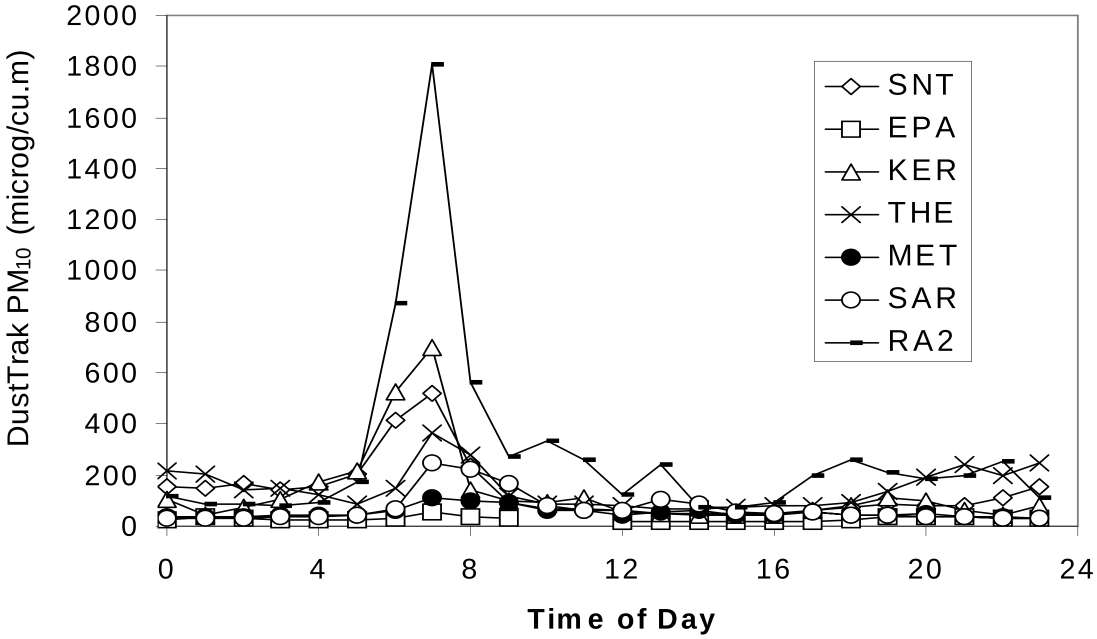


Figure Ethiopia_6: Daily variation of PM_{10} at various stations in Addis Ababa.

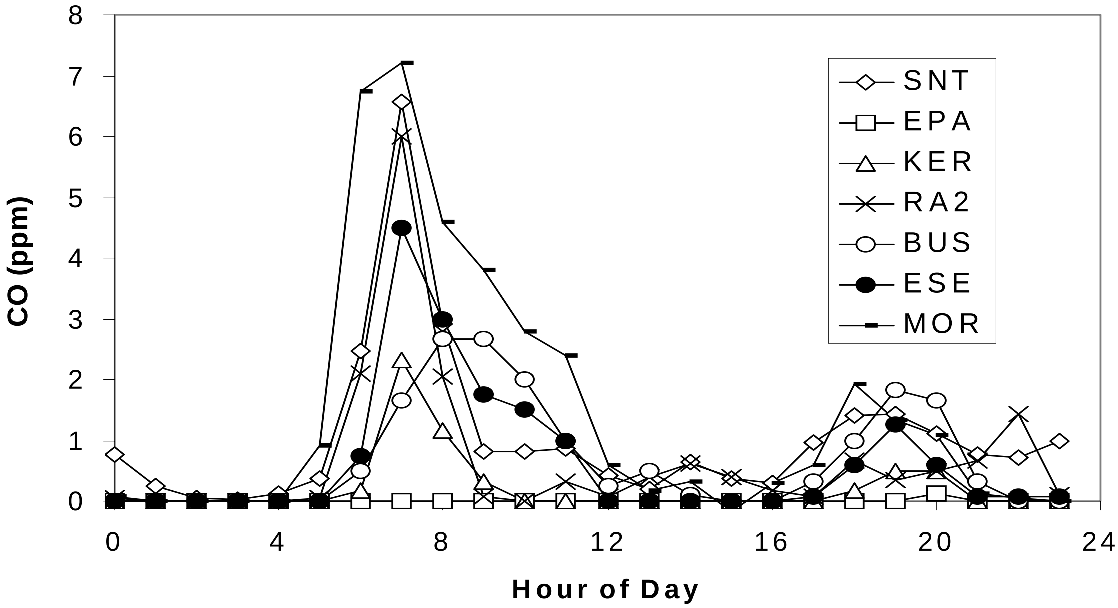


Figure Ethiopia_7: Daily variations of CO at various sites in Addis Ababa.

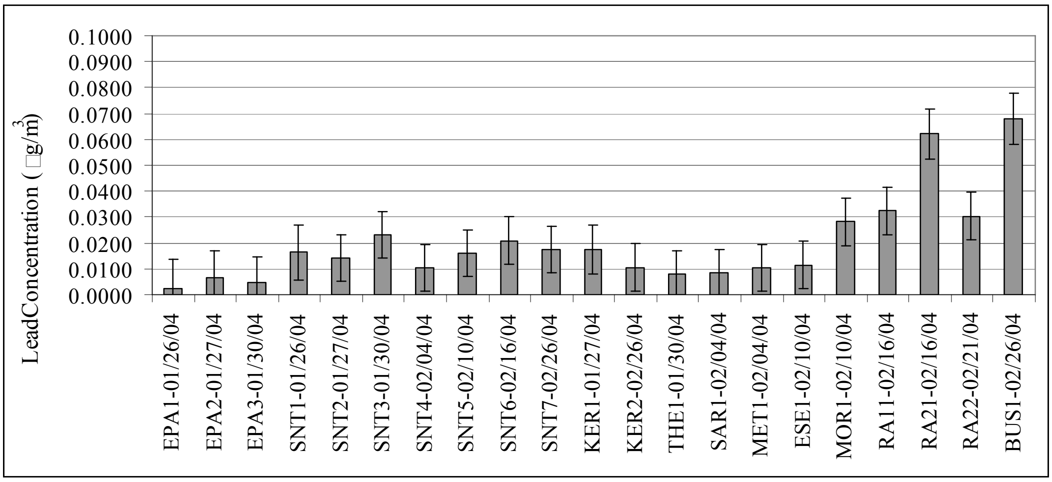


Figure Ethiopia_8 Lead concentrations between 26 January and 26 February 2004.

8.4 Annex Madagascar_1

Report on the workshop dealing with the phase-out of lead in petrol and the improvement of air quality in Antananarivo

The objective of the workshop was to prepare recommendations for the Government of Madagascar to improve the quality of fuels, especially the phase-out of lead in petrol and to start initial work in formulating a multi-sector programme for the improvement of air quality in Antananarivo. Participants of this meeting were staff from the Ministry of Energy and Mines, Ministry of Environment, Water and Forests, the Ministry of Public Transport, the Madagascar Agency of Hydrocarbons, private enterprises, research institutions, non-governmental organisations and the World Bank. In two work groups the following recommendations for phasing-out of lead, fuel specifications and suggestions for improving the air quality in Antananarivo were elaborated.

Phasing-out lead and fuel specifications

Petrol

1. Prohibition of leaded petrol by 1 January 2006.
2. Agree to an extension by 6 month in order to allow stored leaded petrol to be consumed and cleaning of storage tanks
3. Allow for two ratings of unleaded petrol in the market SP 91 (red) and SP 95 (green)
4. State that the adoption of SP 91 does not affect the financial constraints of importing e.g. SP 93
5. Adjust the actual specification to the regional market situation
6. Obligation to equip imported vehicles with catalytic converters as soon as the complete phase-out of lead is achieved
7. Promote a public awareness campaign for the use of unleaded petrol with the possible authorization of anti-knock additives
8. Initiate discussions between OHM/ concession holders/oil producers on the advantages of a unique rating of petrol of 91 RON, beginning 2007.

Diesel

9. Initiate discussions between OHM/concessionists/oil producers on the advantages of reducing sulphur content of diesel from 0.5% to 0.25% or 0.05% in the medium term.

Suggestions for improving the air quality in Antananarivo

1. Revision and enforcement of control structures for existing vehicles
2. Authorisation of the import of second-hand vehicles only if they are equipped with catalytic converters
3. Informing the public to and raising public awareness according to the actual data
4. Insisting on the maintenance of vehicle with decreasing control if the vehicles are well maintained
5. Introducing an indicator of maintenance quality of vehicles in future air pollution studies
6. Land use planning in urban areas
7. Revision and effective and systematic application of transport regulations in relation to exhaust gases

8. Adoption of concrete recommendations which can be inferred from studies of the World Bank
9. Installation of a multi-sector work group addressing air quality, especially building a partnership of researchers and oil producers
10. Studying the effects of air pollutants emitted from 2-stroke engines and raise awareness of importers and consumers with respect to their contribution to combating air pollution
11. Recommend the installation of mobile and stationary sources to monitor air pollution.

8.5 Annex Mali_1: Air quality surveillance project in the Bamako district

8.5.1. Problem Description

Mali like other countries in the sub-region suffers from several problems which weaken its development. Among these is the pollution of ambient air which does not receive as much attention as other environmental resources such as water, flora and fauna.

The entirety of potential sources of air pollution in Mali can be easily identified. Transport is dominated by second hand vehicles (more than 80 per cent of the fleet are older than 11 years and more than 70 per cent are older than 16 years). Energy consumption is mostly covered by oil products. Since five years Mali imports on average 470,000 metric tons of oil per year (of which 45 per cent are gas-oil). In 2000, transport consumed 60 per cent of conventional energy. Mali disposes of 19 thermal power plants which cover the electricity needs of the country. But practically none of them has installed appropriate systems for the treatment of gaseous releases. More than 80 per cent of household energy is provided by combustible solid fuels such as wood and coal. The emissions from these fuels together with those from road traffic have been identified as the main causes of air pollution in the majority of cities in developing countries (UNEP, 2000).

Visible signs of ambient air pollution are already apparent in the majority of major cities and in particular in Bamako. Bamako has reached a population of almost 1,200,000 inhabitants reflecting to an unprecedented urbanization. The need of urban development constitutes a non-negligible threat for air quality. Adverse effects of vehicle pollution have already started to appear. They are essentially caused by emissions from motorized two-wheelers. A study by Wane (2001) has estimated the contribution to the emissions from different vehicles types (Figure 1).

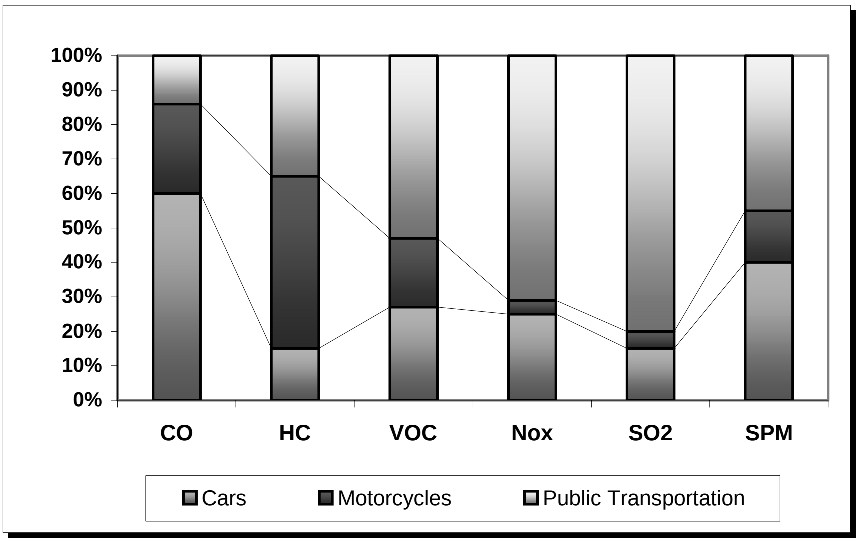


Figure1: Emissions of certain air pollutants from different vehicle types

Figure 1 shows that 50 per cent of hydrocarbons are mainly emitted by motorcycles while 60 per cent of CO and 40 per cent of PM is emitted by cars. Public transport is responsible for about 80 per cent of SO_2 emissions, 70 per cent of NO_x emissions, 55 per cent of VOC emissions and 40 per cent of PM emissions.

Smoke and suspended particles can cause respiratory symptoms and eye irritation observed by pedestrians, particularly when waiting at traffic lights. The impacts of uncontrolled incineration of solid wastes add to these symptoms.

At present, no epidemiologic or toxicological study exists in Mali showing the association between air quality deterioration and health impacts. Notwithstanding this fact it should be noted that acute upper and lower respiratory infections affect on average 30 per cent of Mali's population, more than 40% of which are observed in children of less than 5 years. According to a WHO report, Mali was classified as having a concentration in PM_{10} between 21 and 25 $\mu g/m^3$. In urban areas PM concentrations would be enhanced. Studies show an increased prevalence of bronchitis symptoms and a reduction in lung function parameters in children exposed to concentrations above 30 $\mu g/m^3$ (WHO, 2003). The increase in respiratory problems could be explained by air pollution.

Some studies report an association between ambient air pollution and certain cardiovascular diseases such as arterial hypertension, which constitutes one of the major concerns of recent years. In 1998, they accounted for 31 per cent of medical visits. This state is met by institutional and regulatory deficiencies. Two laws relate to air pollution – law 01-020 of 2001 and the decree N° 01-394 of September 6, 2001. Because data on air pollutant concentrations are lacking enforcement of these laws is difficult. Therefore, in order to address health problems associated with air pollution there is a real need in capacity and skills.

In view of the rapid urbanisation of Bamako, public policies, plans and projects have to address air pollution in the near future.

8.5.2 Desired Situation

Air is an essential element of human life. Air quality deterioration would have important consequences on achieving development objectives. Studies carried out by the World Bank in certain cities of West Africa show that its impact amounts between 1.8 to 2.7% of the GDP. Because of this it is essential to start controlling anthropogenic air pollution. AQM is at the centre of this project. It aims at setting up an effective system of AQM through:

- regular control of the emissions of sources;
- regular evaluation of air quality in the city of Bamako; and
- information of the population on potential risks.

Moreover, it will contribute to the development of a data base for key pollutants in order to facilitate an update of the state of the environment. Undertaking appropriate measurements will open the way to reasonably address the problem. The objective of this project is to allow public policies integrate air pollution aspects in their actions for development and implementation which reduce possible impacts.

8.5.3 Constraints

Major constraints in the realisation of this project include the:

- Lack of qualified human resources;
- Lack of funds;
- Regulatory deficiencies;
- Agreements on the site selection for continuous monitoring

8.5.4 Description of the Project

This project addresses at the same time emission control (i.e. verifying the proper operation of sources) and air quality. But its success depends on the flawless communication among stakeholders concerned with or affected by air pollution. It thus includes three key components

Communication

Information and sensitization remain the fundamental elements essential for a success of this project. Some harmful practises result from ignorance of the impacts that certain pollution sources can cause. Among them are the uncontrolled incineration of solid waste and the abusive use of wood energy.

Stakeholder participation is and remains key need. However, it can be achieved only by undertaking information campaigns leading to a general sensitization, prerequisite to a change of behaviour. The communication strategy will be centred on:

- Information signs on principal arteries of the city;
- Regular publication of monitoring data;
- Radio broadcasts and television spots.

8.5.4.1 Control of emissions

The implementation of this project requires identify the various emission sources. An inventory of all sources will be established. Once identified, these sources will be subject to regular inspection and a process of environmental compliance.

Motorized vehicles, especially cars will be subject to regular exhaust control. With the support of the National Agency for Sanitation and Control of Pollution and Nuisances (DNACPN) labels of compliance will be developed and attached to the vehicles admitted after the technical visit.

After complete phase-out of lead in gasoline, use of the catalytic converter will be enforced as it allows a reduction of about 90% of the automobile emissions.

8.5.4.2 Control of air quality

Among the multiple possible solutions to achieve cleaner air, the installation of an air quality monitoring system appears to be most appropriate. An air surveillance system will provide essential and objective information on pollution levels which allows estimate the population exposure in the city.

This project could be carried out in two phases: a phase of periodic evaluation of air quality and a phase of daily evaluation of air quality.

a) The metrological observatory

In the long-term the metrological observatory will address all pollutants existing in the city. The strategy of monitoring will be adapted according to the data collected. Initially, only key pollutants will be measured: sulphur dioxide, nitrogen oxides, carbon monoxide, lead, ozone and volatile organic compounds such as benzene and suspended particles ($PM_{2.5}$ and PM_{10}).

b) **Phase of moderate pollution**

If air pollution is moderate air quality can be estimated in a series of monitoring campaigns. Monitoring can be undertaken by mobile laboratories and passive samplers. Principal monitoring sites will be those with highest exposure risk at the time of the campaigns. Under these circumstances a first assessment of the state can be undertaken and an effective strategy to abate air pollution can be developed.

c) **Phase of serious pollution**

Air pollution will be considered serious if e.g. WHO air quality guidelines are exceeded. Under this condition it appears necessary to undertake a daily evaluation with the objective to improve measures of abatement and to achieve better results. A network of continuous monitoring stations will be installed at kerbside, industrial and urban background sites. Sites will be chosen according to their potential of significant exposure. This network of fixed stations will deliver data to a central computer via telephone lines. At the end of the day collected data will be processed to indicate air quality in the city of Bamako.

8.4.5.3 Various activities of the project

Creation and equipment of a centre in charge of air quality monitoring in Bamako;
Training of centre staff;
Acquisition of mobile equipment (a mobile laboratory and passive samplers);
Selection of monitoring sites;
Installation of fixed stations and acquisition of their equipment (monitoring analyzers);
Evaluation of air quality (development of an air pollutant index and mapping air pollution)

Milestones for key outputs

a) **Moderate air pollution**

- Training of involved staff — before March 2007
- Purchase of mobile laboratory — before June 2007
- Purchase of passive samplers — before June 2007
- Start of the first campaign — July 2007

b) **Serious pollution**

The milestones for key outputs will be determined in due course of time.

8.4.5.4 Description of key devices

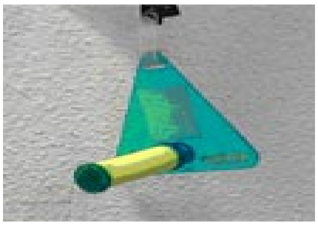
a) The mobile laboratory will be a van of 3.5 tons which is equipped with chemical

pollutant analyzers. It permits determine air pollutant concentrations. The mobile laboratory can be configured according to the needs (the pollutants to measure). It will be powered by the energy supply of Mali (Energie du Mali, EDM). It should dispose of a powerful information processing system, a global positioning system (GPS), a module of acquisition and transmission of collected data (GSM or telephone link) as well as an air-conditioner providing an environment for reliable and efficient monitoring. Devices for meteorological measurements include

- an anemometer (wind speed), a wind vane (wind direction);
- a thermometer;
- a humidity sensor.

b) A trailer laboratory shall be equipped with the same devices as the mobile laboratory. It will be towed to and installed at the monitoring sites.

c) Passive samplers are tubes which can be exposed at several sites to provide spatial coverage of the city. In contrast to mobile analyzers, they are exposed during several days and are sampled for analysis by specialized laboratories. That will make it possible to map the spatial pollutant distribution of in a study area.



d) Fixed stations will be solidly constructed in a area of at least 9 m^2 and equipped with analysers supporting the continuous transmission of data. Devices for monitoring meteorological data such as wind speed, wind direction and temperature will be integrated. The stations will be well lit and also equipped with an air-conditioning system necessary for the good operation of the equipment.

8.5.5 Synthesis of Practicability

The plan of air quality surveillance in the city of Bamako will benefit the whole population. Access to information will be facilitated by the availability of different measured data. This aspect will help better prevent air pollution by enhancing emissions abatement activities directing policies towards better air quality. In summary, the project will allow to control anthropogenic air pollution and provide a better quality of life.

8.5.5.1 Characteristics of the solution

Emission control is component of this project which will allow estimate the contribution of different sources. This will contribute to set up a regular and precise emission balance sheet and to propose action to treat wastes.

Ambient air quality surveillance is justified by the yardstick of providing more or less precise information on pollution levels. Under certain circumstances population exposure can be estimated by real-time surveillance (continuous monitoring). Surveillance may also facilitate the forecasting of serious pollution. In contrast to guesswork or a modelling approach surveillance provides more reliable data.

8.5.5.2 Financial feasibility

The first project of this type in Mali is primarily a social project. Its costs are quite high and require investigations of all partners on how to finance it. However, in view of the costs of potential air pollutant impacts projects costs should not constitute an obstacle to its realisation. Good management of the environment and consideration of the relations between air and other resources could have led to the elimination of the problem of air pollution.

8.5.5.3 Technical feasibility

A ‘conditio sine qua non’ for the feasibility of the project is the training of the personnel. As a matter of fact, the monitoring devices are quite sophisticated and require regular inspection and maintenance.

8.5.5.4 Organisational feasibility

The project will be realised under the auspices of the Ministry of Environment and Sanitation (MEA) by the DNACPN through integration in the frame of it current assignments. Educated staff would conveniently assure the good performance of the project. The organizational frame of the project is given in annex 1.

The sites for building stations to monitor serious pollution will be selected in agreement with the competent authorities. Contracts for building the stations and providing supplies of equipment will be agreed with firms and different suppliers, respectively.

8.5.5.5 Critical conditions

- Existence of a decree on adopted standards for the pollutants to be monitored
- Purchase of equipment necessary for metrology

The study of the various aspects of the project clarifies that in spite of the difficulties associated with this type of project, the necessary expenses for getting reliable data on air quality constitute a reasonable investment. This will serve avoid or at least reduce the risks associated with air pollution.

8.5.6 Logical Framework

Project parameters	Indicators of success	Means of verification	Critical assumptions
Goal Improve air quality	Reduction of respiratory diseases	Statistics of National Health Agency (DNS)	• Impact of regional air pollution • Ignoring regulations
Objective: Survey air pollution in the city of Bamako Objective of the project • Emission control • Pollutant level control • Public awareness raising	• Reduction of pollutant amounts emitted by industrial sources • Reduction of air pollutant concentrations • Reduction of polluting practices	• Inspection reports delivered by DNACPN • Annual report of the surveillance centre • Survey reports by DNACPN	• Staff availability • Equipment availability and performance • Absence of legislation for taxation of industrial emissions • Lack of stakeholder participation
Outputs • Establishment of a surveillance centre • Mobile laboratory • Diffusive tubes • Fixed stations • Evaluation of air quality	• Creation of a management Unit • Mobile laboratory equipped with analysers for key pollutants • Diffusive tubes	• Report of the Unit • Report of contractor	• Consideration of deadlines for construction and supplies • Compliance of services • Contractual agreements
Inputs • Expertise • Contractors • Providers	Personnel: Contractor: Supplier:	Report of surveillance centre	• Availability of funds • State participation

8.5.7 Annual Projected Planning of Activities

8.5.7.1 Moderate Pollution – Period 2007-2011

N°	Activities	Duration	Start	End	MONTH											
					J	F	M	A	M	J	J	A	S	O	N	D
1	Information/sensitisation	1 year	1 Jan	31 Dec	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
2	Inventory of UIP	14 days	15 Feb	28 Feb		xx										
3	Control of UIP emissions	14 days (7 days/semester)	1 March	14 March			xx									
			1 July	14 July							xx					
4	Control of automobile emissions	1 year	1 Jan	31 Dec	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
5	Monitoring campaigns	168 days	1 March	31 May			xxxx	xxxx	xxxx							
			1 July	30 sept							xxxx	xxxx	xxxx			
6	Periodical evaluation of AQ	60 days	1 May	31 May					xxxx							
			1 Sept	31 Sept									xxxx			
7	Reports	7days/trimestre		End trim			x			x			x			x

8.5.7.2 Serious Pollution

N°	Activities	Duration	Start	End	MONTH											
					J	F	M	A	M	J	J	A	S	O	N	D
1	Information/sensitisation	1 year	1 Jan	31 Dec	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
2	Control of UIP emissions	28 days (7 days/semester)					x			x			x			x
3	Control of automobile emissions	1 year	1 Jan	31 Dec	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
4	60 days	60 days	1Dec	30 Dec						xxxx						
			1Dec	30Dec												xxxx
5	Continuous monitoring and evaluation of AQ	1 year	1 Jan	31 Dec	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
6	Report	7days/trimestre		End trim			x			x			x			x

8.5.8 Strategy of Project Realisation

In order to realise the project, the following strategy could be adopted:

8.5.8.1 Attendant measures: enforcement of regulations

The improvement of air quality cannot be achieved without attendant adequate legislation. For that reason the DNACPN has to emphasize that measures are taken with respect to the following topics:

a) Import taxation of second-hand vehicles

In view of the growth of the vehicle fleet and the increase of its age the necessity of a taxation scheme tending to diminish the flux of importation is obvious. Incentives to encourage the import of less aged and less polluting vehicles (age < 5 years) should be developed.

b) Control of vehicle emissions

The decree adopted in 2000 regulating the control of CO_2 and smoke should be implemented in order to get the population used to control as an integral part of the technical inspection. The control could be extended to all pollutants emitted by vehicles.

c) Introduction of the catalytic converter

The phase-out of lead opens the way to introduce the catalytic converter which considerably reduces vehicle pollution (about 90 per cent).

d) Setting national air quality standards

As long as national AQS are not set, the air quality guidelines of the WHO will be used to control air pollution. The monitoring campaigns, once accomplished, will serve as guides to set the standards for certain pollutants.

8.5.8.2 Creation of a air quality surveillance centre (CSA)

It makes sense to create an independent AQ surveillance centre in order to avoid interferences of responsibilities and to facilitate the co-ordination of necessary actions. It will be attached to the DNACPN and will have to be recruited by staff that has been educated in special air pollution training programmes.

8.5.8.3 The training of staff

The implementation of this project requests training of the personnel in charge. Training will address the use of the different equipment, software, maintenance of equipment, evaluation of air quality, etc. A partnership will be negotiated with an agency in charge of surveillance in France, i.e. ASCOPARG, which will provide technical aid during the first 3 years of the project.

8.5.8.4 Sensitization and information dissemination

Information dissemination and sensitization are priority actions to develop public awareness and achieve individual and collective behaviour change. Both will constitute one of the first assignments of the AQ centre. Three target groups have to be addressed – industry, households and schools. All mass media should be involved.

8.5.8.5 The surveillance of air quality

Human expertise, equipment and substantial funding are required. The surveillance of air quality will be envisaged after training of the personnel. The population of the city of Bamako is today of the order of 1 200 000 inhabitants and will augment substantially in the years to come. It exceeds the number of inhabitants in certain pays for which an AQ surveillance system usually is installed.

The surveillance will be undertaken in two phases:

- In a first phase monitoring campaigns will take place which will last as long as the standards are not exceeded (moderate pollution assumed).
- A second phase will be launched when the standards are exceeded (serious pollution).

a) Site selection for campaigns:

The selection of monitoring sites takes into account different sources and the exposure of the population

The implementation of surveillance will include:

- One station in the industrial zone of Bamako
- Four kerbside stations (one on each of the following major roads: Avenue OUA, Route of Koulikoro, Route of Lafiabougou (Avenue Cheick Zayed), Boulevard du peuple
- Six urban background stations (one per community)

Kerbside sites are chosen according to traffic density. They indicate the pollutant levels due to vehicle emissions to which the population are exposed. The industrial site will allow estimate pollution levels in the industrial area. Background station are useful for estimating the average levels to which everybody is exposed.

A grid of 3 x 3 km^2 will be used for monitoring with diffusive samplers. The realisation of this task will be performed by temporary support personnel.

b) Monitoring campaigns

Each year two monitoring campaigns will be organised which will permit observe the development of pollutant levels during the main seasons. At each site observations will be undertaken during two weeks, The first phase will start in 2006; observations will continue until 2010 where the first evaluation will be undertaken.

c) Continuous monitoring:

Continuous monitoring does not take place unless air pollution is judged “serious”. Under these circumstances fixed stations are installed and equipped with analysers for continuous monitoring. Daily evaluations of AQ data will be performed.

8.5.8.6 Regular evaluation

The MEA will evaluate periodically the project through annual visits of project partners. End of 2010 a joint effort of MEA and its partners will be organised with the aim to evaluate the results of the first phase of the project with respect to its continuation (continuation of campaigns or starting phase II).

8.5.8.7 Collaboration with others institutions

The CSA will collaborate with other institutions with direct or indirect links to air pollution, especially the head of national meteorological offices, the Ministry of health and the university of Bamako.

In order to better understand the influence of meteorological parameters on air pollution as well as their consequences in the city of Bamako information and data exchanges will be organised. The Ministry of Health (DNS) and the Faculty of Medicine will contribute epidemiological studies for establishing the existing associations between air pollution and related health effects. Depending on the monitoring results proposals for studies will be made.

8.5.8.8 Study on financing

In view of the importance of fund mobilisation for the realisation of this project a study on how to finance it is indispensable. The proposed dossier will be submitted to different partners. In addition, setting taxes for industrial polluters and motor vehicles could help finance the activities of the centre.

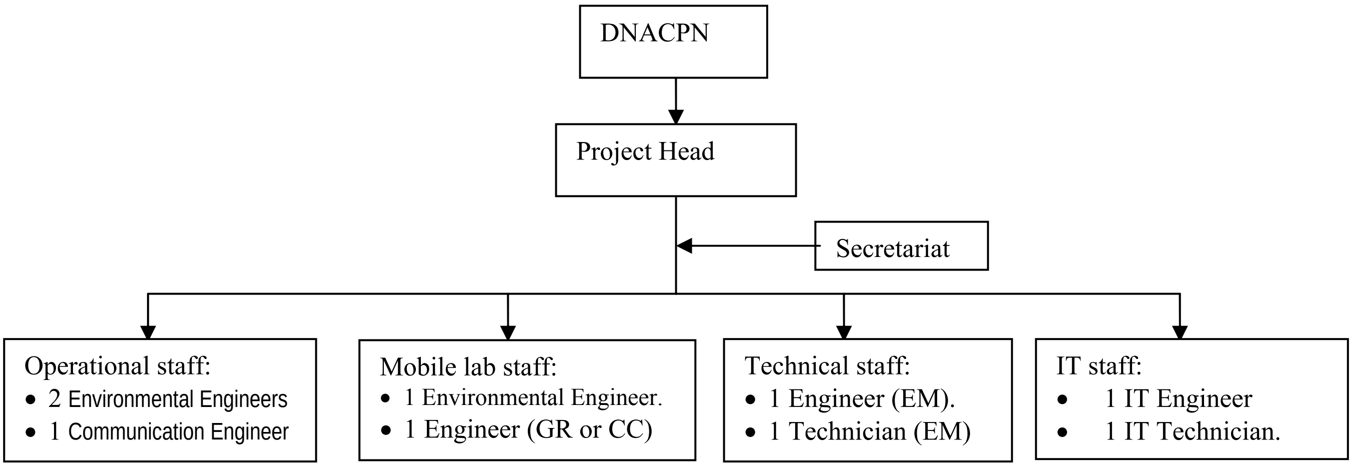
8.5.8.9 Study on exoneration for equipment importation

Negotiations with the responsible authorities will be held to exonerate all equipment needed for the realisation of this project in order to keep the total costs lower.

8.5.9 ANNEXES

8.5.9.1 Annex 1: Organizational frame of the Centre for AQ surveillance (CSA)

8.5.9.1.1 Organisation chart for the CSA



8.5.9.1.2 Operational procedure of the CSA

Composed of a dozen members, the CSA will operate continuously during the whole duration of the project. Initially, activities will be centred essentially on:

- Information and sensitization;
- The inventory of industrial sources and estimate of their emissions:
- Organization of monitoring campaigns.

The main objective of this first approach is to familiarize personnel with the task of AQ surveillance. It will help in the establishment of the AQ state which is necessary for the selection of appropriate abatement or prevention actions.

The second phase approach will be initiated according to the evolution of pollution. When the monitoring campaigns will indicate exceedance of standards for certain pollutants, it will be necessary then to concentrate on:

- Information and sensitization;
- Control of the source emissions;
- Monitoring continuously pollution levels by installation of a fixed network of monitors.

8.5.9.1.3 Contribution of different services

8.5.9.1.3.1 Operational service

The operational service will assure to provision of key functions of the centre. It will be in charge of:

- Follow-up of monitoring
- Environmental evaluation of monitoring
- Development of an air pollution index
- Elaboration of daily or periodical information bulletins
- Delivery of information to the public

8.5.9.1.3.2 Mobile laboratory service

This service will be in charge of:

- Good undertaking of monitoring campaigns (exposure of mobile stations and passive monitors, controlling exposure duration of samplers);
- Generation of pollution maps once sampled data have been evaluated.

8.5.9.1.3.3 Technical service

It will assure:

- Inspection and maintenance of equipment;
- Error detection in case of technical failures of monitoring equipment;
- Repair of equipment;
- Data validation technique.

8.5.9.1.3.4 The IT service

This supporting service is in charge of:

- Management of the computer network;
- Training of personnel in using the key software;
- Creation of a website and its regular update.

8.5.9.1.4 Activity reports

Quarterly reports of activities will be elaborated and presented to DNACPN and MEA. They will compile a synthesis of information collected during the reporting period. An annual report will be also worked out at the end of each year.

8.5.9.2 Annex 2: Estimated project costs

8.5.9.2.1. Phase of moderate pollution

8.5.9.2.1.1 Investment needs

Element	**Element breakdown**	**Quantity**	**Amount (FCFA)**	**Amount (€)**
1. Three-month training				
	Training fees (1 000€/pers)	8	5,240,000	8,000
	Accommodation (400€/mois/2pers)	12	3,144,000	4,800
	Transport (Return ticket: 1,200,000 FCFA/person)	8	9,600,000	14,800
	Monthly costs of move (50€/month/person)	24	818,750	1,200
	Perdiem: 50€/day/pers	720	23,580,000	36,000
Subtotal training			**42,382,750**	**64,800**
2.Offices (location of centre)				
	Location rent	12 months	2,400,000	3,700
	Bureau equipment		10,000,000	15,400
Subtotal bureau			**12 400 000**	
3. Periodical AQ surveillance				
	3.1 mobile laboratory and equipment			
	Mobile laboratory van “Master Renault”	1	19,650,000	30,000
	Van equipment			
	Acquisition station	1	4,257,500	6,500
	Modem GSM	1	196,500	300
	Meteo telescope mast	1	655,000	1,000
	Anemometer	1	982,500	1,500
	SO_2 analyser	1	10,806,845	16,500
	NO_x analyser	1	10,611,000	16,200
	O_3 analyser	1	8,187,500	12,500
	CO analyser	1	8,056,500	12,300
	PM_{10} analyser r	1	16,375,000	25,000
	Two-channel air-conditioner	1	2,000,000	3,000
Subtotal van and equipment			**81,778,345**	**124,800**
	3.2 Trailer laboratory and equipment			
	Trailer laboratory	1	10,807,500	16,500
	Acquisition station	1	4,257,500	6,500
	Modem	1	196,500	300
	Meteo telescope mast	1	655,000	1,000
	SO_2 analyser	1	10,806,845	16,500
	NO_x analyser	1	10,611,000	16,200
	O_3 analyser	1	8,187,500	12,500
	CO analyser	1	8,056,500	12,300

	PM_{10} analyser	1	16,375,000	25,000
Subtotal trailer laboratory			**69 953 345**	**106,800**
	3.3 Diffusive samplers (+ protective covers + analysis costs) Provider: Passam.AG			
	Tube NO_x	1000	6,550,000	10,000
	Protective cover NO_x	1000	8,842,500	13,500
	Tube SO_2	1000	11,593,500	17,800
	Protective cover SO_2	1000	10,480,000	16,000
	Tube O_3	1000	7,008,500	10.800
	Protective cover O_3	1000	23,580,000	36,000
Subtotal diffusive samplers			**68 054 500**	**104,100**

Supplementary equipment

Equipment type	**Designation**	**Quantity**	**Amount (FCFA)**	**Amount (€)**
1. Equipment and computer software				
	Computers, printers	10	10,000,000	15,300
	Software ISATIS: 10000€ Training (2 weeks): 6900€ TTC	1	11,069,500	16,900
	MAP INFO 7,5	1	864,600	1,300
	Photocopier	1	2,000,000	3,000
2. Transport costs				
	Pick up of vehicles	2	40,000,000	61,000
Subtotal of supplementary equipment			**63,934,100**	**97,500**

Expenses for transportation of equipment: 20% of equipment costs. Provided prices being in TTC, tax exemption could allow cover these expenses.

8.5.9.2.1.2 Expenses for operation

Activities	Needs	Quantity	Amount (FCFA)	Amount (€)
1. Communication				
	Posters, panels, brochures		3,000,000	4,600
	Radio debates, television spots		7,000,000	10,800
2. Emission control				
	Fuel (20l/day for 30 days)	600	300,000	460
3. AQ surveillance				
	Computer consumables and office equipment		10,000,000	15,300
	Electricity consumption, telecommunications (van laboratory and mobile station)		10,000,000	15,300
	Installation of passive samplers		1,000,000	1,500
4. Technical assistance (two specialists per year for three years)				
	Travel (return ticket)	2	2,400,575	3,700
	Accommodation (1week)	140	1,834,000	2,800
	Per diem	100	1,310,000	2,000
Bonuses for staff				
	Project leader (200,000 FCFA/month)	12	2,400,000	3,700
	Personnel: 8 persons (100,000 FCFA/month)	12	9,600,000	14,700
	Secretary 65,500 FCFA/month	12	786,000	1,200
Subtotal operation			**49,630,575**	**76,060**

8.5.9.2.2. Phase of serious pollution

8.5.9.2.2.1 Investment needs

Element	Element breakdown	Quantity	Amount (FCFA)	Amount (€)
Fixed stations	Building of fixed stations (civil engineering work)	11	66,000,000	
Station equipment	Analysers meteorological equipment, air condition	11	683,415,865	
Subtotal investment			**749,415,865**	

8.5.9.2.2.2 Expenses for operation

Element	Element breakdown	Quantity	Amount (FCFA)	Amount (€)
1. Communication				
	Posters, panels, brochures		3,000,000	4,600
	Radio debates, television spots		7,000,000	10,800
2. Emission control				
	Fuel (20l/day for 30 days)	600	300,000	460
3. AQ surveillance				
	Computer consumables and office equipment		10,000,000	15,300
	Electricity consumption, telecommunications (van laboratory and mobile station)		10,000,000	15,300
Bonuses for staff				
	Project leader (200,000 FCFA/month)	12	2,400,000	3,700
	Personnel: 8 persons (100,000 FCFA/month)	12	9,600,000	14,700
	Secretary 65,500 FCFA/month	12	786,000	1,200
Subtotal operation			**43,086,000**	**66,060**

8.5.9.2.2.3 Summary table of expenses for phase I – moderate pollution: 2007-2011 (FCFA)

N°	Needs	Year				
		2007	2008	2009	2010	2011
I	**INVESTMENT**					
1	Training	42,383,085				
2	Rent for offices	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000
3	Equipment of offices	10,000,000				
4	Equipments for surveillance					
4.1	Van laboratory	81,778,715				
4.2	Trailer laboratory	69,953,345				
4.3	Passive samplers	68,054500	68,054,500	68,054,500	68,054,500	68,054,500
5	Supplementary equipment					
5.1	Software: ISATIS (training included), MAP INFO 7,5	11,069,500 864,600				
5.2	Photocopier	2,000,000				
5.3	IT material	10,000,000				
5.4	Vehicle pick up expenses	40,000,000				
6	Expenses for transport of equipment (20%)	52,226,425	13,610,900	13,610,900	13,610,900	13,610,900
	Subtotal investment	**390,730,170**	**84,065,400**	**84,065,400**	**84,065,400**	**84,065,400**
II	**OPERATION**					
1	Communication	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000
2	Emission control	300,000	300,000	300,000	300,000	300,000
3	Establishment of passive samplers	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
4	Consumables and consumption (electricity, telephone,…)	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000
5	Technical assistance	5,544,575	5,544,575	5,544,575		
6	Bonuses for staff	12,786,000	12,786,000	12,786,000	12,786,000	12,786,000
	Subtotal operation	**49,630,575**	**49,630,575**	**49,630,575**	**44,086,000**	**44,086,000**
	Total/year	**440,360,745**	**133,695,975**	**133,695,975**	**128,151,400**	**128,151,400**
	TOTAL	**FCFA 964,055,495**			**€ 1,500,000**	

8.6 Annex Mauritius_1: Revision of standards for ambient air quality

Mauritian standards for air quality date back to 1998 and experience gained over the implementation of these standards over the past years has revealed a number of loopholes. Numerous consultants have since recommended a review of the standards so as to be in line with the latest development in this field (e.g. World Health Organisation, World Bank guidelines and other countries emissions standards) and to correct certain loopholes in the regulations.

The MoE had thus approved the constitution of a Technical Standards Committee in April 2003 to review the current air standards (*Environment Protection (Standards for Air) Regulations 1998 (GN No. 105 of 1998 – in force since 1 February 1999))*.

Strategy/objectives
An in-depth review exercise has been undertaken and recommendations have been formulated and submitted to Government in October 2005.
The technical report aims to assist the Government of Mauritius in the formulation of appropriate standards so that they reflect the actual needs of the country and in the design and implementation of policies and management tools to improve air quality.

Recommendations
An integrated approach has been proposed towards tackling air pollution, comprising prevention, enforcement, monitoring and education.
The major provisions of the recommendations (details at annex) formulated are:

- ambient air standards would be revised taking into account international standards such as World Bank proposals, World Health Organisation guidelines, limits laid down in European Directives and United States Environment Protection Agency standards,
- Industries would be required to comply with four parameters; sulphur dioxide, particulate matter, carbon monoxide and oxides of nitrogen given the nature of industrial activities and local monitoring capacity,
- Stacks of industrial boilers and incinerators would be required to comply with "Good Engineering Practice" guidelines, viz., nearby structures, exhaust velocity and stack height,
- existing and new thermal power plants would be regulated differently due to constraints of space, technology and design,
- industrial boilers would be regulated through environmental performance monitoring and appropriate stack design and height. Larger capacity boilers would also be required an annual stack emissions monitoring,
- incinerators would be categorised as small and large and specific regulations would provide for municipal waste incinerators, medical waste incinerators and other incinerators,
- Provisions would cater for stone crushing plants and foundries,

Status
The recommendations of the Technical Committee on Chemistry and the Environment are being analysed by Government prior to implementation in the short, medium and long terms.

The AQS of Mauritius as recommended by the Committee are summarised in Table Mauritius_1 in Section 6.

8.7 Annex Mauritius_2: Emission standards for stationary sources

8.7.1 Particulate Matter (PM_{10})

Based on the best available technology locally, a single limit of 200 mg/Nm^3, applicable to all industries, was recommended.

When there are more than one stack on the premises, the total mass of the particulate emissions from all the chimneys divided by the total volume of such emissions shall not exceed 200 mg/Nm3 and the particulate emissions from each of such stack shall not exceed 400 mg/Nm3 at any point in time.

8.7.2 Sulphur Dioxide (SO_2)

8.7.2.1 Thermal Power Stations

8.7.2.1.1 New plants

A maximum rate of emission of 200kg SO_2 per day per MW (with a maximum allowable concentration of 2 000 mg/Nm^3 of SO_2 in flue gasses), as recommended by the World Bank Guidelines, 1998 concerning **new thermal power plants** of a capacity not exceeding 500 MW.

8.7.2.1.2 Existing plants

Adoption of World Bank guidelines was not realistic for existing thermal power plants due to constraints of space, technology and design. Some of the existing thermal power plants still have an operating life-span of around 20 years, and that it would not be realistic and cost-effective to replace such plants. It is proposed that these plants be required to comply with ambient SO_2 levels. It is recommended that CEB, as part of its corporate social responsibility, be approached to install continuous ambient air monitoring stations near power plants. This will enable effective decision making both by CEB and by the Department of Environment.

Industrial Boilers

Type	**Recommendations**
Boilers with a capacity ≤ 5 tons steam per hour	• Stack monitoring is not required • Environmental Performance Monitoring mandatory • Proper stack design and height according to GEP.
Boilers with a capacity > 5 tons steam per hour	• Environmental Performance Monitoring and Permit application 2. Proper stack design and height according to GEP. 3. Annual Stack Emissions monitoring

The Committee also recommends that the following be included in the regulations:

- The DoE should be empowered to impose a change in fuel type for factories near residential areas that cause ambient SO_2 standards not being met.

- For new power plants and new factories with large boilers, an air pollution modelling (prior to application for an EIA license) would be mandatory, irrespective of the location.
- Existing industries would be given a grace period of three years for compliance.

8.7.3 Nitrogen Oxides (NO_x)

A NO_x standard maximum limit of 1,000 mg/Nm^3 applicable to all industries and power plants was recommended.

Engines being run for power production at the different CEB plants were initially designed for ships. At low running speeds, such engines emit excessive NO_x. World Bank Guidelines had special provisions for such engines where a maximum permissible NO_x limit of 2 000 mg/Nm^3 is specified, provided the Environmental Impact Assessment (EIA) could demonstrate that ambient air standards were not exceeded. It is recommended to adopt NO_x World Bank Guidelines of 2,000 mg/Nm^3 for engine-driven power plants for existing and new plants, provided that the EIA and a modelling and monitoring exercise could prove compliance with ambient NO_x standards.

8.7.4 Carbon Monoxide (CO)

The committee agreed to keep the carbon monoxide standards as being 1,000 mg/Nm^3.

8.7.5 Volatile Organic Compounds(VOCs)

As per World Bank Guidelines, it is recommended to adopt a standard of 20 mg/Nm^3 for VOCs.

8.7.6 Regulations on Stack Design

The committee recommends the following:

- In no case the stack height shall be less than 11 meters. Any factory operating a boiler with a capacity above 5 tons of steam per hour should have a minimum stack height of 20m.
- The stack height must be according to Good Engineering Practice. It is the responsibility of the factory to demonstrate that the stack has been designed according to GEP. If the stack is less than the GEP or if any adjacent structures are taller than the stack, air quality modelling must be performed to document that ambient AQS will not be exceeded.

8.7.7 Energy

8.7.7.1 Cleaner Production in Industry and Energy Audits

The Cleaner Production concept and culture need to be introduced in the factories. Training on Cleaner production tools such as waste audits must be organized .

Efficient Use of Energy

Efficient use of energy is one of the main strategic measures not only for the conservation of fossil energy resources but also for abatement of air pollution.

Power sector opportunities include greater efficiency in conventional power plants and use of cogeneration plants that produce both electricity and heat. Government should also provide incentives to push towards centralized generation of steam to ensure cleaner and more efficient utilization of fuel.

Many of the technical options for energy saving in industry require only small investments and are easy to implement. In several cases, even simple organizational changes bring about considerable energy savings, yielding not only environmental benefits but also financial returns. To identify energy saving potential within an industrial plant is to carry out an energy audit.

There are many industries which are using fuels in an inefficient way. It is worthwhile to consider introducing an Energy Efficiency Act to ensure that users consume their fuel as efficiently and cleanly as possible.

8.7.7.2 Environmental Performance Monitoring of Boilers

The Ministry could specify simple performance-standards that includes pre-treatment of fuels, equipment maintenance, operator training and record keeping requirements. An initial certification must be submitted and certify annually that the facility meets environmental performance standards. Under the program the factory submits an initial certification within 3 months following the start of boiler operations. In subsequent years an annual compliance certification must be filled out, signed and submitted to the DOE. The specific air quality requirements will include the following:

- Fuel requirements
- Emission limits
- Performance standards-tune ups, efficiency tests
- Record keeping requirements
- Stack design requirements

❖ There is a need to devise workbooks/training materials to provide information to factories so that they understand how to meet environmental obligations.

❖ To ensure efficient combustion and compliance with emission standards, boilers must be operated and maintained according to the manufacturer's instructions. Tune-ups, including efficiency testing, are considered crucial to efficient, clean operation. One of several tune-up options is required, depending on the type of fuel burned:

   i. If natural gas is the fuel, one annual tune up is required
   ii. If liquid fuels is the primary fuel, two tune-ups must be performed annually
   iii. Boilers equipped and operated with an automated combustion control system are not required to receive tune-ups. However, such boilers must be maintained and serviced as specified by the manufacturer.
   iv. Tune-ups must incorporate an efficiency test. Efficiency tests must include measurement of carbon monoxide, carbon dioxide, oxygen concentrations and flue gas temperature. The tune-ups must be kept onsite for three years.

The factory must keep the following records onsite for at least three years. This means that each individual record must be retained on site for three years from the date it was generated. Record Keeping Requirements refer for the following:

Monthly record of type and amount of fuel used

- Sulphur content of fuel (as certified by the fuel suppler)
- Results of tune-ups and combustion efficiency tests

- All purchase orders and invoices related to boiler combustion.

The following must be kept on site for the life of the boiler:
- Manufacturers operating instructions and Boiler installation tests
- Qualifications of operating personnel
- Emission monitoring results.

An Environmental Performance Monitoring Document need to be designed by the Ministry and it should be obligatory for all boiler operators to abide by this document.

8.8 Annex Mauritius_3: Introduction of unleaded motor gasoline (September 2000 - 2002)

BRIEF SUMMARY:
Following several studies previously carried out on air quality and vehicle emissions, Government took the decision, in 2001, to introduce unleaded motor gasoline (ULG). The Technical Committee chaired by the Ministry of Environment (MOE) and involving all major stakeholders recommended a complete switch to ULG so as to avoid unnecessary investments. MOE was responsible to coordinate the sensitization campaign. The transitional period during which mixed coloured petrol was dispensed at the petrol stations was smoothly passed. ULG was considered to be effectively introduced in September 2002 when levels of lead in the dispensed petrol were at or below 13 mg/L. ULG was doped with a green dye and all petrol stations displayed labels indicating "Unleaded Petrol".

The move towards unleaded petrol had been a Government decision and therefore the program could be regarded as a sustainable large-scale project. Furthermore, regulations on control of vehicle emissions have been promulgated and provide that, as from 01 January 2003, only petrol-driven vehicles capable of running on unleaded gasoline shall be registered in Mauritius.

KEY CHALLENGES/OBJECTIVES:
Within the overall aim of improving air quality in Mauritius, the introduction of unleaded motor gasoline had as main objectives -

- The reduction of lead emitted by petrol vehicles exhaust, which is a major contributor to air pollution,
- The use of catalytic converters for reducing emissions from vehicles of pollutants other than lead.

RESULTS ACHIEVED AND KNOWN IMPACTS
A shift from leaded (from a level of 0.4 g/L) to unleaded petrol had allowed an immediate removal of more than 50 metric tons of lead from the atmosphere. Ambient air monitoring confirmed a decrease in lead levels from the ambient air from an average of 0.1 $\mu g/m^3$ to trace levels only.

MAIN OBSTACLES FACED:

- Availability of unleaded motor gasoline from usual suppliers
- Owners of vehicles over 10-15 years feared they might experience knocking and pinking of their engines (due to engine corrosion and valve seat recession)
- A program of clean-up and replacement of tanks (at main depot and at petrol pumping stations) to remove sludge from previous consignments had to be undertaken
- Consumer protection organisations feared that the level of benzene in unleaded motor gasoline might be excessive

KEY LESSONS LEARNT:

- The project should be steered by a lead institution (e.g. Ministry of Environment).

- Close consultation and collaboration of all major stakeholders is essential (e.g. Local oil companies, motor vehicles associations, concerned ministries,/authorities, etc.)
- Complete switch to ULG instead of phased reduction of leaded gasoline was the preferred option for both economic and practical reasons.
- Sustained sensitisation is needed prior to the introduction of unleaded petrol and during the transition period through press articles, radio and television spots, etc. so as to get the public prepared and allay any fears.
- Hotlines at the various motor vehicle dealers to respond to public queries
- Close monitoring of the levels of lead in the gasoline dispensed at the petrol stations during the transitional period.
- As a precautionary measure, potassium-based additives in small containers (25 and 50 mL) were put on sale at the petrol stations for owners of old vehicles who wished to dope their fuel; however, in the months following the introduction of the ULG, sale of additives had drastically dropped, and to-date no old vehicles are using the additives.

8.9 Annex Mauritius_4: Control of Vehicle Emissions

The Government of Mauritius commissioned in 1996 Singapore Environmental Management and Engineering Services (SEMES) Pte Ltd to study the impacts of vehicle emissions on the air quality and to formulate suitable and practical vehicle emission control programmes, including review of existing legislation and development of institutional set-ups to implement the recommended programmes. The country has adopted a phased approach. Improvement of fuel quality is being looked into by a technical advisory committee set up within the Ministry of Environment

KEY CHALLENGE/OBJECTIVE:
To improve air quality in Mauritius by reducing the environmental impacts of vehicle emissions

STRATEGY USED TO MEET OBJECTIVE:
- Improvement of automotive fuel quality (phasing out of leaded petrol and reducing the sulphur content of diesel from 0.5 % to 0.25 %),
- Setting up of vehicle emissions standards based on Japanese and European limits (since most vehicles were of Japanese and European Origin),
- Ensuring proper maintenance of vehicles through periodic inspection,
- Conduct proper enforcement programme on smoky vehicles,
- Survey on the smoky vehicle situation,
- Establish a proper vehicle de-registration and scrapping system,
- Provide training to key personnel and conduct regular and effective public education.

RESULTS ACHIEVED AND KNOWN IMPACTS:
Results achieved include improvement of fuel quality by reduction of sulphur content in diesel from 1% to 0.5% in the first instance with a further reduction to 0.25% by weight in September 2001; the introduction of unleaded petrol as of September 2002; and capping of benzene levels at 5% max. by volume.
By lead phase-out more than 50 metric tons of lead were removed from the atmosphere and a substantial decrease of lead concentrations to traces only. Another result was the promulgation of the Road Traffic (Control of Vehicle Emissions) Regulations. Mass sensitisation campaigns were organised to promote unleaded petrol prior to its introduction in September 2002. An aggressive sensitisation campaign was organised during the month of August 2003 - (vehicles roadside checks, posters distributed in filling stations, radio and television spots aired for a week and advertisements in the press, holding of a workshop for garages and mechanics on "Emissions Control of Diesel and Petrol Automotive Engines"). Further achievements included the procurement of smoke meters by the National Transport Authority and Department of Environment and a training of enforcement officers. Regular contraventions were taken by officers of the "*Environment Police*" Unit set up within the Ministry of Environment) on owners of smoky vehicles during roadside checks.

The key lessons learnt are that the project should be steered by a lead institution with regular meetings to keep track of progress and incentives are needed to further encourage public participation with respect to de-registration of older vehicles.

8.10 Annex Mauritius_5: Introduction of unleaded motor gasoline

Following several studies previously carried out on air quality and vehicle emissions, Government took the decision, in 2001, to introduce unleaded motor gasoline (ULG). The Technical Committee chaired by the Ministry of Environment (MOE) and involving all major stakeholders recommended a complete switch to ULG so as to avoid unnecessary investments. MOE was responsible to coordinate the sensitization campaign. The transitional period during which mixed coloured petrol was dispensed at the petrol stations was smoothly passed. ULG was considered to be effectively introduced in September 2002 when levels of lead in the dispensed petrol were at or below 13 mg/L. ULG was doped with a green dye and all petrol stations displayed labels indicating “Unleaded Petrol”.

The move towards unleaded petrol had been a Government decision and therefore the program could be regarded as a sustainable large-scale project. Furthermore, regulations on control of vehicle emissions have been promulgated and provide that, as from 01 January 2003, only petrol-driven vehicles capable of running on unleaded gasoline shall be registered in Mauritius.

KEY CHALLENGES/OBJECTIVES:
Within the overall aim of improving air quality in Mauritius, the introduction of unleaded motor gasoline had as main objectives the reduction of lead emitted by petrol vehicles exhaust and the use of catalytic converters for reducing emissions from vehicles of pollutants other than lead.

RESULTS ACHIEVED AND KNOWN IMPACTS
A shift from leaded (from a level of 0.4 g/L) to unleaded petrol had allowed an immediate removal of more than 50 metric tons of lead from the atmosphere. Ambient air monitoring confirmed a decrease in lead levels from the ambient air from an average of 0.1 $\mu g/m^3$ to trace levels only.

MAIN OBSTACLES FACED:
- Availability of unleaded motor gasoline from usual suppliers
- Owners of vehicles over 10-15 years feared they might experience knocking and pinking of their engines (due to engine corrosion and valve seat recession)
- A program of clean-up and replacement of tanks (at main depot and at petrol pumping stations) to remove sludge from previous consignments had to be undertaken
- Consumer protection organisations feared that the level of benzene in unleaded motor gasoline might be excessive

KEY LESSONS LEARNT:
- The project should be steered by a lead institution (e.g. Ministry of Environment).
- Close consultation and collaboration of all major stakeholders is essential (e.g. Local oil companies, motor vehicles associations, concerned ministries,/authorities, etc.)
- Complete switch to ULG instead of phased reduction of leaded gasoline was the preferred option for both economic and practical reasons.
- Sustained sensitisation is needed prior to the introduction of unleaded petrol and during the transition period through press articles, radio and television spots, etc. so as to get the public prepared and allay any fears.
- Hotlines at the various motor vehicle dealers to respond to public queries

- Close monitoring of the levels of lead in the gasoline dispensed at the petrol stations during the transitional period.
- As a precautionary measure, potassium-based additives in small containers (25 and 50 mL) were put on sale at the petrol stations for owners of old vehicles who wished to dope their fuel; however, in the months following the introduction of the ULG, sale of additives had drastically dropped, and to-date no old vehicles are using the additives.

8.11 Annex Mauritius_6: Environmental Management of Industrial Estates

This project which focused on the Vacoas-Phoenix Industrial Estate and the surrounding village of Valentina and Petit Camp, is a pilot project that will be used as reference for later projects on environmental management of industrial estates in Mauritius, the region and other small islands states.

The project was in line with Government's strategy to encourage the use of cleaner production technologies by enterprises. The strategy of the project was also in line with the programme of the new UNDP Country Cooperation Framework 2001-2003 focusing on environmental protection and management in Mauritius, with emphasis on eliminating land and sea-based sources of pollution. This project provided guidelines and options on how to reconcile conflicting demands for land use in industrial areas which are located in the vicinity of residential areas

KEY CHALLENGES/ OBJECTIVES:

- To quantify the different types of industrial pollution at the Vacoas-Phoenix Industrial Estate
- To analyse the effects of pollution on the surrounding environment, particularly on the population of Valentina village
- To propose solutions backed by cost-benefit analysis

The ultimate aim of the project was to ensure sustainable development of industrial estates through the adoption of appropriate methods and procedures that will enable profitable operations for the enterprises and, at the same time, provide acceptable quality of life for both the inhabitants living in their vicinity and the workers

RESULTS ACHIEVED AND KNOWN IMPACTS:

Various recommendations have been proposed to tackle the major pollution problems that the inhabitants have been facing for many years and a pollution monitoring plan has been proposed. Partnerships between the inhabitants, the industrialists, the different ministries and organisations and other stakeholders have been revitalised through this project. Each stakeholder has been encouraged to shoulder its responsibility in the efficient management of the industrial estate.

The industries' involvement in the project was successful and sensitisation workshops were successfully carried with all stakeholders. A health survey report and a cost-benefit analysis report were also produced. Necessary equipment and training that are required to perform scientific monitoring of air, water and soil pollution have been identified.

MAIN OBSTACLES FACED:

There were also some problems regarding the synchronisation of timing of the different events/ activities of the project that resulted in a delay in the completion of the project.

KEY LESSONS LEARNT:

The traditional approach to the environmental impacts of the industrial estate had been to investigate emissions to air and water, disposal of solid and hazardous waste, etc with a focus on activities of individual companies in the estate. The new strategy that was proposed was to consider environmental impacts and solutions at the industrial estate level and emphasize on the community of companies, and to promote cooperative approaches to environmental management.

8.12 Annex Nigeria_1: Impacts of air pollution

Acid Precipitation. The degree of acidity as measured by wet precipitation could be attributed to a variety of sources. Studies indicate the pH values to range from 3.3 to 6.2 for the Niger Delta and 4.1 to 5.5 for Lagos metropolitan areas. About 24% and 77% of the samples in the Niger Delta for instance had pH values below 4.5 and 5.6 respectively. Nriagu et. al.(1985), using precipitation studies around steel production factories reported pH values of$\leq$ 5.1 with a minimum value of 3.2 around the factory site. They also attempted estimates of gaseous pollutant emissions known to be associated with the operation of the steel industries. It is known that for pH values between 4.5 and 5.6 recorded in 53% of rain precipitation samples, the immediate sources could be a combination of natural and anthropogenic sources (natural sulphur cycle, strong and weak organic acids from combustion processes), but below 4.5, strong predominance of anthropogenic over natural sources (from strong inorganic acidic precursors - NO_x and SO_2) are confirmed. Measurements so far carried out indicate that in addition to NO_x and SO_2, strong contribution to the acidity of the Niger Delta region could arise from organic acids such as acetic, butyrate and propanoic acids (from natural or anthropogenic sources). Positive correlations exist between the acidic anions in wet precipitation and the atmospheric mixing values of the precursor gases. Based on factor analysis method, soil, anthropogenic combustion sources, and sea salt contribute 30-41%, 20-55% and 12-26% respectively to the acid rain in the area. The measured wash-out factors (deposition rates) of major acidifying pollutants from the atmosphere to the soil and water resources are high, and comparable to typical industrial areas.

With most sources nationwide capable of contributing to acid rain phenomena in the country located around the coast (Lagos and Niger Delta) and the middle to extreme northern boundaries (Jos, Kaduna and Kano States), it is expected that inter-regional exchanges are to be accelerated by the impact of the two major trade winds across the region and the boundaries of the inter-continental discontinuity (ITD) whose southern most location is at about 4°N and northern-most location at about 22°N. This means with the exception of plume rise associated with boundary layer heating and other convective processes, the total emissions in the region are capable of being trapped within the region bounded by latitude 4 and 22°N, irrespective of the seasonal changes in the trade wind direction. Hence high possibility for strong mixing exists to reduce the gradient between urban and rural mixing values for long lived pollutants. The consequence of this is that areas outside the urban centres which form the nucleus of agricultural activities may adequately be influenced by emissions and acidification processes of the urban centres, with very serious implications for agricultural productivity not hither-to given any national attention.

Urban Temperatures, Solar Irradiance and Greenhouse Effect. Measurements of day-time net radiation (Ojo, 1981) shows that highest values of 0.28 ly/min occur between 1000hr and 1500hr in areas of high traffic and building densities in the mainland areas of Lagos. Ojo ascribed these high values to greenhouse effect from atmospheric pollutants from industrial, and high traffic densities of the area. Spatial and temporal variations of temperature in the area, shows that the urban heat island effect (ΔT_{u-r}) is experienced at noon or in the late afternoon over Tinubu square in Lagos Island, and in the Mushin/Oshodi areas of the city. Typical ΔT_{u-r} values of between 2° and 4°C were obtained by Oguntoyinbo (1984). Studies over other cities (e.g. Ibadan) show similar trends in heat island effect and solar irradiance.

The annual minimum and maximum temperature anomalies computed from the monthly mean values are presented for Kano, Calabar and Lagos (Obioh, 1995). Good correlation exist between the mean annual emissions and urban temperatures measured during the period. The rates of these increases however vary among the cities, being highest for Lagos ~(1°C rise between 1965 and 1990), and nearly equal increases for Kano and Calabar ~(0.75°C to 1.0°C rise between 1945 and 1990). Urban temperature variations are a result of a combination of factors. The influence of population and industrial growth on the occurrence and magnitude of urban heat island effects has been well documented. Between 1963 and 1988, population estimates for Calabar and Kano cities may have changed by a factor of 2 and that of Lagos by a factor of 4 (FOS, 1966; 1989). This will certainly have significant impact on the urban surface air temperature increases. It is however, significant to note that the good correlations between urban temperature changes and national emissions may indicate substantial contribution from GHGs to the urban temperature changes.

Bio-indicators and Stress Analysis. Studies using trace metals levels in biological species, and in soils as biological indicators and stress analysis in biological samples due to pollution has been carried out as a measure of the extent of pollution in urban and industrial environments. Onianwa and Egunjobi (1983) used studies of Pb in mosses to show that lead (Pb) contamination in city centres of Ibadan, with high traffic densities (Pb~ 151.2 μg/g) is much higher than in rural areas (University of Ibadan zoo represented the rural area, Pb 13 to 30 μg/g). The difference in the mean and standard deviation patterns between the city and the rural area samples for zinc (Zn) was also significant but the authors could not identify specific sources associated. They suggested general level of human activities such as refuse burning, metal works and other activities which could contribute to Zn emission is higher in the city than in the rural areas. Ndiokwere (1984) investigated the distribution of heavy metals concentration in soils and plant leaves along a high way (traffic density~ 34000 vehicles/day), and obtained mean Pb concentrations of 247 and 243 μg/g respectively, at 1.5m from the highway. The concentration was generally found to be decreasing towards the direction of increasing distance from the highway, being 11.7 and 4.1 μg/g in soil and plant leaves respectively at 50m from the highway. Similar studies in Lagos (Ogunsola et al, 1993) indicate Pb in road side dust along highways (traffic density~ 10000 vehicles/hour during the daytime) to be approximately 871 μg/g. Lead metal loading in the air in industrial cities, has also been found to be very high. Ogunsola et al (1993; Olise 2004; Obioh etal, 2005) measured Pb concentration in the air in urban Lagos to be in the following ranges 0.5 - 15.7 μg/m^3 in residential/commercial areas(TD~ 1874 vehicles/hour); 0.3 - 9.0 μg/m^3 in industrial/highway areas (TD~ 3460 vehicles/hr); 0.9 - 9.0 μg/m^3 along highways(TD~ 10,000 vehicles/hr); 0.1 - 6.5 μg/m^3 in marine areas (TD~ 1530 vehicles/hr), and 0.2 - 19.4 μg/m^3 at bus stops(TD~ 2800 vehicles/hr). In general, ambient TSP concentrations measured ranged from 61 - 1903 μg/m^3 through the five ranges of locations. Similar measurements in Ile-Ife showed Pb~ -0.6 - 5.2 μg/m^3 (TD~ 1060 vehicles/hr) and TSP values of 120 to 750 μg/m^3. All indicate Pb and TSP levels higher than recommended by Federal Environmental Protection Agency (FEPA) guidelines. Stress studies have been carried out by Isichei and Sanford (1976) on the effect of gas flares on the vegetation around a flare site in Rivers State. They reported increases in air, leaf and soil temperature up to distances of between 80 to 110 m from the flare sites. They also reported relative humidity suppression, decline in flowering and alteration of species composition for considerable distances away from the flare.

Occupational Exposure Measurements

Some measurement now exist to indicate that many urban dwellers in Nigeria may be occupationally exposed to very high degrees of air and other forms of pollution (Obioh, 1988; Jain and Partrick, 1983; Baumbach et al, 1995; Adejumo et al, 1994; Ogunsola et al, 1994; Oyedele et al, 1995) and Owoade (2006). Some of these measurements indicate that air and other pollution in workplaces exceed national and international values by large factors. These are expected to have adverse implications for the health of the workers in these places.

Human Health Impacts Survey

Increased urbanization is associated with urban pollution problems. These are expected to inflict various injuries to the population and industrial growth. Acidification of the atmosphere, soil, and water resources is one of the potential spin-offs from the expected increased pollution loading nationally. Some of these pollution eventually are dissipated on man through water, food chain and respiration, and result in a variety of ailments.

A variety of human health impacts isolated include lung function disorders, blood contamination leading to a number of effects. Pulmonary functions in different work places (cement industries, traffic, etc) were found to be highly reduced (Erhabor et al, 1993). Also, blood lead levels in traffic wardens and people who sell or spend a lot of time in high traffic zones have shown that their blood lead levels are significantly higher than normal with lead levels increasing with age. These have various consequences for mental development especially in children. It is worthy of note that lead content of the Nigerian gasoline estimated to be 0.74 g Pb/litre is one of the highest in the world, exceeding EU standard of 0.15 g Pb/litre. Hence comparative risk analysis in Nigeria and other developing countries have shown Pb to represent one of the most significant health risk problems of air pollution. This more acute as a sizeable fraction of the urban dwellers spend their time on the road sides with high traffic population selling goods (some of which are food stuffs) and performing other jobs for more than 8 hours of the day. The impact of urban air pollution on blood haemoglobin content has also been investigated in Lagos. Preliminary results are firm that CO concentrations (and hence blood absorption) are much higher than recommended threshold limit values. Impact of these on health is well documented.

The impact of these emissions on regional air pollution and air basin physico-chemical processes has not yet been assessed adequately due to the demand in quantity and scope of studies required to adequately isolate the problems. However, during the last few years various studies (Ogunsola et al, 1993 & 1994; Oluwole et al, 1994; Baumbach et al, 1995; Obioh et al, 1994, and Akeredolu, 1994) have been reported on the atmospheric mixing values of principal air pollutants: total suspended particulate (TSP), lead (Pb), SO_2, NO_x, VOC, CO, and some specific carcinogenic hydrocarbons such as benzene. Major results from the few available studies are that national and international AQS in the urban areas are violated. Apart from potential contribution to atmospheric acidification of the region, that atmospheric AQS are violated by many pollutants for a substantial part of the year also possesses serious dangers to human health and ecology.

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8.13 Annex Nigeria_2 Projects/Programmes

8.13.1 AQM Study in Lagos (Nigeria)

This project was advertised by the World Bank as part of the Clean Air Initiative in Sub-Saharan African Cities (CAI-SSA). The current status of the implementation is however not known. The World Bank is understood to be executing the trust fund from the Europe-Aid Co-operation Office of the European Commission, to finance the AQM Study in Lagos (Nigeria). In an advert early this year, the World Bank solicited an expression of interests from prospective consultants to implement the project under the following TOR:

- Using a participative and multi-sector process with the various local partners involved in the management of air quality, the consultant will develop for the metropolitan area of Lagos, a simple interactive model for AQM which will cover emissions, air quality, health impacts, management options and costs.
- Using low sophistication and low cost techniques, the consultant will collect data on fine particulates, SO_x, NO_x and CO_2 concentrations to allow calculation of 24-hour average concentrations for one day each week over a one-year period.
- The consultant would develop a plan of immediate and longer term actions (covering the investment, policy, economic, and technical aspects) to improve air quality in each city; this action plan will be based on workshops with key stakeholders to be organized by the consultant.

Project Contact Point:

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8.13.2 Nimet-Arial Programme To Revamp The Lagos Automatic Ambient Air Quality Station

The Nigerian Meteorological Agency (NIMET) and the Atmospheric Research and Information Analysis Laboratory (ARIAL), Centre for Energy Research and development (CERD), Obafemi Awolowo University, Ile-Ife, Nigeria signed a memorandum of understanding (MOU) in January 2004, to undertake some joint research programmes in the areas of interest of the two institutions. The Programme to revamp the Lagos automatic ambient air quality station (LAAAQS) is one of the recent activities to be undertaken under the auspices of the MOU. The LAAAQS was set-up with funds from the EEC funded Project on Environmental Monitoring and Impact Assessment Coordinated by Obafemi Awolowo University, Ile-Ife in the early 1990s. the station was shut down after the expiration of the EEC Project. Efforts to to revamp the station was stiffled for many years due to low level of financial resources available locally.

Lagos automatic air quality station (CO_2, CO, NO_X, O_3, SO_2, TSP (by beta gauge) and 6 meteorological variables); and PM_{10} Samplers. Of these the Lagos Automatic Air Quality Monitoring Station is the most significant of this infrastructure, obtained through the EU/ACP funded project on Environmental Monitoring and Impacts Assessment (1989 to 1994). The project has since wound up and funds to sustain equipment maintenance, calibration, and purchase of essential consumable had since exhausted. The primary air of the Phase I of this project will be to reactivate all equipment currently available but not optimally utilized. The most significant of these is the Lagos air quality station, supplied to the University in 1991 but currently short down. The essential requirements for the reactivation of the station, as diagnosed, include:

- *Repair of the CO analyzer (CPU-board, catalytic CO scrubber, sample pump, etc)*
- *Repair NO_X analyzer (sample pump, restrictor and O-rings for reaction chamber, NOX-converter cartridge molybdenum).*
- *Repair of SO_2 analyzer (sample pump, UV lamp)*
- *Supply of multi-point calibration gases for the CO, CO_2, NO_X, SO_2, and O_3 analysers.*
- *Upgrade of the data acquisition system.*
- *Connection box for the meteorological signal.*
- *Supply of some consumables and essential spare parts.*

The revamping of the Lagos automatic station will be very valuable in upgrading the facilities on ground to support training and research across the region. Based on the complete revamp of the automatic monitoring station in Lagos, it would become necessary to re-train more graduate students and other experts, and expand the current regional spread of human capacity to:

- *Undertake the monitoring of air quality under different monitoring systems.*
- *Design an air quality monitoring network which would provide the basis for wide area coverage of the region.*
- *Develop an air quality monitoring data system which would be used to archive any existing and future air quality data, as may become available through the network.*
- *Develop human capacity which could support future air quality network implementation.*
- *Provide the design details to the air quality network needed to support improved grid coverage of the national air quality monitoring system.*
- *Provision of a monitoring plan and a programme to ensure the successful implementation of target monitoring plan*

The Nigerian Meteorological Agency (NIMET) under the MOU with ARIAL showed interest in seeking funds from local sources to support the revamp of the station along-side their WMO supported Global Atmosphere Watch (GAW) stations being managed by NIMET, and which is also facing low activities due to limited funds for spare parts and calibration of equipment. Discussions on a Programme to revamp the LAAAQS have been held with the vendor that supplied the station, Umweltechnik MCZ GmbH, Ober-Morlen, Frankfurt, Germany, and who was responsible for the service and maintenance of the station while it was operational. A visit by MCZ Service engineer has been fixed for mid-July 2006.

The visit by MCZ Service Engineer to Nigeria to evaluate the status of both the Station in Lagos would provide advice on the requirements for repair and upgrade of both stations. NIMET is exploring to ensure that this revamp of the station is completed before the end of 2006. Where possible new facilities that could support the safe and sustainable operations of the existing station.

8.13.3 Calabar Air-Shed Systematic Monitoring and Assessment Project

Calabar was until recently, an urban, semi-industrial city. Calabar has now been designated the export processing zone for Nigeria, and this project will soon to take off. During this period the city is expected to witness large growth in industrial and commercial activity. An early urban air quality monitoring for the city is therefore expected to provide data for environmental planning during the city's time evolution from medium to large city. It is also expected that monitoring will provide the means for assessing whether or not the controls provided are effective in reducing the atmospheric mixing values of all pollutants in the city's air-basin to limits which are in conformity with national AQS. Such results may be useful in assessing and managing the air pollution problems of other emerging fast growing cities in the country.

In order to support continuous monitoring of air quality and related issues in the region, improve the understanding of general air quality dynamics, provide the basis for improved human capacity development and the over all framework to sustain research, make research products available to policy makers in the public and private sector, the Environmental Research Laboratory (ERL), Department of Physics and the Atmospheric Research and Information and Analysis Laboratory (ARIAL), Centre for Energy Research and Development, both of Obafemi Awolowo University, have developed a joint research programme with the Department of Physics, University of Calabar. The basis for this research collaborating is to develop joint infrastructure and human resources and bring this together to establish systematic monitoring stations in the Calabar air shed as the basis for improved understanding of physical dynamics and the chemical transformation of the different compounds in the atmosphere generated from anthropogenic activities. The basis of this is currently a self-supported research activity named the Calabar Air Shed Systematic Monitoring and Assessment (CASSMA) Project.

OBJECTIVES

- Establishment of continuous monitoring network within the air-shed
- Identify all possible sources contributing to the air quality deteriorations in the air shed through inventories and monitoring
- Determine the levels of major, minor and trace constituents in polluted and unpolluted (background) atmospheres
- Establish the pathways for pollution transport to various receptor points within the network.
- Establish the pathways for interception of the various pollutants by human and other receptors.
- Establish impacts of the air quality deteriorations to human health, ecology and economy.
- Undertake human and institutional capacity building to support all monitoring and assessment programmes
- Identify and link-up within national and international programmes which would provide the basis for sustaining all the initiatives.
-

SCOPE

- **Research**
  - Systematic Observations for atmospheric trace gases, particulate matter and some heavy metals (SO_2, NO_X, CO/CO_2, CH_4, NMVOC, TSP, PM_{10}, $PM_{2.5}$, Pb, etc)

- Urban Air Quality Assessment for various applications (health, ecology, etc): trace gases and particulate matter as above, toxic trace elements especially heavy metals.
- Undertake the measurement of source emissions and establish emission factors for various sources.
- Undertake regular inventories to establish annual emissions from all sources in the region.
- Develop and apply atomic, nuclear and other relevant analytical techniques.
- Development and apply various numerical models to air quality assessment (dispersion, receptor models, and long-range transport models to evaluate the impact of distanced sources to local air quality deteriorations.
- Undertake the monitoring of meteorological and climatological indices and their influence on local air quality indices.

- **Training**
  - Develop graduate studies programme to train younger scientists to use relevant techniques of physics, chemistry and applied sciences to study air quality.
  - Develop and implement training programmes for technologists to develop and manage all infrastructure needed to support the systematic air quality monitoring and management.
  - Encourage research visits among scientists to the institutions within the research network and to other institutions with relevance.
  - Develop and implement short term courses and workshops to improve the understanding of major stakeholders in public and private sector, in applying air quality information to development.

<u>STATUS</u>

The CASSMA Project is still at its early stage. The current activities have been geared towards the development of new generation of experts to support air quality monitoring at the University of Calabar, using the resources and expertise at the Obafemi Awolowo University, Ile-Ife. In order to attain these, two graduate students are being trained at the University of Calabar under the joint supervision from Obafemi Awolowo University, Ile-Ife. A project on the monitoring of total suspended particulate (TSP) and the total atmospheric deposition (TAD) sampling across a range of urban source categories is being used to facilitate the graduate studies Programme. Approximate 8 TSP and TAD stations have been set up. Twice monthly sampling of TSP and monthly TAD sampling is being undertaken for 12 calendar months. The Obafemi Awolowo University is providing the sampling and analytical facilities support for the studies.

8.13.4 Source-Receptor Assessment of Urban Aerosols in Ikeja and Environs, Lagos State

The study of SPM as at 1991 at Ikeja shows the mean level of SPM as $176 \pm 78\mu g/m^3$ (Oluyemi 2001) which although satisfies the Nigerian ambient air quality standard of 250ug/m3 is most likely to have appreciated since all these years. Hence the need to identify and quantify the relative contributions of various pollutant sources in the air-shed. In order to address this, receptor modelling which provides an estimate of impact of various sources at given time and location based on the chemical characteristics of the various source emissions and the chemical character of the ambient samples collected at any receptor would be utilized. The information are needed in order to respond to the pollution abatement requirement, occupational exposure reduction as well as regulatory compliance at state and national levels.

Aims and objectives of the research

The overall objective of the study is to improve the understanding of some anthropogenic activities on ambient air quality, to quantify the relative contributions of various pollutant sources and attempt to assess some impact of the particulates on humans.

The specific objectives are to:

- Determine the ambient air mixing values for $PM_{2.5}$ PM_{10}, TSP, and hydrocarbon compounds associated with the industrial, traffic, residential, agricultural burning, waste burning, other biomass burning, sea-breeze, and other identified operations in the locality.
- Determination of dry and wet deposition rates near major sources and within urban well mixed areas at time scales which would allow the isolation of major emission events.
- Detailed characterization of all particulate, dry and wet deposition samples, using a combination of instrumental techniques (XRF, GC-MS, AAS, PIXE, PIGE, RBS, among others) to determine the concentrations of elements, hydrocarbons and volatile organic compounds in the samples.
- Determination of source profiles for major and minor sources within the air shed, which are needed to support source-finger print analysis.
- Determine the contribution of these sources to the overall air quality deterioration in the neighbourhood and use source-apportionment modelling to provide guide to the contribution of other facilities/processes to the general air quality deterioration in the neighbourhood, based on two approaches:
    - Chemistry approach using the source profiles of major and minor sources in the locality.
    - Meteorological approach: based on air-back dispersion modelling.
- Development and implementation of the source-apportionment model for both the chemistry and meteorological approaches, which would provide the basis for model inter-comparison.

STATUS:

This project is purely a research project at the university level. It is still at planning stage and would be implemented as M.Sc. and Ph. D research projects. Results are to be made available to a wide range of stake holders in research and policy communities.

8.13.5 Development and Implementation of Urban Air-Shed Dispersion Modelling for Urban Air Quality Forecasting (UAQF): Pilot Study for Lagos and Abuja

Lagos is considered one of the fastest growing cities in the world today, having a population of about 12 million people by the World Bank, although national statistics still maintains a value of just over 5 million people. However, both values point to the fact that Lagos is fast becoming a mega-city by international standards. Modelling of dispersion from point and multi-source environments, and regional air pollution exchange is currently becoming an important activity which should support national efforts at the implementation of preventive health care programme. Nigeria, in the last four decades has witnessed an accelerated growth in both infrastructure and population growth. In view of the national efforts to restructure in urban development focus, the proposal in the late 1970s that Nigeria should re-invest in a new federal capital city as a panacea for decongesting Lagos, became realized in 1991, when the seat of government formally moved to Abuja. The development of Abuja has had its share of problems and efforts to maintain the origin master-plan and foresight has been part of current efforts of the development of the Federal Capital Territory.

In view of the accelerated development of both Lagos and Abuja, there is a need to assessment the exposure of the general population in the two cities, to different doses of air pollutants at different parts of each city and for different times of the day. This can be attained using monitoring programmes and also through the forecast of dispersion and transport to different receptor sites within each city. The dispersion studies will include photochemistry of air quality in the region to evaluate the potential of formation and transport of secondary pollutants such as O_3 and PAN to adjourning rural areas.

Lagos

Lagos has over the years remained Nigeria's fastest growing city and the industrial/economic capital, having until recently been the Nigeria's federal capital. The city has witnessed a large urban growth rate occasioned by growth in population and industrial activity. The only ambient air monitoring station in Nigeria is currently located in this city, but cannot adequately cover the large source variation in such a large city. Air pollution trends in Lagos in the last few years indicate that CO, NO_x and VOC (including benzene, PAH etc) are many times higher than national and WHO standards during a substantial part of the year. These are highest in areas of high traffic densities hence the current station is located mainly in a high traffic region of the city.

Abuja

The Federal Capital Territory, Abuja, was initiated and developed at a time when environmental issues had become central in global issues. The development of the FCT is therefore to include programmes geared towards correcting the lapses in the development of earlier urban centres in Nigeria, by incorporating necessary environmental management programmes into the territory's developmental efforts. This becomes especially mandatory since Abuja is the country's political and administrative nerve centre. From the experience with Lagos, the city may, with time also become the country's industrial nerve centre. On the basis of the experience gained in the last few years on the FCT growth, Abuja may well become one of the fastest growing cities in the world today. The management of urban air pollution in the Federal Capital Territory, Abuja must therefore be conscious of its fast growth rate by providing early monitoring, planning and systematic modelling of the territory's expected evolution with time (in respect of present and future industrial, traffic, domestic and other urban facilities) to enable the provisions of an adequate air pollution management scheme that will take care of current and future air pollution problems of the FCT in line with its time evolution.

Objectives and Scope of the Project

The main objective of the project shall be to develop and implement short-term forecast of the spatial and temporal evolution of urban pollution dispersion based on the forecast of sources emissions and multipoint dispersion arising therefore usable to provide early warning on pollution fumigation episodes within the city. The specific objectives shall include:

- The mapping of the city to provide geospatial information on all possible emission sources which would contribute to urban air quality deterioration.
- Acquisition of both source emissions data and micro-meteorological data for the urban area at grid scales adequate to support multi-point dispersion modelling for pollution forecasting.
- The development of multi-point dispersion studies, including the photochemistry to evaluate the potential of formation and transport of secondary pollutants such as O_3 and PAN, in the urban area, using the techniques of urban air-shed dispersion.

- Provision of early warning forecast services to the general public as a means of improving human health protection

- The project shall be implemented in the following two phases:
  - Phase I: Mapping and Implementation of a Data System to support modelling (1 year).
  - Phase II: Model Development and Implementation (1½ years).

Project Status:

This project is still at its planning stage, and would be implemented in partnerhip with the Nigerian Meteorological Agency (NIMET) under the NIMET-ARIAL MOU.

8.14 Annex Tanzania_1 Brief Progress Report on the AQ Monitoring Capacity Building Project

Introduction

AQMCBP is a multi-stakeholder project that aims at enhancing capacity of participating institutions for monitoring of specific air quality parameters. The monitoring results will form basis for the development of long term monitoring program and formation of database to be utilized by different stakeholders. The project is implemented by NEMC and coordinated by DoE since 2004.

Project duration and funding sources

The first two phases of the project are expected to last for 12 months beginning January 2006. The funding comes from UNEP, the equipment and technical support is donated by US EPA/USAID, whereas the Government of Tanzania through its participating agencies provide in kind contributions that include manpower, information, laboratory services and office space.

Objectives and expected output

The objective of AQMCBP is to build capacity on management of air quality and establish baseline data and information on levels of selected air impurities. The expected outputs of the project include a comprehensive and consistent database on the quality of air in urban centres in Tanzania. The project is also expected to provide information that would assist in standards formulation process.

Institutional arrangement and Project support

AQMCBP is being implemented by the National Environment Management Council (NEMC) and coordinated by the Division of Environment (DoE) under Vice President's Office. Other stakeholders involved in the project implementation include Dar es Salaam City Council, Tanzania Bureau of Standards, Government Chemist Laboratory Agency, Tanzania Meteorological Agency and Ministry of Health, Research and Academic institutions, which are represented by UCLAS and TIRDO.

Steering and Technical Committees

AQMCBP is administered by two committees, namely Project Technical Committee (PTC) and Project Steering Committee (PSC). As a matter of procedure PTC meetings and deliberations precedes PSC which provide policy guidance to the project.

Main components of AQMCBP and achievements

The main components of AQMCBP include capacity building; with sub-activities including; training of the teams involved in routine monitoring activities, establishing and upkeep of sampling sites (need to conform to international sampling protocols), and conducting air monitoring and sampling activities. Laboratory works also form significant part of the projects activities as sampling equipment and filters requires conditioning before and after each round of sampling activity.

Challenges

The unavailability of sampling and monitoring equipment in the local market, frequent change of trained team members and limited resources are the key factors affecting project's operations. The monitoring activities also are constantly interrupted by frequent electric cuts, and inability to undertake some measurements on specific parameter thus compelling the project to export part of samples to US for analysis.

Results/output

The short sampling and monitoring period, few number of sites, frequent power cuts and sampling of just selected parameters have contributed to delays in developing a concrete picture of state of air quality in Dar es Salaam city. Generally the recorded values indicate low levels in PM10, SO2 and NO2 with few escalated values which are skewed possibly due to various reasons including human and technical error; however most of results fall within permissible limits.

Financial summary

The total UNEP budget received for supporting Phase 1 implementation amounts to US$ 33,210.00. Phase 2 of the project expected to receive financial support from UNEP to the tune of US$ 50,000.00, of which part has been disbursed to the project. Currently the local contribution to the project is largely in-kind.

Way forward

AQMCBP aims at contributing significantly into development of AQS in the country/region. The project will focus on surveys related to air pollution and its links to adverse health effects. The project also aims at increasing level of awareness among policy makers, authoritative organizations, stakeholders and general public.

Financial assistance will be required to support proposed exchange programs among participating countries, that will improve teams capacity through sharing of experiences and techniques applied by each team.

8.14.1 Introduction

Air pollution is the most widespread form of pollution and impacts at local, national and global levels affecting human health and well-being, vegetation, crops, wildlife, buildings and other materials, and world's climate.

Lack of air quality data due to inadequate monitoring makes it difficult to characterize the severity and nature of air pollution issues facing many cities in Africa. Such data is required to most effectively target problem areas and in development of cost-effective solutions. This data can also be used to enhance public understanding of air pollution as a public health issue, convince decision-makers of the need to develop AQM programs, and develop a baseline against which to measure the benefits of planned investments.

Now that many African countries have phased out leaded gasoline, a next obvious step is to gather information on the current levels of priority air pollutants in order to allow policymakers to make informed decisions on how best to reduce pollutants such as Particulate Matter (PM), Carbon Monoxide (CO), Sulphur Dioxide (SO_2), Nitrous Oxides (NO_x) and Ozone (O_3). Mobile and stationary sources of air pollution present a serious threat to human health and the environment. Ozone, air toxics, and particulate matter have direct negative impacts on human health, while hydrocarbons, nitrogen oxides and carbon dioxide contribute significantly to the concentration of greenhouse gases in the atmosphere.

Air Quality Monitoring Capacity Building Project (AQMCBP) will establish institutionalized local capacity to conduct regular monitoring that is critical for making informed decisions in targeting priority sources and the first step in the development of a broad AQM program.

AQMCBP is being implemented in three municipalities of the city of Dar es Salaam. The purpose is to establish baseline data and information on the content of selected impurities in ambient air. AQMCBP as a national project is implemented through NEMC in collaboration with other stakeholders, which include Dar es Salaam City Council (DCC), Tanzania Bureau of Standards (TBS), Government Chemist Laboratory Agency (GCLA), University College of Lands and Architectural Studies (UCLAS) and Tanzania Meteorological Agency (TMA). The major project activities include monitoring of air quality through analyses of samples and results provides input to the database that would be used as reference on status of air quality in Dar es Salaam.

The project is funded by the Government of Tanzania and UNEP, with the first two phases of the project expected to last for 12 months beginning January 2006.

8.14.2 Background information, objectives and expected output

Background
As the environmental impacts for air pollution are becoming better understood, so legislation is being put in place to control, reduce and prevent it. For instance, the Environmental Management Act (2004) came into force in July 2005. EMA 2004 provides for stronger emphasis on local government authorities to participate in management of air quality, as quoted in section 132(1) saying; ‘the local government authorities shall prescribe rules specifying emission of carbon monoxide, hydrocarbons, other noxious emissions and standards for exhaust emission applicable in areas of jurisdiction of a local government authority concerned.

Dar es Salaam is the largest city, main centre for administration, industries, commerce in Tanzania and is the trade, education and cultural and transportation centre in Tanzania. It has population of more than 3millions and hosts 80% of the industries in Tanzania. Just as in many African countries, as the rate of urbanization, motorization and economic activities increase, air quality in African cities is increasingly deteriorating. Air pollution is emerging as key threat to human health, the environment and the quality of life of millions of Africans. It is the poor, young, elderly and sick who are suffering disproportionately from the impacts of urban air pollution. Typical examples of causes for urban air impairment include, open waste burning, charcoal burning, dust, particulate matter high noise and industrial emissions.

The extent of the air pollution problem in Tanzania and the city of Dar es Salaam in particular has not been studied adequately to be able to track trends and quantify magnitude of the problem and respective impacts to the public health and the environment.

There have been various studies on air quality within Dar es Salaam conducted by various institutions. These studies were taken at different times and using different methods, thus resulting in data inconsistence (see annex 3). Factors that contributed to the inconsistence are such as variations in monitoring site locations, equipment used and laboratory instrumentation. This situation has been aggravated further by a number of factors that include; inadequate expertise in air quality monitoring, inadequate monitoring facilities, lack of sufficient regulatory mechanism during the time of studies as EMA was not yet in force. Others include inadequate instrument in AQM and financial constraints as some of the projects are donor funded. For example:

In **1993**, NEMC commissioned the Department of Chemistry University of Dar es Salaam to carry out a study to determine levels of Carbon Monoxide, Sulphur Dioxide, Nitrogen Dioxide, Lead and suspended particulate matter. The coverage of the study included Ubungo, Kariakoo, Gerezani, Morogoro Road/Samora Avenue (Askari monument), Muhimbili and Bahari Beach. In this study, a Draeger detector (tubes) was used to measure pollutants for 15 minutes in the field. When compared with WHO guidelines, the results indicated that Carbon Monoxide levels were lower, Sulphur Dioxide levels were higher, Nitrogen Dioxide levels were higher, and levels of Lead were much higher. Suspended particles (dust) levels were also higher than the WHO guidelines indicating that there is pollution in ambient air.

In **1994** University College of Lands and Architectural Studies (UCLAS), with the support from JICA, analyzed levels for Nitrogen Dioxide and Carbon Monoxide at Chang`ombe

Road, Rashidi Kawawa Road, and New Kigogo Road using the same Draeger detector. The results indicated that the levels of both pollutants were lower than the WHO guidelines.

In **1996**, NEMC commissioned the Centre for Energy Environment Science and Technology (CEEST) to carry out air quality study at Morogoro Rd/ Samora Avenue (Askari Monument), Ubungo, Kariakoo, Dar s Salaam International Airport (Mwl. Nyerere International Airport) and Oysterbay. The study established the state of air quality in Dar es Salaam as well as provided input into the baseline data for air quality in Tanzania. Parameters measured include Carbon Monoxide, Sulphur Dioxide and Suspended Particulate Matter (SPM). All measured parameters recorded below WHO guidelines levels and Tanzania AQS.

Apart from the aforementioned studies other surveys were conducted in 1997, 2002 and 2003.

In **2002** measurements were taken for SPM, Lead and Nitrogen Dioxide from same areas, which are Ubungo, Askari Monument, Fire Station area, Kariakoo, Uhuru Primary School and University of Dar es Salaam, and the average results showed that levels of pollutants increased above WHO guidelines.

In **2003** two separate surveys were carried out at selected 8 bus stations and 8 road junctions. The levels were all above recommended WHO guidelines levels. These findings indicate an increasing trend in air quality deterioration.

These studies indicate that there is degradation of air quality in Dar es Salaam which needs our attention. Emissions of pollutants do result into adverse impacts on the environment and public health. It is in this light that the phasing out of Leaded petrol has been promoted. Existing data on the air quality is scattered and inconsistent.

In **2005** the Air Quality Monitoring Capacity Building Project (AQMCBP) was launched in Tanzania in March 2005 and started its implementation 5 months later in three municipalities of Dar es Salaam city (Kinondoni, Ilala and Temeke).

Project objective

The objective of AQMCBP is to build capacity on management of air quality and establish baseline data and information on levels of selected air impurities, which are Particulate matter measured at 10 microns diameter (PM10), Nitrogen Dioxide, Sulphur Dioxide, Ozone, Lead and Carbon Monoxide, in ambient air in Dar es Salaam and later throughout the country.

Expected Output

The expected outputs of the project include a comprehensive and consistent database on the quality of air in urban centres in Tanzania. This information will be useful input in standards formulation process and would be useful tool in implementation of the Environmental Management Act 2004 regarding compliance and enforcement environmental quality standards.

Other outputs include establishment of enforcement strategies and regulations using information in the database and the use of data in various researches and studies, the outcomes of which are expected to include reduced health impacts emanating from air pollution; thus improved people’s health as a result of increased public awareness.

8.14.3 Institutional arrangement and Project support

AQMCBP is being implemented by the National Environment Management Council (NEMC) and coordinated by the Division of Environment (DoE) under Vice President's Office. The project receives financial and technical support from UNEP and USAID/US EPA. The actual field activities are being carried out in collaboration with various stakeholders which include Dar es Salaam City Council, Tanzania Bureau of Standards, Government Chemist Laboratory Agency, Tanzania Meteorological Agency and Ministry of Health, Research and Academic institutions, which are represented by UCLAS and TIRDO.

NEMC and UNEP signed Memorandum of Understanding (MoU) for Phase 1 of AQMCBP in 2004/5. The MoU defined project objectives and provided guidelines, in terms of sources of finances, responsibilities and mode of implementation. MoU was signed in June 2005 authorizing use of US$ 33,000.00 from UNEP for the period that ended in October 2005. Preparatory and site installation activities caused a delay for monitoring and sampling activities until August 2005. Similar process was completed for Phase 2 of the project where MoU authorizing the sum of US$ 50,000 from UNEP was signed.

8.14.4 Steering and Technical Committees

AQMCBP is administered by two committees, namely Project Technical Committee and Project Steering Committee. The project steering and technical committee meetings took place during the project implementation period to discuss and resolve relevant issues. Three Steering Committee meetings and one Technical Committee meeting took place between December 2004 and December 2005. The Steering Committee meetings took place in December 2004, March 2005 and October 2005, and was coordinated and chaired by the Division of Environment, Vice Presidents Office. The Technical Committee meeting took place in December 2005, and was coordinated by NEMC.

The composition of Steering Committee is as follows:
Director of Environment, Vice President Office (Chairman), members from Ministry of Health, UCLAS, Director General – NEMC, Lawyer Environment Action Team (LEAT), Cleaner Production Centre of Tanzania (CPCT), Tanzania Bureau of Standards, Ministry of Industries and Trade, Dar es Salaam Rapid Bus Transit Project (DART), Tanzania Meteorological Agency, Central Water Laboratory, Ministry of Water and Dar es Salaam City Council. Others are Dean, Faculty of Mechanical and Chemical Engineering, UDSM, and Air Pollution Information Network for Africa (APINA).

Technical Committee is composed of following members;

1. Dr. Jackson Msafiri UCLAS - (Chairman)
2. Dr. Masanja UDSM - (member)
3. Mr. Kinabo TBS - (member)
4. Mr. Kitila PORALG - (member)
5. Ms Asteria Mlambo DART/DCC - (member)
6. Mr. Paul Kijazi NEMC - (secretary)
7. Mr. Bonaventura Baya NEMC - member
8. Dr. Nelson Pyuza (Tanzania Meteorological Agency) - member

The main issues that surfaced in the meetings conducted by steering committees and technical committee are as summarized below.

a) Technical matters: Discussed the need to ensure capacity in the project to undertake all required analyses locally, using local laboratories. The matter has not yet been resolved though budget proposals have been made to procure suitable equipment for analyses of samples.
b) Financial matters: Participating institutions were requested to increase assistance to the project in form of in-kind contribution. These included provision of information and data on climate, analysis services to project and streamline these activities within their budget allocation to assist implementing project activities.

8.14.5 Main components of AQMCBP and achievements

8.14.5.1 Capacity building

Training was conducted for the stakeholder on monitoring, sampling and laboratory skills in March 2005 by resource persons from US-EPA and RTI. The training was specifically for the team which was earmarked to carry out sampling and monitoring activities of the AQMCBP. About 25 participants from participating institutions received the training and 10 were trained to ToT level. Training involved theory as well as practical hands-on training. The Laboratory Technician are responsible for preparation of the filters and OGAWA badges by conditioning them prior and post sampling periods. Hands-on training was provided to sampling team in July during the visit of RTI expert prior to the sampling activities. Additional personnel for samples collection were trained in October 2005 to monitor added sampling sites.

8.14.5.2 Sampling sites

The AQMCBP has planned to set 11 sampling stations in the city of Dar es Salaam. Installation during Phase 1 project was completed in six (6) sites, at Tandika, Kariakoo-Gerezani, Mwenge, Kariakoo-DDC, Fire Station and Urafiki-Ubungo. A typical sampling site consists of a rectangle cage of size 2.0 meter long, 1.5 meter wide and 1.0 meter high, made up of iron bars. In the middle of the cage is the platform on which equipment is set. It is supplied with electricity and security guard. A typical site facility is presented in picture below.

In Phase 2 the installation will continues in 5 new sites planned and total sites will be eleven (11). The additional sites will be located at Mburahati, Tazara, Kivukoni, Nelson Mandela/Kilwa Road and Nelson Mandela/Mabibo Area.

8.14.5.3 Air monitoring and sampling activities

Sampling at installed sites is being conducted on continuous basis following specific agreed schedule by US-EPA/RTI and NEMC. Samples are taken after every 6 days, for 24 hours for *SSI* and *Mini Vol* filters, *OGAWA* badges are left at site for six (6) days. Draeger tubes are exposed to ambient air where readings are taken after first and fifth day consecutively. Routine procedures are being followed prior to the sample collection, which involves laboratory preparation and conditioning of filters and *OGAWA* badges. At present these preparations are carried out at TBS laboratory. The sampling results are presented in subsequent sections below.

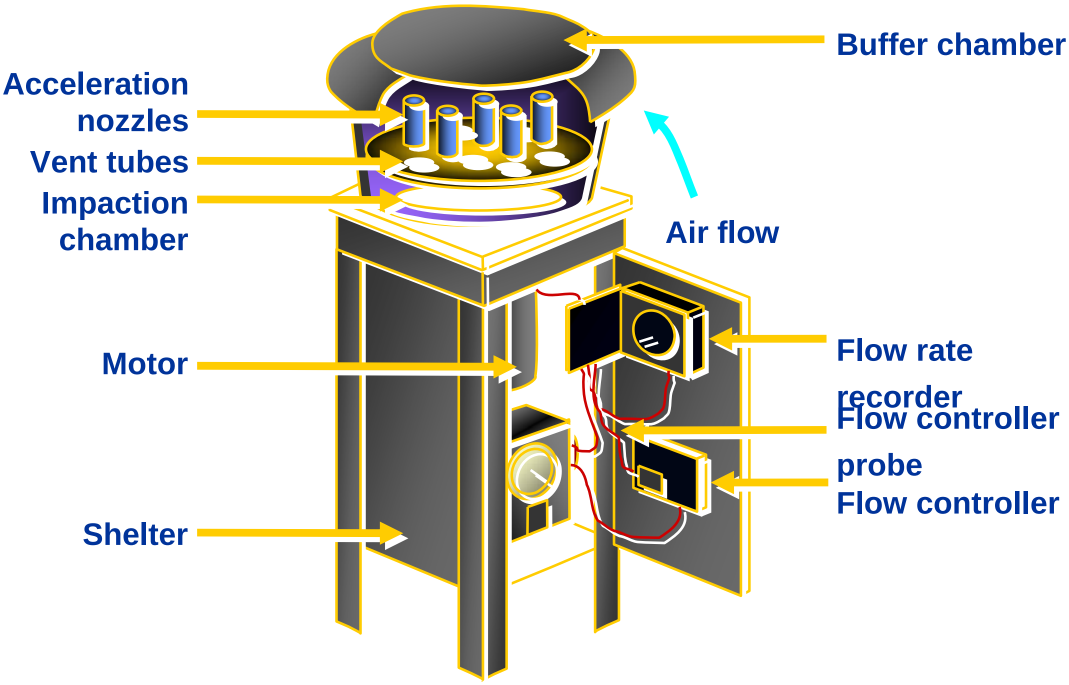


Plate 1: The SSI sampler unit.

Plate2: Mini-Vol unit.-Typical instrument used for PM10 measurement.

There are long term plans to undertake an indoor air quality sampling activities. These activities are planned to measure quality of indoor air in various sites under 3 categories: the area considered as low income residential; medium income residential and higher income residential in Dar es Salaam. The actual sites have already been identified as Manzese, Mwenge and Regent Estate for low, medium and high income residential areas respectively. NEMC in collaboration with Ministry of Health and Social Welfare is preparing a work plan, and in meanwhile is involved in the search for appropriate an equipment (*HOBO sampler*) for activities.

8.14.6 Laboratory work

TBS laboratory is involved with preparation of filters and *OGAWA* badges used for sampling. However, training has been carried out to provide similar capacity to GCLA so that there is alternative laboratory that can provide such service, and to create more capacity to local laboratories. The final analysis for the first two-month samples was done at US EPA/RTI laboratories in the United States. During the July 2005 visit by the US EPA expert Jeff Nichols, negotiations were made between NEMC and Ministry of Health and Social Welfare (MoHSW) to find ways of equipping local laboratories such that they have adequate equipment and capacity to undertake similar analyses locally. MoHSW has planned to provide Ion Chromatography –IC during Phase 2 of the project implementation (NEMC will follow up on this pledge).

8.14.7 Critical risks and project sustainability

The project is facing significant challenges that threaten its sustainability. The obvious risks encountered by the project include:

- ***Frequent changes of monitoring team***: one of major project initial investment was to ensure that training was provided to the monitoring team members prior to undertake actual field monitoring activities. The project has suffered from departure of some of trained team members due to various reasons.
- ***The availability of sampling equipment***: the 100% dependency on equipment from developed countries is a big challenge. The existing equipment was supplied by US EPA and furthermore, monitoring equipment is expensive, and ordering of new ones involves a cumbersome and tedious procedures. The present requirement for the project to allow extension plan need 7 sampling equipment (*Mini-Vols*) for new stations to be established later this year (2006).
- ***Financial support***: at present the project is financially supported by local and donor funding. The donor funds (which are temporarily available during a specific project period) play a significant role on providing support for maintenance of equipment purchase of spares and consumables.

These challenges are being dealt with through integrating and mainstreaming routine activities of stakeholder institutions. For instance MoHSW have shown positive response on the matter, while TBS have shown their commitment into execution of specific activities, (providing laboratory services to the project at no cost and TMA provides meteorological data to project without charging the service).

8.14.8 Challenges

So far, the implementation of the project has faced several challenges particularly the pre-sampling activities as follows:

- ***Electric cuts***: occurred at Tandika site, causing incomplete sampling by SSI for PM10 samples. The Steering and Technical Committee meetings discussed on this problem and provided suggestions; the TC and SC proposed the installation of electricity-free samplers, i.e. those using batteries, solar-powered, diesel/petrol running equipment.

- ***Analysis of OGAWA badges***: analysis of OGAWA filters for identification levels of NOx, SO2 and Ozone is still a problem. The existing equipment at TBS laboratories had technical problems that hampered analysis to be completed locally, and therefore RTI laboratories (USA) was requested to handle the analysis at extra freight costs. Analyzing samples abroad did not promote one of key project objectives, which is to build local capacity in monitoring activities. In order to solve this problem, the MoHSW has proposed a budget allocation to procure required equipment.

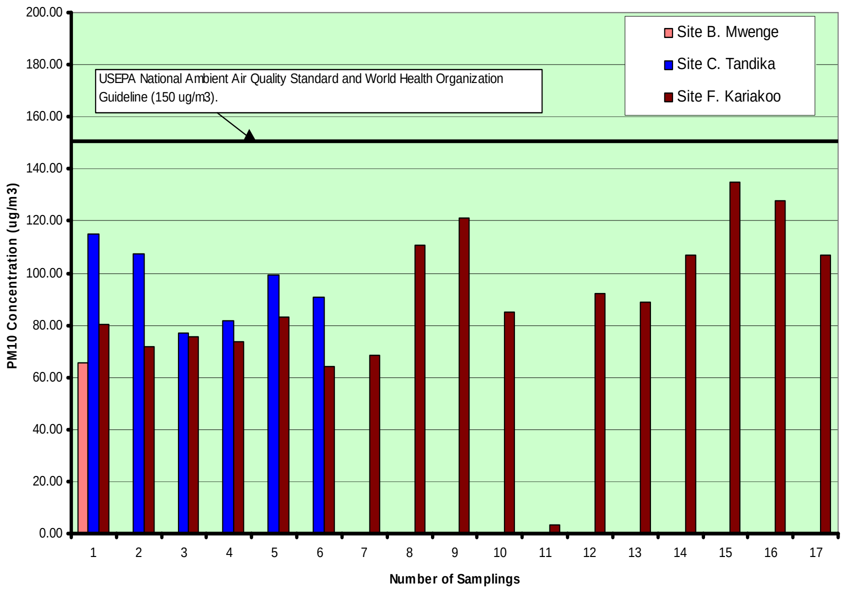
8.14.9 Results/output

The actual sampling and monitoring activities began in August 2005; hence the state of air quality in Dar es Salaam is in its initial stage of being developed. Several factors have contributed to this state, including:

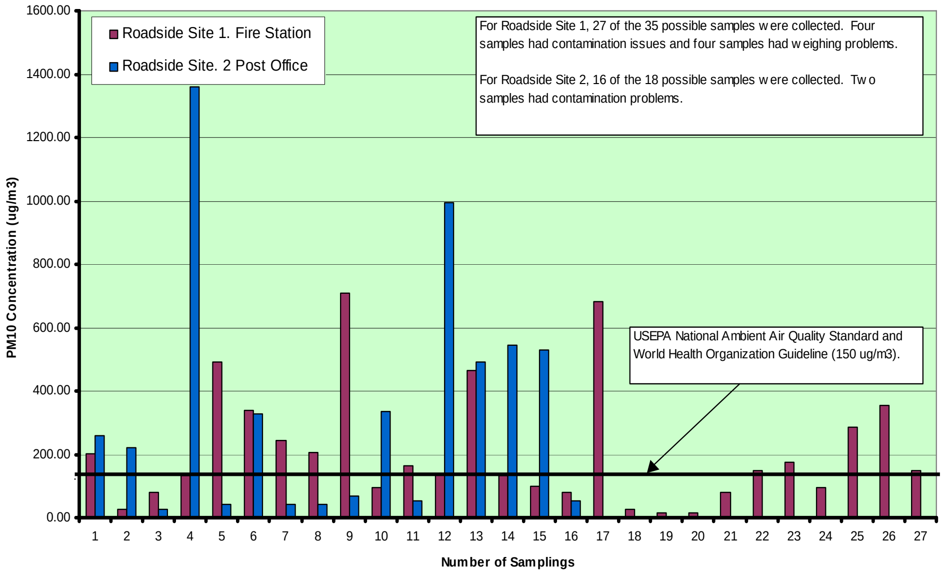
- Short period of sampling in the Phase 1 project (5 months);
- Few stations established;
- Inconsistency in running of sampling stations due to electricity problems; and
- Sampling of limited parameters.

Graphical representation of the results is as shown below:

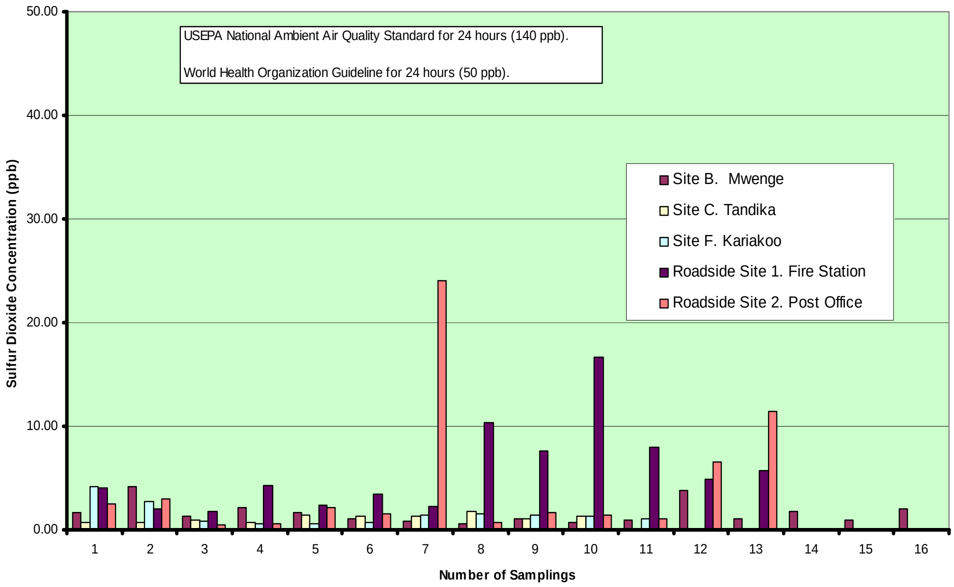
PM10 Initial Results: Two Residential and One Commercial Sites in Dar es Salaam



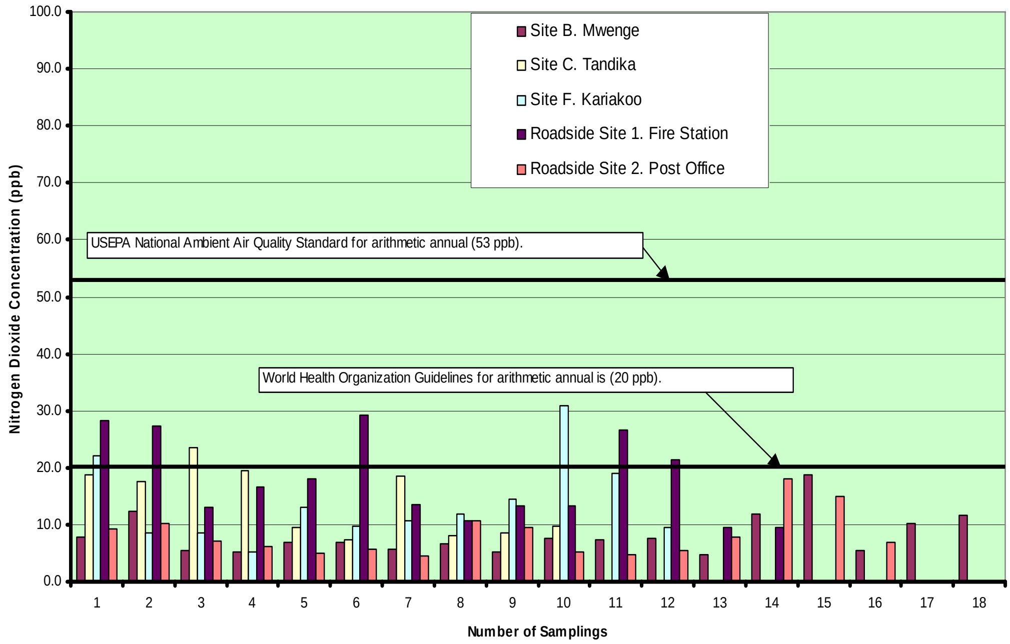
PM10 Initial Results: Two Roadside Sites in Dar es Salaam



Sulphur Dioxide Initial Results: Dar es Salaam Sites



Nitrogen Dioxide Initial Results: All Dar es Salaam Sites



The results above indicate of some parameters measured from sampling stations located in Dar es Salaam. Generally the recorded values indicate low levels in PM10, SO2 and NO2 with few escalated values; however most of them fall within permissible limits. Some high levels of NO2 were recorded at Fire Station, most probably the recorded levels is due to excessive vehicular emissions. The PM10 along road side points recorded high values as compared to permissible limit levels by US EPA, while SO2 in all sites recorded low values.

8.14.10 Outreach programs and workshop

The AQMCB project Outreach Workshop was conducted from 1st to 3rd November 2005 with main objective being to review and discuss the project progress, and formulate strategies for ensuring future sustainability. The workshop incorporated ideas from various stakeholders in AQM, which include donor agencies, private sector, governmental and non-governmental organizations. The **workshop proceedings** will be made available upon request (report is approximately 70 pages).

8.14.11 Financial summary

The total UNEP budget received for supporting Phase 1 implementation is US$ 33,210.00. The disbursed fund is US$ 30,210.00. The project has spent a total of US$ 30,278.00 since its inception to the closing of Phase 1. The project Phase 2 is expecting a total UNEP support of US$ 50,000.00, of which part has been disbursed to the project. Currently the local contribution to the project is in-kind through manpower, project offices, laboratory services and sites allocated for installation of equipment at sampling and monitoring stations.

8.14.12 Concluding remarks and Way forward

The Air Quality Monitoring Capacity Building Project (AQMCBP), Phase 2 started in January 2006 under the support of UNEP, USAID, US EPA and local stakeholders. The new MoU was prepared and signed by UNEP and the Government of Tanzania, in which US EPA will continue to provide technical assistance. Phase 2 of AQMCBP aims at broadening the project scope and new subject areas will be developed. UNEP will continue providing financial assistance to the tune of US$ 50,000.00 to address issues of surveys, installation and run 5 new sites that will increases the present number of sites to 11 in the Dar es Salaam city; and will continue with capacity building for local institutions on AQM issues. Some of the recommended key issues to be addressed during implementation of Phase 2 are outlined below:

Standards formulation process:
During the implementation of project Phase 2, contribution into AQS developing process will be focused. As is well known that AQS formulation process began some years back under the leadership of Tanzania Bureau of Standards, the approach to this task is directed to formulation of standards on basis of specific source. Already standards aimed at controlling vehicular emission and cement factories have been established. The project aims at providing information that may be utilized in standards formulation process especially for vehicular emission, residential areas, indoor and commercial areas. NEMC is organizing another workshop on Air Quality and Standards formulation issues to be held in June 2006.
The technical support proposal from US EPA has identified main activities to assist into standards formulation process. To effect this task, an air pollution and standards formulation expert will be visiting the project later this year (2006), in Dar es Salaam.

Survey on Health problems linkage to Air Quality:
Phase 2 of the project is planning to conduct surveys related to air pollution and its links to adverse health effects on vulnerable population. The surveys are planned to be coordinated jointly/collaboratively by NEMC and MoHSW.

Outreach programmes:
Outreach programmes are scheduled to take place during Phase2, with the objective to increasing level of awareness among policy makers, authoritative organizations, stakeholders and general public.

Exchange programs:
Exchange programs have been proposed for the teams working in project within African countries and the rest of the World. Funds will be required to support exchange programs among the participating countries, to improve teams capacity through sharing of experiences and techniques applied by each team.

8.14.13 Link between AQMCBP, EMA (2004), and regional programs

The implementation of AQMCBP is timely when the EMA 2004 emphasizes on reduction of air pollution by industries and vehicular emissions. The project fits in the national strategy pronounced by National Environmental Policy of 1997 and later by EMA 2004. Sections 74 provides for the need of protecting the atmosphere, while S130, S131 and S132 of EMA 2004 provide directives for local governments to adequately address the issue air quality in their local areas from various sources. Since the project started being implemented in Dar es Salaam, the long term objective is to expand further to other urban centres in the country.

The project has been in close collaboration with APINA regional initiatives on the subject of AQM. The project provides information to Air Pollution Information Network for Africa (APINA). APINA is also member of the steering committee for the project.

AQMCBP will provide reliable source of air quality information to many stakeholders, institutions and organizations such as Tanzania Statistical Bureau, University of Dar es Salaam and individual researchers.

8.14.14 Annexes

1. AQMCBP Outreach Workshop, 1 – 3 November 2005, – Proceeding of the Workshop
2. BAQ-SSA 2006 Conference Programme; Training session, Policy session and Ministerial session, UNEP, Nairobi.
3. Sample data on Air Quality Monitoring from Various Studies in Dar es Salaam

8.15 Annex Zambia_1: Monitoring campaign EKZ-NILU 1998-1999

Some results of the NILU campaign using diffusive samplers are compiled in Figure Zambia_2 and Zambia_3.

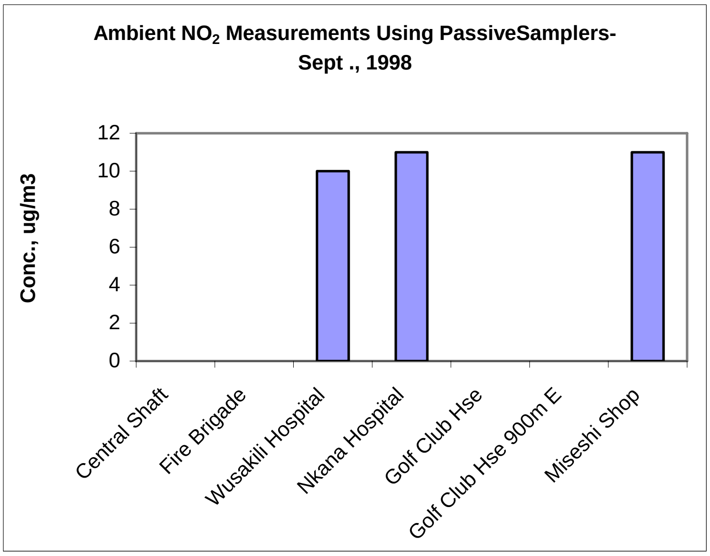


Figure Zambia_2: Monitoring results with diffusive samplers for NO_2

Measured *NO_2* concentrations were well below the *WHO* air quality guidelines in 1998.

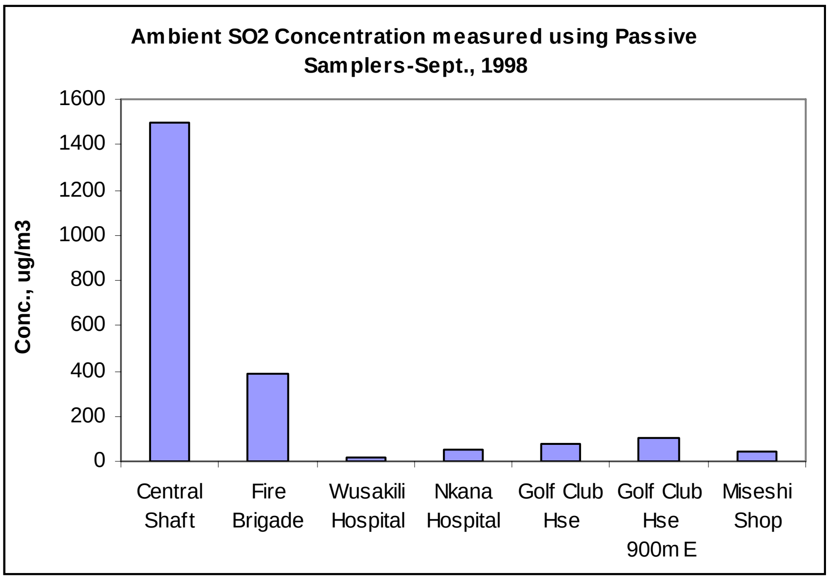


Figure Zambia_3: Monitoring results with diffusive samplers for SO_2

In contrast, SO_2 concentrations well exceed the WHO guideline value of 2000 (50 $\mu g/m^3$).

8.16 Annex Zambia_2 Monitoring results of Konkola Copper Mines 2001

Both Nkana and Mufulira mines have ambient air quality monitoring systems in form of

- Meteorological stations that give data on ambient temperature, wind speed, wind direction, precipitation, solar radiation and pressure.
- Analytical Gas Analyser samplers (wet chemical bubbling method) for sampling sulphur dioxide, total solids, sulphates, copper, cobalt and iron.

Data reported here are generated from the use of passive samplers for sulphur dioxide monitoring that took place in 2001 (Namayanga, 2004b).

Figure Zambia_4 shows the annual SO_2 means in *2001* at various locations in Kitwe.

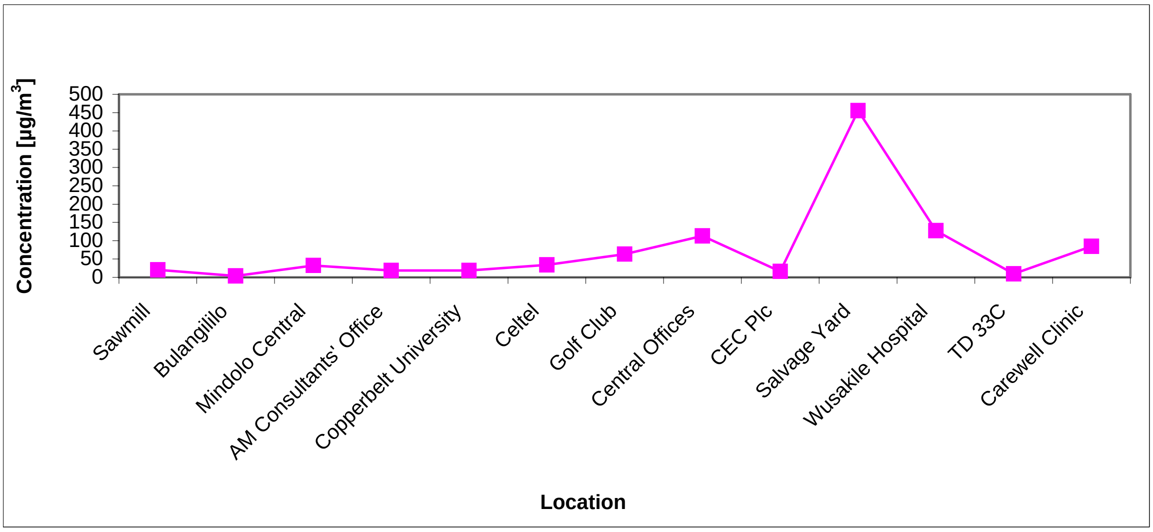


Figure Zambia_4: SO_2 annual means at several locations in Kitwe

Source: Konkola Copper Mines *(KCM)* Plc managed SmelterCo.

The Salvage Yard within the smelter premises represents the exposure of mine workers and has a high annual ambient air concentration of SO_2 of $455\ \mu g/m^3$. This spatial distribution also persists when aggregating data in the cool and dry season, see Figure Zambia_5.

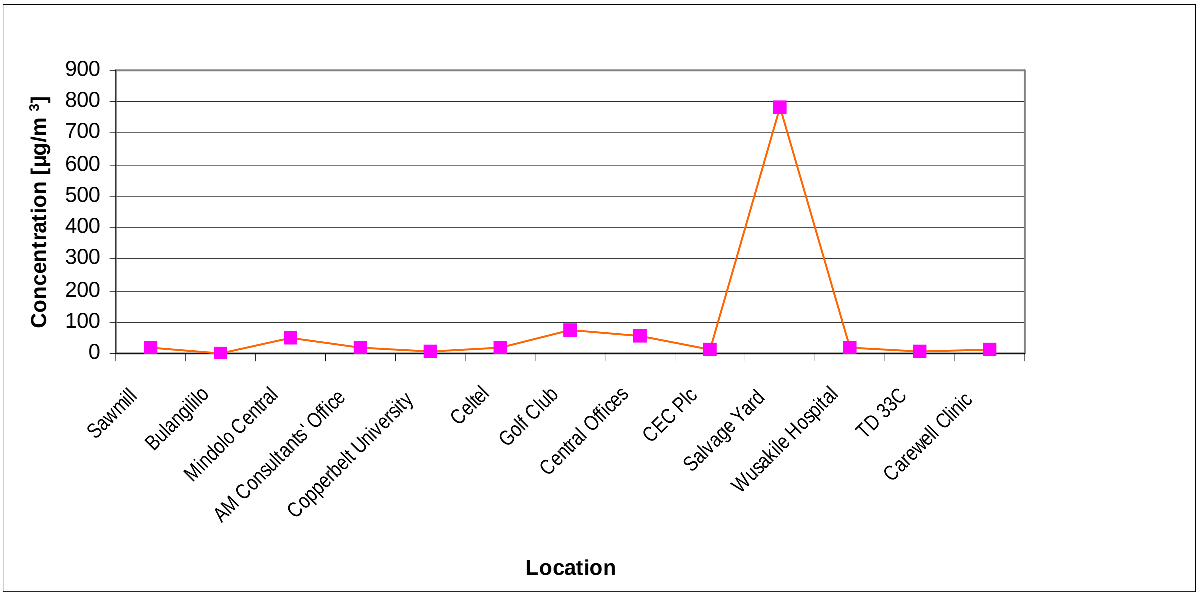


Figure Zambia_5: Average SO_2 concentrations at different locations in the cool-and-dry season.
Source: Konkola Copper Mines *(KCM)* Plc managed SmelterCo.

Additional peaks at different locations are observed in the hot-and-dry and the warm-and-wet seasons, Figures Zambia_6 and Zambia_7.

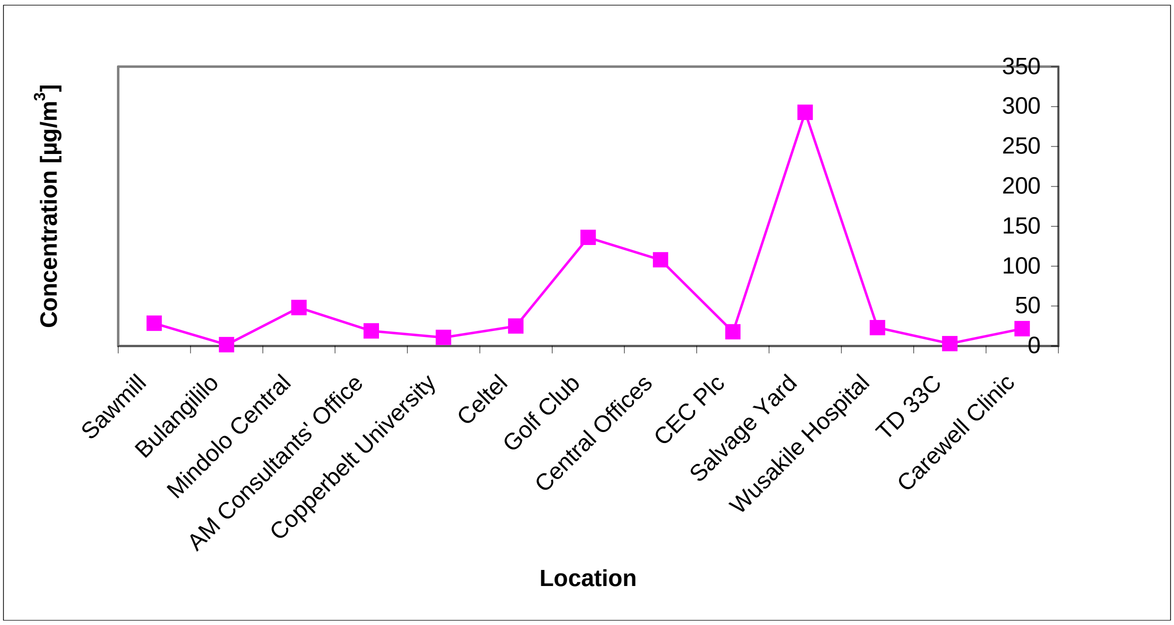


Figure Zambia_6: Average SO2 concentrations at different locations in Kitwe in the hot-and-dry season
Source: Konkola Copper Mines *(KCM)* Plc managed SmelterCo.

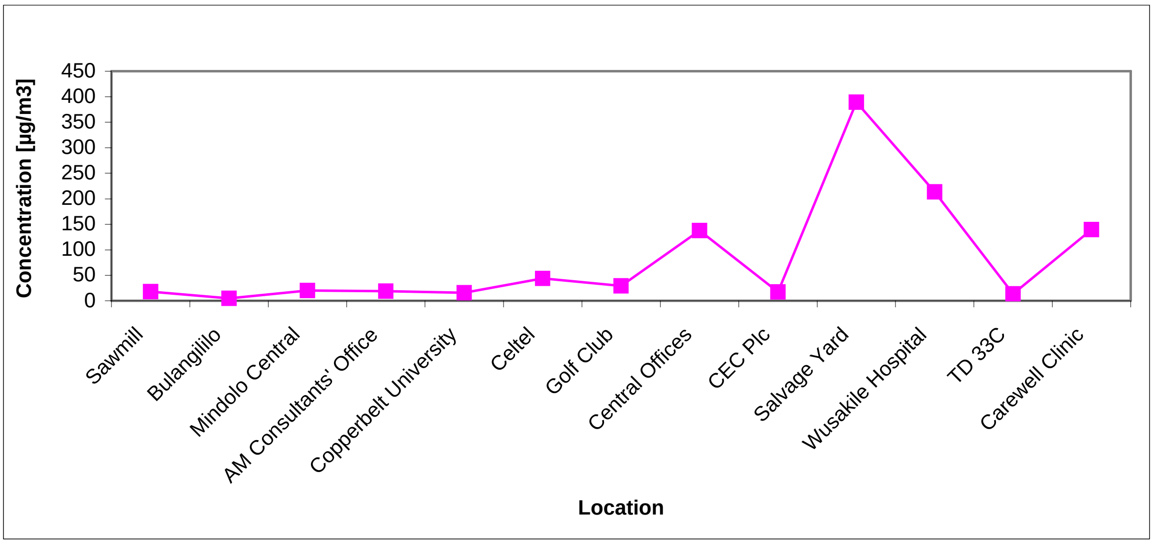


Figure Zambia_7: Average SO2 concentrations at different locations in Kitwe in the warm-and-wet season.

Source: Konkola Copper Mines *(KCM)* Plc managed SmelterCo.