KwaZulu-Natal Department of Agriculture and Environmental Affairs

Emission inventory report

03 December 2007

Prepared by

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EXECUTIVE SUMMARY

The emission inventory report for the Province of KwaZulu-Natal (KZN) is presented by Zanokuhle Environmental Services (ZES). The report highlights the pollutant emissions for each of the 11 district municipalities within the Province, namely eThekwini Metropolitan which has the highest population, Ugu (DC21), Umgungundlovu (DC22), Uthukela (DC23), Umzinyathi (DC24), Amajuba (DC25), Zululand (DC26), Umkhanyakude (DC27), Uthungulu (DC28), Ilembe (DC29) and Sisonke District Municipality (DC43), as per the scope of work detailed by the Department of Agriculture and Environmental Affairs (DAEA).

Although there are a range of air pollutants in existence, the inventory focuses only on those of particular interest to the Provincial and National Government. These included sulphur dioxide, oxides of nitrogen, particulate matter (PM), volatile organic compounds, lead and carbon monoxide.

One of the main objectives of the programme is to enable the Department of Agriculture and Environmental Affairs to develop control strategies relative to air quality management and climate change initiatives. Carbon dioxide (CO_2), one of the gases contributing most significantly to the natural greenhouse warming of the earth is not included in the study since this aspect was highlighted in a separate study undertaken by DAEA. Some of the industries did submit their levels carbon dioxide emission and this data is available on the emission inventory database.

The report categorises emissions into point sources, mobile sources and non-point sources. The emission inventory will provide the DAEA with the technical foundation to assist development and assessment of air quality management options and will provide a breakdown of estimated total emissions of specified pollutants across the province. In locations where air quality is of concern, this emission inventory can be used to identify the main contributors to emissions of a pollutant of concern and identify major sources. Thus this inventory can be used as a tool for identifying the specific emission sources that should be targeted if a reduction in emissions is required and can be used to assess the carrying capacity of specific areas.

Furthermore, the compilation of this document will be used by the DAEA to conduct air quality modeling assessments in KwaZulu Natal, to develop regional and local strategies, policies and legislation (i.e. Bylaws), to track trends of emissions over time and for the compilation of Air Quality Management plans by municipalities.

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LIST OF ABBREVIATIONS

APUs	**Auxiliary power units**
AQMP	**Air Quality Management Plan**
BTEX	**Benzene, Toluene, Ethyl benzene, Xylene Compounds**
CARB	**California Air Resources Board**
CBD	**Central Business District**
CO	**Carbon monoxide**
CO_2	**Carbon dioxide**
DAEA	**Department of Agriculture & Environmental Affairs**
DEAT	**Department of Environmental Affairs and Tourism**
DIA	**Durban International Airport**
EMFAC	**Emission Factors Model**
FAA	**Federal Aviation Agency (FAA)**
FBAs	**Fuel Burning Appliances**
GIS	**Geographic information system**
HFO	**Heavy furnace oil**
ICAO	**International Civil Aviation Organisation**
IDP	**Integrated Development Plan**
KZN	**KwaZulu-Natal**
LTO	**Landing and Take-Off**
LPG	**Liquefied petroleum gas**

NO_x	**Oxides of nitrogen**
NAAQS	**National Ambient Air Quality Standards (US standard)**
NPI	**National Pollutant Inventory**
Pb	**Lead**
Ppb	**Parts per billion**
PM_{10}	**Particulate matter smaller than 10 m in aerodynamic diameter)**
RBCAA	**Richards Bay Clean Air Association**
SAAQS	**South African Air Quality Standards**
SANRA	**South African National Roads Agency**
SASA	**South African Sugar Association**
SAPIA	**South African Petroleum Industries Association**
SO_2	**Sulphur dioxide**
SoER	**State of the Environment Report**
TIMs	**Times in Mode**
VOC	**Volatile organic compounds**
US EPA	**EPA United States Environmental Protection Agency**
VOC	**Volatile organic compounds**
WHO	**World Health Organization**
ZES	**Zanokuhle Environmental Services**

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1. INTRODUCTION

1.1 Background

The Department of Agriculture and Environmental Affairs (DAEA) in KwaZulu-Natal (KZN) appointed Zanokuhle Environmental Services (ZES) to compile a Provincial Emission Inventory Database. The terms of reference noted that the inventory must include the following:

- Stationary and mobile source emissions.
- Stationary sources classified into point; non-point and biogenic sources including emissions from veld; stockpiles; sugarcane burning and timber plantations
- Mobile sources including road motor vehicles and others.
- Information would be sourced from the Department of Environmental Affairs and Tourism (DEAT) with regards to Permits for Schedule Processes and available data.
- Methodologies and techniques used to produce a reliable emission inventory
- Statistics reporting format in an Excel spread sheet.

The main objectives of the programme are to enable the Department of Agriculture and Environmental Affairs to:

- Develop control strategies relative to air quality management and climate change initiatives.
- Calculate the spatial distribution of pollutants and determine permissible emissions for specific locations in the KZN Province in terms of the National Environmental Management: Air Quality Act 2004.
- Use the research provided for the State of the Environment Report (SoER).
- Determine effects of source emissions at specific locations on vulnerable community and receptors through available case studies and complaints.
- Establish exceedances of ambient air quality guidelines in the KZN Province for the past decade.
- Conduct an air quality modelling assessment for the determination of emission patterns in the KZN Province.
- Serve as a base against which subsequent inventories can be compared in order to evaluate the necessary regulatory programmes.
- Reference the data spatially on a GIS to be updated annually by DAEA.
- Collect information necessary for decision making and for the compilation of an Air Quality Management Plan for the KZN Province.
- Recommend an effective database management for continuous operations.

The inventoried data is based on year 2006 emissions. Inventoried sources are discussed in more detail in section 2 as point, mobile and non-point sources including methodologies used for data collection and reporting.

Biogenic sources

Biogenic sources were not inventoried because of the complexity and specialization. Biogenic emissions are natural emissions of various chemicals and can play an important role in the atmospheric chemistry. The most important sources of biogenic emissions are trees, which can emit various compounds. Pine trees, for example, produce compounds called pinenes, which have the familiar resinous aroma of pine needles. There are many factors affecting biogenic emissions. In order to keep track of the effects of the many different factors, computer models such as GLOBEIS are used to estimate these emissions.

Land use/land cover (LULC) map - Based upon satellite data, field surveys, and aerial photography of the area of interest, researchers determine whether the land is covered by forest, pasture, swamp, pavement, housing, or other natural and man-made materials. Each parcel of land in the area of interest is classified, and this map forms the basis of the biogenic emissions model. Researchers then determine the type and density of vegetation that each land category supports.

- **Species composition** - The relative abundance of different types of trees in the area to be modeled is particularly important because different types of trees emit different types and vastly different quantities of VOC. Species composition is ascertained primarily from field surveys.
- **Leaf biomass density** - Emissions are directly related to the leaf biomass - all other factors being equal, more leaf biomass means more emissions. Leaf biomass density is determined by field study and by remote sensing. Surveyors first identify the tree and then measure the height of the tree and diameter of the trunk.
- **Meteorological variables** - Emissions depend strongly upon the temperature and solar radiation to which the leaves are exposed.

As noted above, the biogenic sources were not included in this study for the reasons highlighted. However, even with his exclusion, the emission inventory detailed in this report, will provide the DAEA with the technical foundation to assist development and assessment of air quality management options in the Province.

1.2 Study Area KwaZulu-Natal Province

Topography

The KwaZulu-Natal Province covers an area of 92,100 km² with a total population of 9.9million (STATS SA). The province comprises three different geographic areas:

The lowland region along the Indian Ocean coast is extremely narrow in the south, widening in the northern part of the province. The central region is the Natal Midlands and is an undulating hilly plateau rising towards the west. There are two mountainous areas, the Drakensberg Mountains in the west and the Lebombo Mountains in the north. The midlands have moist grasslands and isolated pockets of Afromontane Forest. The north has a primarily moist savanna habitat, whilst the Drakensberg region hosts mostly alpine grassland. The coastal regions typically have subtropical thickets and deeper ravines and steep slopes host some true Afromontane Forest.

The former Eastern Cape enclave of the town of Umzimkulu and its hinterland has been incorporated into KwaZulu-Natal following the 12th amendment of the Constitution of South Africa. In addition, a change made to the southern border of the province has had an impact on major industries and sugarcane farming boundaries.

Profile

The Province of KwaZulu-Natal is divided into eleven district municipalities, namely eThekwini Metropolitan which has the highest population, Ugu (DC21), Umgungundlovu (DC22), Uthukela (DC23), Umzinyathi (DC24), Amajuba (DC25), Zululand (DC26), Umkhanyakude (DC27), Uthungulu (DC28), Ilembe (DC29) and Sisonke District Municipality (DC43). Furthermore, these district municipalities are constituted by fifty-one (51) local municipalities. A portion of thirty-five (35) percent of district municipalities is heavily industrialised including eThekwini Metropolitan, Uthungulu, Amajuba and Ilembe. The remaining municipalities are predominantly rural and are partially industrialised, dominated by sawmills. As a result of partial industrialisation, most of the municipalities lack infrastructure such as tarred roads. In municipalities such as these, emissions from sawmills, cane burning and dust from unpaved roads and ploughing form major emission sources.

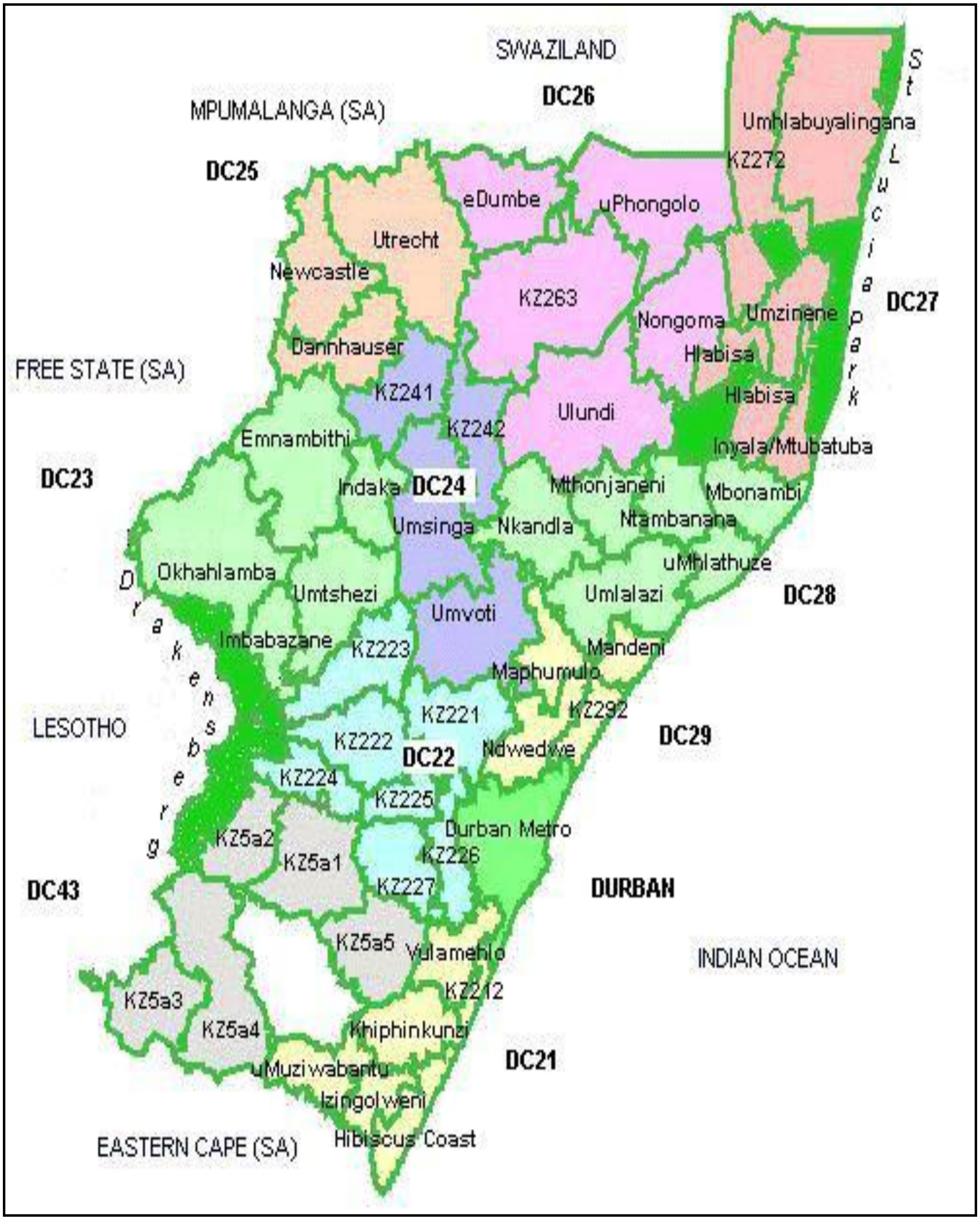
Climate

KwaZulu-Natal has a very varied, yet verdant climate, as a result of the varied and complex topography. Generally, the coast is subtropical with inland regions becoming progressively colder. Durban on the south coast has an annual rainfall of 1009mm, with daytime maximum temperatures peaking from January to March at 28ºC (min: 21ºC), dropping to daytime high's from June to August of 23ºC (min: 11ºC). Temperature drops towards the hinterland, with Pietermaritzburg weather being similar in the summer, but much cooler in the winter. Ladysmith in the Tugela River Valley in the interior reaches 30ºC in the summer, but often drops below freezing on winter evenings. The Drakensberg can experience heavy winter snow and sometimes light snow even occurs on the highest peaks in summer. The Zululand area, situated on the north coast has the warmest and most humid climate.

Winds along the coastal regions blow predominantly from the SSW to south-west and NNE to north-east in roughly equal proportions. During winter, land breezes are common at night and katabatic drainage flow occurs from higher lying areas down to river valleys. Sea breezes tend to blow during the daytime.

Inland winds are predominantly from the south-east. Local topography can play a larger part in local winds. Temperature inversions are common during winter. These occur when the country is dominated by high pressure over the interior. Inversions strengthen and descend to lower levels prior to the approach of a coastal low or cold front. The temperature inversions are a major influence on limiting pollution dispersion potential. Topography can further limit pollution dispersion, particularly in lower lying areas, where pollutants can become trapped below the inversion and cannot disperse horizontally due to surrounding mountains or undulating landscapes.

Map 1 District Municipalities in KwaZulu-Natal



Source: websitehttp://devplan.kzntl.gov.za/ASALGP/Resources/Activity

1.3 Pollutants collected

Although there are a range of air pollutants in existence, the inventory focuses on those of particular interest to the Provincial and National Government. These pollutants are considered significant as a result of being associated with a number of health problems in the region. The table below describes the common sources and adverse effects associated with each of the pollutants inventoried.

Table 1: Inventoried pollutants with associated health effects

Pollutant	Characteristics
Sulphur Dioxide (SO_2)	Colourless gas with a pungent odour. Ambient SO_2 results largely from stationary sources such as coal and oil combustion, steel mills, refineries, pulp and paper mills and from nonferrous smelters. Sulphur dioxide can cause temporary breathing difficulties for people with asthma. It can also react with other chemicals to form sulphate particles that could be a cause of reduced visibility in many parts of the province. It is the main contributor to acid deposition.
Oxides of Nitrogen (NOx)	Oxides of nitrogen are believed to aggravate asthmatic conditions. It reacts with other pollutants to form nitrate particles that are a significant contributor to visibility reduction in many parts of the province. It is a contributor to acid deposition. The primary sources of NOx are motor vehicles, electric utilities, and other industrial, commercial, and residential areas that burn fuels.
Volatile Organic Compounds (VOC)	The health effects depend on the specific composition of the Volatile Organic Compounds present, the concentration and the length of exposure. High concentrations of some compounds which may occur when working with materials or processes that emit VOCs could have serious health effects. These should be considered under the effects of the specific component. General effects of lower concentrations include eye, nose, and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney, and central nervous system. Industrial processes involving solvents, paints or the use of chemicals are major sources.

Particulate Matter (PM_{10})	Particulate matter is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulphates), organic chemicals, metals, and soil or dust particles. The size of particles is directly linked to their potential for causing health problems. Particulate matter can come from tyre burning, fireplaces and cars driving on unpaved roads as well as the smoke from large industrial plants.
Carbon Monoxide (CO)	Carbon monoxide is an odorless, colorless gas produced by fuel combustion, particularly mobile sources. It may cause chest pain and aggravate cardiovascular diseases, affect mental alertness and vision in healthy individuals.

1.4 Proposed ambient air standards

Air quality standards are set by each country to protect the public health of their citizens and as such are an important component of national risk management and environmental policies (World Health Organization). South Africa has proposed the following ambient air quality standards in order to protect human health and well being.

Table 2 Proposed South African Standards (*Source:www.environment/vaal/)*

Pollutant	Averaging Period	Limit Value ($\mu g/m^3$)	Limit Value (ppb)
Sulphur dioxide SO_2	10-minute running average	500	191
	24-hour	125	48
	Annual average	50	19
Nitrogen dioxide NO_2	1-hour	200	106
	Annual average	40	21
Carbon monoxide CO	1-hour	30 000	26 000
	8-hourly running average	10 000	8 700
Particulate Matter PM_{10}	24-hour	75	-
	Annual average	40	-
Lead Pb	Annual average	0.5	-
Benzene C_6H_6	Annual average	5	1.6

2. TYPICAL AIR EMISSION SOURCES

An emission inventory is a listing of all sources of air pollution within a defined region, and is an essential tool for air quality planning. It provides information on the types of emission sources in a region, their location and the amount of air pollution emitted, for a given time period.

A fundamental requirement in the effort to control pollution in any form is to quantify the emissions being released. It is necessary to understand the relationship between emissions and the ambient concentrations, and to develop appropriate policies and methods to ensure that ambient pollutant concentrations remain within acceptable limits. Section 16 of the National Environmental Management: Air Quality Act 39 of 2004 requires that provinces develop Air Quality Management Plans. One of the key components of such a plan is the compilation of an emissions inventory database that contains data on point, non-point and mobile sources.

Air pollutants can be emitted due to human activities (anthropogenic), or they may occur naturally (non-anthropogenic). For ease of reporting and analysis, the typical air emission sources within KwaZulu-Natal are categorised as point sources, mobile sources (including non-road mobile sources), and non-point sources.

Point sources include major industrial facilities like chemical plants, steel mills, oil refineries, power plants, and hazardous waste incinerators. In KwaZulu-Natal these facilities are mainly found in Newcastle in Amajuba District Municipality, eThekwini Metropolitan, Pietermaritzburg in Msunduzi Local Municipality, Richards Bay in Umhlathuzi Local Municipality and Stanger and Mandini within the iLembe District Mucipality. No hazardous waste incinerators were inventoried during the study because of time constraints.

Mobile sources include both on-road vehicles (such as cars, trucks and buses) and off-road equipment (such as recreational engines and vehicles, construction equipment and vehicles, industrial equipment, lawn and garden equipment, farm equipment, commercial equipment, logging equipment, airport service equipment and vehicles, railway maintenance equipment, recreational marine vessels, aircraft, marine vessels and locomotives). Data for on-road vehicles is available in this report. Only aircraft from Durban International Airport were inventoried for off-road equipment. DAEA made a decision to include other equipment in the next phase of the study.

Non-point sources of pollution on the other hand refer to those inputs which occur over a wide area and are associated with particular land uses, as opposed to individual point source discharges. They are often more difficult to control than point source pollution. Non-point sources include sugarcane burning and in this inventory, only sugar cane burning was included for non-point sources as a result of the prevelance within the province. Information for sugarcane burning is available in section 2.3 of this report.

2.1 Point sources

2.1.1 Introduction

Point sources are defined as a single identifiable source and fixed location of atmospheric emission, and include smoke stacks and residential chimneys. In KwaZulu-Natal point sources include major industrial facilities like chemical plants, steel mills, petroleum refineries, sugar mills, fertilizer manufacturers and paper mills. Provincially, point sources contribute to the majority of sulphur dioxide (SO_2) emissions, accounting for nearly 73%. Point sources are also emitters of particulate matter (PM_{10}), accounting for about 13% of total emissions, and 9% of carbon monoxide (CO) and 7% of oxides of nitrogen. Point sources are less important sources of volatile organic compounds (VOCs) and lead comprising less than 3% in total.

2.1.2 Methodology

Data collection

A contact database of industries was developed using data from different sources including the following:

- The data from industries within the Msunduzi Municipality was collected by the Local Municipality's Health Department. This data was made available to the project team.
- A list of emission sources from Amajuba District Municipality was received from local DAEA offices.
- EThekwini Metropolitan Municipality list of industries was obtained from the Air Pollution Control Office, eThekwini City Health.
- The Environmental Health Officer of the Ugu District Municipality supplied a list of industries within their jurisdiction.
- Contact information on industries in other areas was collected using telephone directories and the Braby's website.

Questionnaire

An emission inventory questionnaire was designed to retrieve data from industries within the province and a guideline document was developed to assist respondents in completing the questionnaire.

ZES personnel contacted all the industries telephonically to confirm the questionnaire recipient so that the right person received and completed the questionnaire timeously.

Respondents were given 14 working days to complete and return questionnaires. After the deadline, a follow-up on outstanding questionnaires was done as a reminder and to ensure that any further queries were resolved. None of the industries returned questionnaires during the stipulated time. The average turn-around time for most industries was three months.

A letter from the Department of Agriculture and Environmental Affairs was also sent to industries either via fax or e-mail introducing the project and the team. In some instances these documents were hand delivered and in others, the data collection team had to visit respondents at their premises to assist in completion of the questionnaire. Most respondents were assisted telephonically.

A low response rate was experienced within the eThekwini Metropolitan Municipality. In other instances the intervention from the Department of Agriculture and Environment Affairs was required in order to retrieve outstanding responses.

Overall, most of the completed questionnaires received were from the smaller industries. Further to this, not all questionnaires were returned.

Database Design

The collation of industrial point source emissions into a single, accessible inventory required the use of a custom designed database to allow for ease of input and reporting. The database was designed using Microsoft Access due to the anticipated size and complexity of the inventory and to allow for information sharing without the need of dedicated database servers.

The database consists of 10 relational tables and 1 table for the data input method chosen. These are as follows:

Table 3: Database entries

Table Name	Description
CityNames	List of cities/towns within Local Councils
CompanyDetails	General details of companies included in emissions inventory
Districts	List of district councils within KZN
FuelBurnData	Fuel burning data with schedule of operation, etc.
LocalCouncils	List of local councils within district councils
ProcessFuelData	Consumption rates and types of fuel used in processes
ProcessFugitiveEmissionData	Emission data measured/calculated that does not exit a specific stack
ProductionData	Production rates of processes
SectorCode	Divides industries by type of sector
StackData	Emission data for stacks, including physical parameters and cleaning device methods

The database is continually updated with each set of data received from respondents. The data initially undergoes a quality control check before being uploaded into the database.

2.1.3 Results

Introduction

The results presented include all the data ZES collected through means described above. Sixty three (63)% of questionnaires were returned. Of the 200 industries approached to provide information regarding atmospheric emissions of pollutants, 50% responded adequately. Of the respondents, about 15% did not contain adequate information for entry into the database. ZES did additional calculations to 6% of completed questionnaires to arrange data into the relevant input format.

In addition to this, a number of industries requested assistance with the calculations. The United States Environment Protection Agency AP 42 (US EPA AP42) and Australian National Pollutant Inventory (NPI) Emission Estimation Techniques were used during this process. Emission estimations were calculated using two methods:

- Mass balance
- Engineering calculations
- Direct measurement or
- Emission factors

Data was received in different units from respondents. Most point sources reported their operation as continuous, while others reported differing operating schedules. For some sources, hourly emissions data was reported. All these results had to be converted as per the relevant emission estimation technique. ZES applied the relevant conversion factors.

Estimation of emissions represents a less accurate methodology compared to emissions measurements and mass balances, but was necessary due to inadequate information supplied by some industries.

Collected data

This section presents all emission data received from different industries in the KwaZulu-Natal Province. Most of the results have not been validated since this is the first provincial emission inventory database. EThekwini Metropolitan carried out a full emission inventory study in 1998, but this data was not available. The sulphur dioxide data, dated 2005, from major industries in the South Durban Basin presented in the Municipality's Air Quality Management Plan (AQMP) was used to validate some of the data received from these industries.

A desktop study was performed in 2004 for the Richards Bay Clean Air Association (RBCAA) in the Umhlathuze Local Municipal Area. This study targeted the larger industries in the Richards

Bay area. The pollutants of concern were particulate matter and sulphur dioxide. The data was used for validation and comparison. A decrease of emissions compared to the 2004 study is noticeable.

The data collected is presented below by means of tables and graphs:

Table 4: Overall point sources' results

Districts	CO2	CO	SO2	NOX	PM	LEAD	VOCs	OTHERS
Umgungundlovu	114747.33	3497.63	634.38	516.02	2009.89	0.00	0.67	0.00
Amajuba	36197.00	80.04	2573.68	243.86	3030.40	0.00	1.23	0.00
Umkhanyakude	20890.00	14974.00	0.42	0.00	1882.00	0.00	0.00	0.00
Ugu	208674.00	1265.85	26.92	511.36	345.74	0.03	36.81	0.00
Zululand	7154.00	922.00	0.16	0.00	394.00	0.00	0.00	0.00
Uthungulu	103395.00	134685.04	26787.95	702.20	2102.52	0.94	253.84	1309.70
Ilembe	0.00	3149.22	2492.10	1072.00	961.46	1.03	14.63	0.00
Sisonke	0.00	60.00	0.00	300.00	0.00	0.00	0.00	0.00
eThekwini	3747.17	17023.37	26807.06	23087.17	3327.07	1.25	245.75	6226.50
Uthukela	0.00	973.26	546.42	181.16	655.66	0.00	105.24	0.00
Umzinyathi	0.00	0.03	1.65	0.50	0.26	0.00	0.00	0.00
TOTAL	**494804.50**	**176630.44**	**59870.74**	**26614.27**	**14709.00**	**3.25**	**658.17**	**7536.20**

The carbon dioxide is reflected in table 4 but was not part of the study. Most industries included carbon dioxide emissions during their reporting. The column noted as "others" includes BTEX and other pollutants.

It can be seen in table 4 above that the highest contributor of carbon monoxide is Uthungulu District Municipality with eThekwini Metropolitan being the highest contributor of sulphur dioxide (SO_2) and oxides of nitrogen (NO_x). Amajuba District Municipality is the highest contributor of particulate matter. The total emissions of volatile organic compounds (VOCs) are equal to 658.17 tons per annum. This figure would be inflated should smaller facilities like spray painting, printing, bakeries, and service stations be included in the inventory.

Figure 1: Breakdown of point source emissions by pollutant in KZN

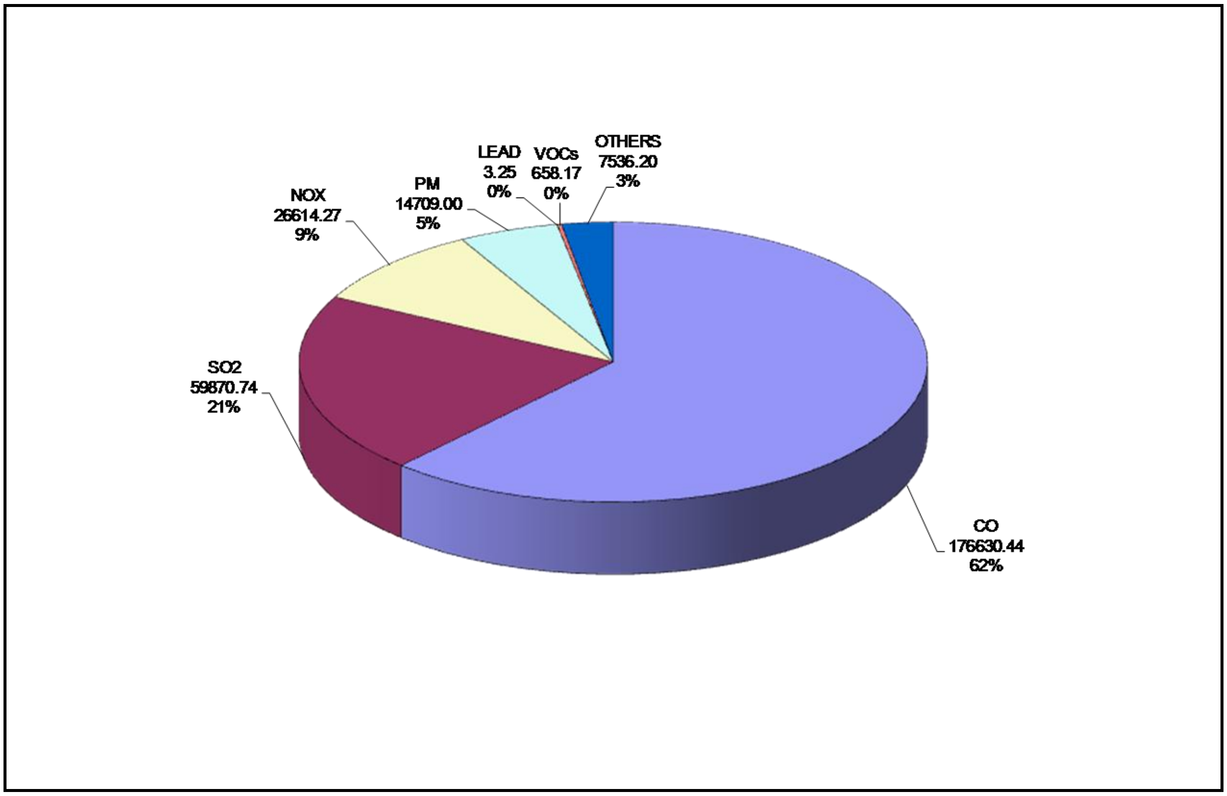
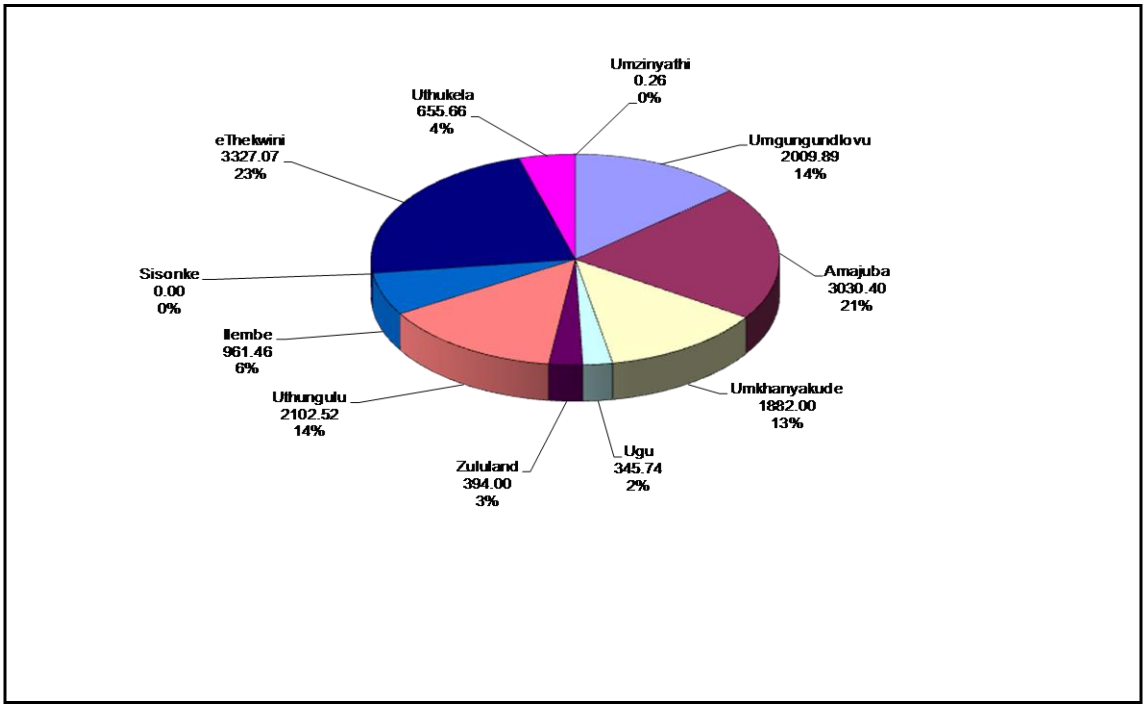


Figure 1 shows the total emissions by all pollutants from point sources in Kwazulu-Natal. Carbon monoxide contributes 62% to Provincial air emissions. The larger percentage of CO is contributed by smelters in Richards Bay, uThungulu District Municipality. SO_2 comprised 21% of air emissions, with the larger portion from eThekwini Metropolitan and Uthungulu District Municipalities. PM and NOx contributed 5% and 9% respectively. The contributions from VOCs and lead are small compared with the other pollutants.

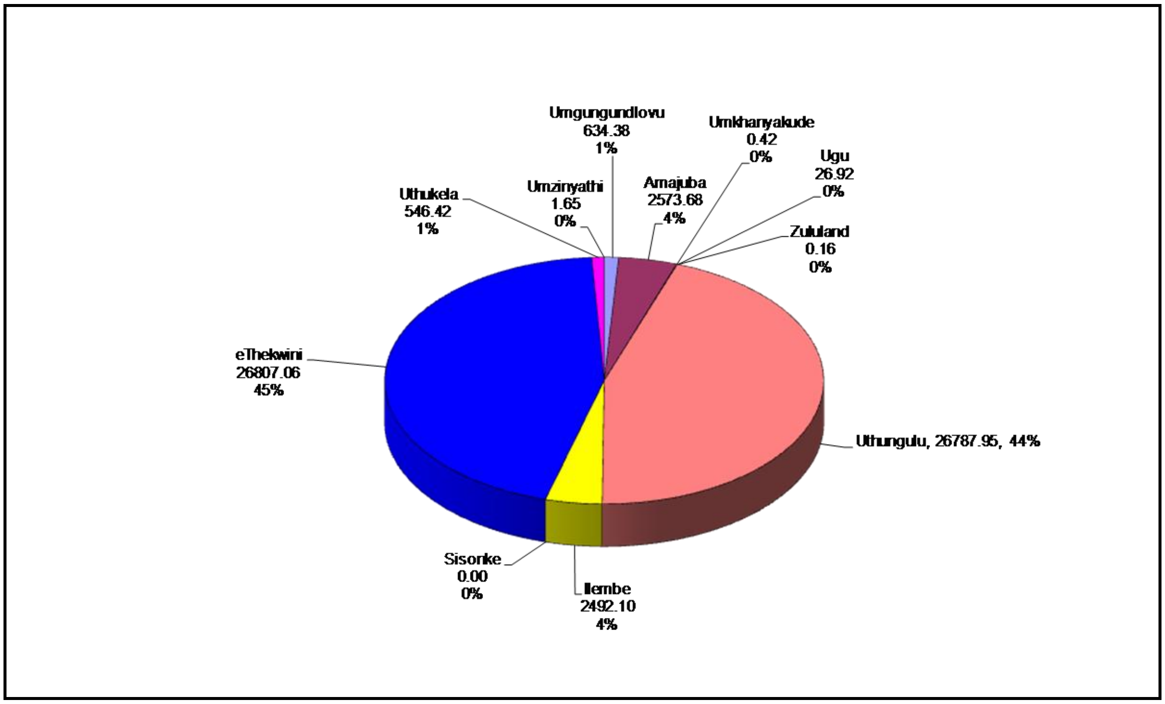
Data for some of the industries that did not return questionnaires in South Durban were extracted from the eThekwini Air Quality Management Plan Report (AQMP) dated 2005. An emission inventory spreadsheet dated 2004 was also used to extract data for smaller facilities. Data from facilities that are no longer operational was removed from the spreadsheet.

Figure 2: Particulate matter distribution from point sources per district municipality in KwaZulu-Natal



The highest percentage (23%) of industrial particulate matter is allocated to eThekwini Metropolitan Municipality, followed by Amajuba District Municipality at 21% and UMgungundlovu and Uthungulu District Municipalities are jointly contributing 14% of particulate emissions.

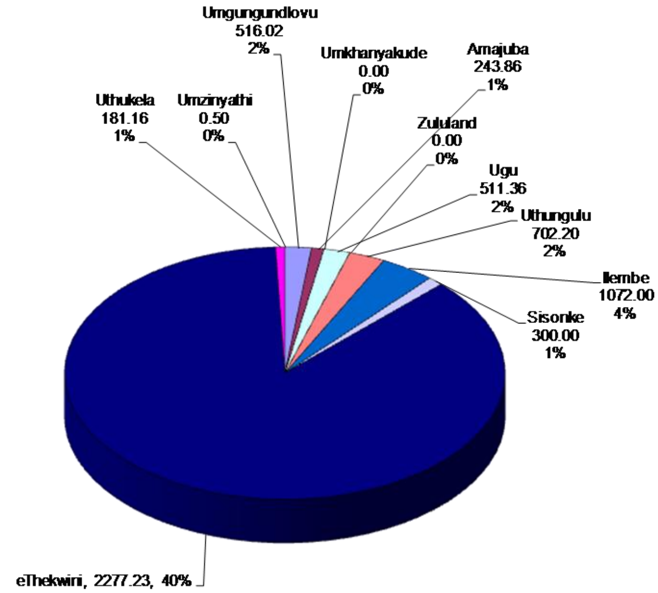
Figure 3: Sulphur dioxide distribution from point sources in KwaZulu-Natal per district municipality



The highest percentage of sulphur dioxide emissions is derived from the eThekwini Metropolitan area (45%), followed by Uthungulu (44%). These municipalities are well known for their industrial status. Had all major eThekwini industries returned questionnaires, the emission contribution of the Metro would be higher. Ilembe and Amajuba District Municipalities are jointly in third place with a 4% contribution. The emissions for Ilembe District Municipality are also under-estimated as only 35% of industries responded.

Sisonke, Zululand, Umzinyathi and Umkhanyakude District Municipalities are fairly rural and dominated by sawmills.

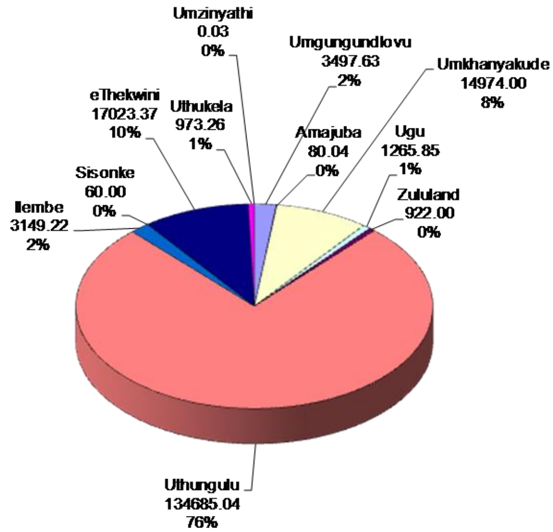
Figure 4: Provincial NOx distribution from Point Sources per district municipality



Emission estimates for oxides of nitrogen from the eThekwini Metropolitan area are higher than for those of other District Municipalities. This is an indication of the advanced industrialized zones within this area.

NOx emissions from other District Municipalities are insignificant in comparison, ranging between 0% and 4%.

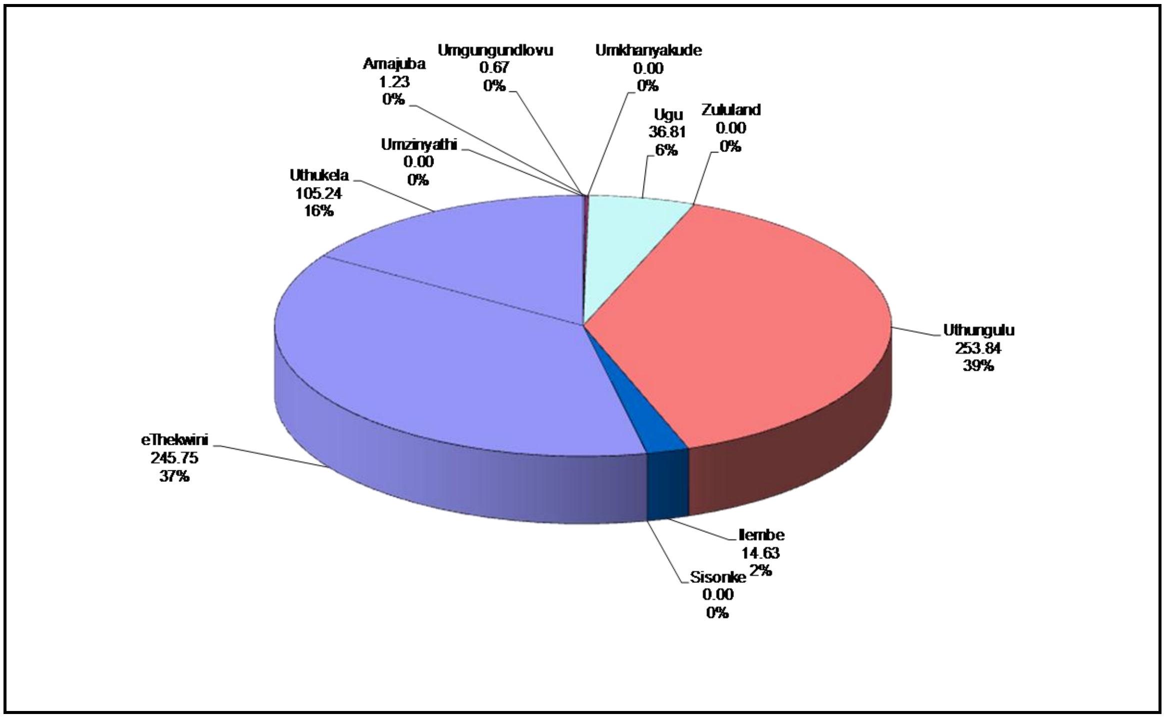
Figure 5: Carbon monoxide distribution from point sources in KwaZulu-Natal per district municipality



Different levels of Carbon Monoxide (CO) emissions from all District Municipalities are illustrated in figure 5 above. Uthungulu District Municipality is the highest contributor of carbon monoxide emissions (75%). The highest carbon monoxide contributors within this district are the Richards Bay aluminium smelters.

The eThekwini Metropolitan follows with a contribution of only 10% to the total CO emissions. As indicated previously, not all questionnaires were returned by major industries within this Municipality, in particular by major industries in the South Durban Basin, so this is most likely an under-estimate and would need to be re-evaluated in the future.

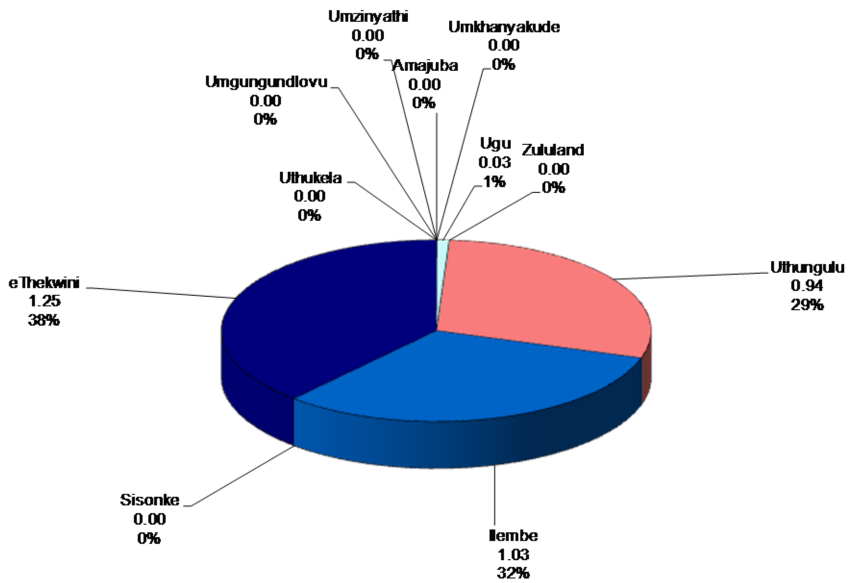
Figure 6: Volatile organic compounds distribution from point sources in KwaZulu-Natal per district municipality



The inventory identifies that volatile organic compounds are predominantly from eThekwini Metropolitan with a contribution of 37% to the estimated total load of 245.75 tons per annum, closely followed by Uthungulu District Municipality with 39%. The main contributor to volatile organic compounds in Uthungulu is a chemical storage facility in Richards Bay.

The third highest contributor is Uthukela District Municipality with 27%, derived mainly from wood fibre-board manufacturers. Many of the districts have no recorded VOC emissions owing to the fact that no data was provided on the questionnaire. These emissions are also under-reported since major VOCs contributors could not be properly inventoried as a result of a lack of response to questionnaires. Paint manufacturers and dry cleaners were not included in this phase of the study.

Figure 7: Lead emissions distribution per district municipality for point sources in KwaZulu-Natal



The total lead estimates from the whole Province is 3.25 tons per annum. The highest emission estimate is from eThekwini Metropolitan with 1.25 tons per annum followed by Ilembe District Municipality with 1.03 and UThungulu District Municipality with 0.94 tons. Lead emissions were possibly under-reported in the smaller municipalities due to lack of data available. The use of unleaded gasoline for fuel has contributed to the reduced Lead (Pb) emissions.

2.2 Mobile sources

2.2.1 Introduction

Mobile sources include on-road sources such as cars and light trucks, heavy trucks and buses, off-road recreational vehicles (such as dirt bikes and snowmobiles), farm and construction machines, lawn and garden equipment, marine engines, aircraft, and locomotives.

Provincially, mobile sources are responsible for approximately 65% of carbon monoxide emissions, and more oxides of nitrogen emissions than non-point or point sources. Vehicles and aircraft are the only mobile sources included in this inventory. The other mobile sources will be considered in the second phase of the study.

2.2.2 Vehicle emissions

Introduction

ZES contacted the Provincial Transport Department regarding the available traffic count data. Data was available for the period between 1975 and 1999. More recent data was sourced from the South African National Roads Agency (SANRA). This information was required for modelling purposes using the California Air Resources Board (CARB) Emission Factors (EMFAC) model. This approach was abandoned because it was not possible to collate sufficient input data required by the model. It was then resolved to calculate vehicle emissions based on fuel consumption.

Emissions from road traffic were calculated using total fuel use. Emissions of SO_2 were calculated using a simple mass balance approach (i.e. assuming that all of the sulphur in the fuel is converted to SO_2), which is a commonly-used approach. Emissions of other pollutants (NO_x, VOC, PM and CO) have also been based on fuel use, with emission factors derived from the "Brown Haze Study" used to estimate pollutant emissions.

Methodology

The scope of work included estimating the NOx, VOC, total particulate matter (PM), CO, SO_2 and lead emissions from vehicles. It was assumed that the amount of lead used in the fuels is approximately zero and lead emissions were excluded due to a reduction of lead emissions used in unleaded fuel. The data was acquired from the South African Petroleum Industry Association (SAPIA).

Fuel consumption data for various fuels such as diesel, furnace oils, paraffin, jet oil, LPG and petrol were provided by SAPIA for various areas in KZN for the year 2006. The data supplied by SAPIA was per magisterial area. The data was then allocated to relevant district municipalities.

Emission factors associated with the Brown Haze Study[1] were used to estimate emissions of NOx, VOC, PM and CO from petrol and diesel. For all other fuels, emission factors from US-EPA, AP-42[2] were used.

It is known that Clean Fuel Regulations have been introduced following the Brown Haze Study. Therefore, updated data on the sulphur content of fuel currently used was sought and used to estimate SO_2 emissions. The sulphur content of the fuels that was used to approximate the SO_2 emissions is given below:

Petrol: 500ppm (ULP), 1500ppm (LRP)

Diesel: 500ppm

Paraffin: 0.1%

Jet Fuel: 0.1%

Furnace oils: 3.2%

LPG: 9mg/m3 [assumed to be the same as for Sasol Gas]

Calculations

The SO_2 emissions were determined using a mass balance approach, i.e. assuming that all the sulphur in the fuel will be converted to SO_2 (according to the equation below). This provided a conservative estimate of SO_2 emissions.

$S + O_2 \rightarrow SO_2$

The following assumptions were made:

- Fuel purchased within a district municipality would be consumed within that area.
- Some fuel purchased in KwaZulu-Natal would be consumed outside the KZN area.
- It was also assumed that the volume of fuel purchased outside KZN and consumed within the Province is likely to be counter balanced by the volume of fuel purchased within and consumed outside the area.

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[1] Note that there is a possibility that some work on the development of vehicular emission factors for the South African vehicle fleet may have been done since the Brown Haze Study. Reporters are not aware of such emission factors and are proposing to use the emission factors from the Brown Haze Study.

[2] The United States Environmental Protection Agency (US EPA) has published a set of documents termed the *Compilation of Air Pollutant Emission Factors* (AP-42). Emission factors from this document were used to estimate emissions.

This would not predominately be applicable; however it gives an indication of the emissions from that magisterial area. For the oxides of nitrogen, particulate matter, volatile organic compounds and carbon monoxide the emission factors associated with the Brown Haze Study[3] were used to estimate emissions.

Table 5: Fuel data from SAPIA

2006 SALES IN LITRES

	DIESEL	FURNACE OILS	PARAFFIN	JET	LPG	PETROL
ALFRED	4476085		1334648			8602597
BABANANGO	107504		225474			279153
BERGVILLE	3651388		353251			7629121
CAMPERDOWN	26312804	1662287	248217		8700	23971828
CHATSWORTH	10628380		477236			57036078
DANNHAUSER	2152031		19965			2045021
DUNDEE	11680756		217292			12734927
DURBAN	749026597	45075350	94260288	86414003	157263654	575129537
ESHOWE	7306446	739663	1777145		224529	16696953
ESTCOURT	22742893	7150401	3461939			30224210
GLENCOE	2557275					2547265
HLABISA	14747672		1225075			22773342
IMPENDLE	681406		6450			2625063
INANDA	40143533	911058	2920765		293371	124146334
INGWAVUMA	4690822		300029			10088336
IXOPO	2222038		-331276			311829
KLIPRIVIER	37374445	543465	5574954	60400		51750816
KRANSKOP	538240		78111			1917980
LIONS RIVER	6486537	47908	185273	91907		13848591
LOWER TUGELA	38091689	866603	1060576			52150873
LOWER UMFOLOZI	109730742	4268447	6377393	158924		86419144
MAHLABATINI	5096632		1056186			13605069
MAPUMULO	267757					865145
MOOIRIVIER	2888187	341536	10759			3046140
MOUNT CURRIE	13122957	268047	4521495			21803007
MSINGA	655708		427035			4631970
MTONJANENI	5476201		419475			7904839
MTUNZINI	9553666	1889870	686299			14505771
NDWEDWE	1128184					317138
NEWCASTLE	38676840	276678	3559657	45729		54203085
NEW HANOVER	4820265		458760			5509566
NGOTSHE	2227812		306946			283278
NKANDLA	607437		213611			2685468
NONGOMA	2034416		1706523			9645512
NQUTU	1203770		1660563			7659709
PAULPIETERSBURG	1621300		197759			1812231
PIETERMARITZBURG	125302317	22851546	10823961	400044	34589202	168106571
PINETOWN	101661564	4511856	5051307		2492833	147255569
POLELA	623601					2011773
PORT SHEPSTONE	35932999	1907339	2016971	163782		66698886
RICHMOND (NATAL)	2201337	259304	163301	4000		2688644
SIMDLANGENTSHA	7374950		100			2531997
UBOMBO	6916781		202692			12191668
UMBUMBULU	4339611	34143				11500840
UMLAZI	1640705		44248		93117	28016322
UMVOTI	5157908	174751	838269			9269612
UMZINTO	13631993	503680	448533			26572369
UNDERBERG	1961622		27915			2654825
UTRECHT	1223600		10627			2513145
VRYHEID	43035634	19886	3675070			38590739
WEENEN	1094893		8850			1736656

[3] Note that there is a possibility that some work on the development of vehicular emission factors for the South African vehicle fleet may have been done since the Brown Haze Study. Reporters are not aware of such emission factors and are proposing to use the emission factors from the Brown Haze Study.

Results

This section gives a summary of vehicle emissions based on fuel consumption.

Table 6: Summary of vehicle emission results (tpa)

Districts	CO_2	CO	SO_2	NO_X	PM	LEAD	VOCs
Umgungundlovu		85532.89	958.78	12765.10	2646.10	0.00	16091.67
Amajuba		21965.37	182.86	3107.87	6060.80	0.00	4116.60
Umkhanyakude		36367.31	319.20	4910.99	990.51	0.00	6783.55
Ugu		42751.39	473.91	11408.94	994.00	0.00	6711.87
Zululand		25030.49	206.59	4158.09	905.11	0.00	4777.80
Uthungulu		48471.63	841.41	8715.10	1942.65	0.00	9341.65
Ilembe		4696.45	33.27	514.61	93.51	0.00	859.21
Sisonke		1877.41	15.33	320.69	70.51	0.00	359.67
eThekwini		351521.32	7502.61	61163.52	13351.77	0.00	67359.98
Uthukela		34143.82	750.01	4864.81	996.96	0.00	6395.96
Umzinyathi		14411.31	115.49	1777.69	342.96	0.00	2663.45
TOTAL		**1333538.78**	**22798.93**	**227414.82**	**56789.75**	**0.00**	**250922.82**

Table 6 above gives a summary of emissions per district municipality in tons per annum. Carbon monoxide emissions are highest when compared with other emission types, followed by volatile organic compounds and oxides of nitrogen. These results are typical of vehicle emissions.

EThekwini Metropolitan Municipality is the major contributor of all estimated emissions. Amajuba District Municipality follows as the second highest contributor of PM (20%). In all other pollutants eThekwini Metropolitan Municipality is leading followed by Umgungundlovu District Municipality.

Figure 8: Breakdown of vehicle source emissions by pollutant for KZN

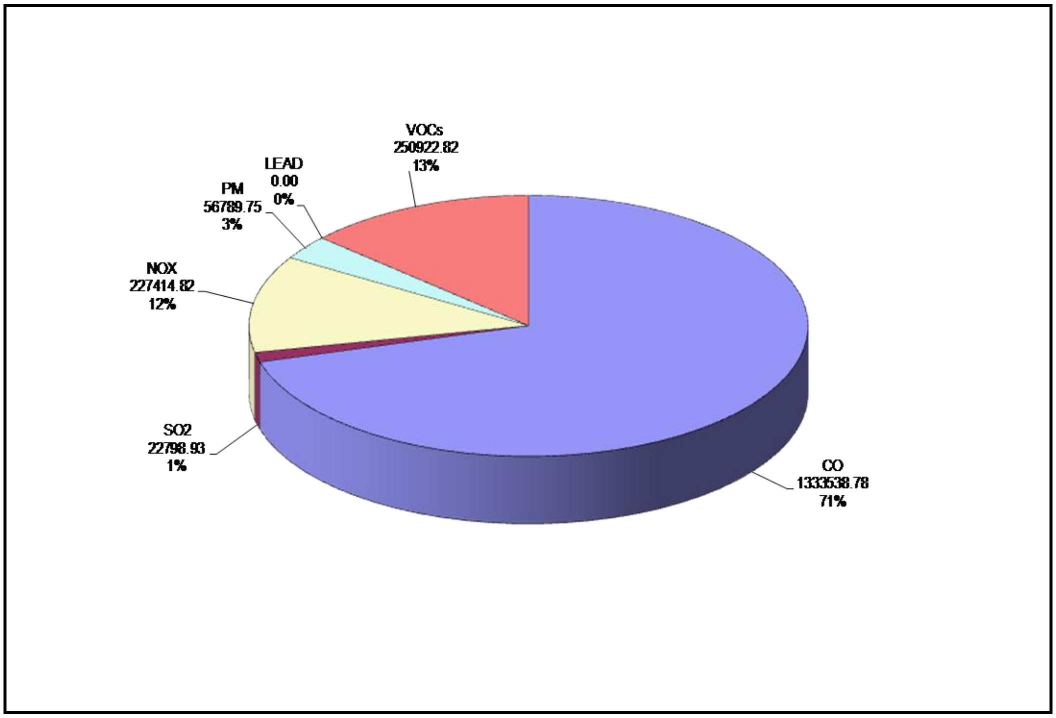


Figure 9: Particulate matter emissions from Vehicles in KZN per district municipality

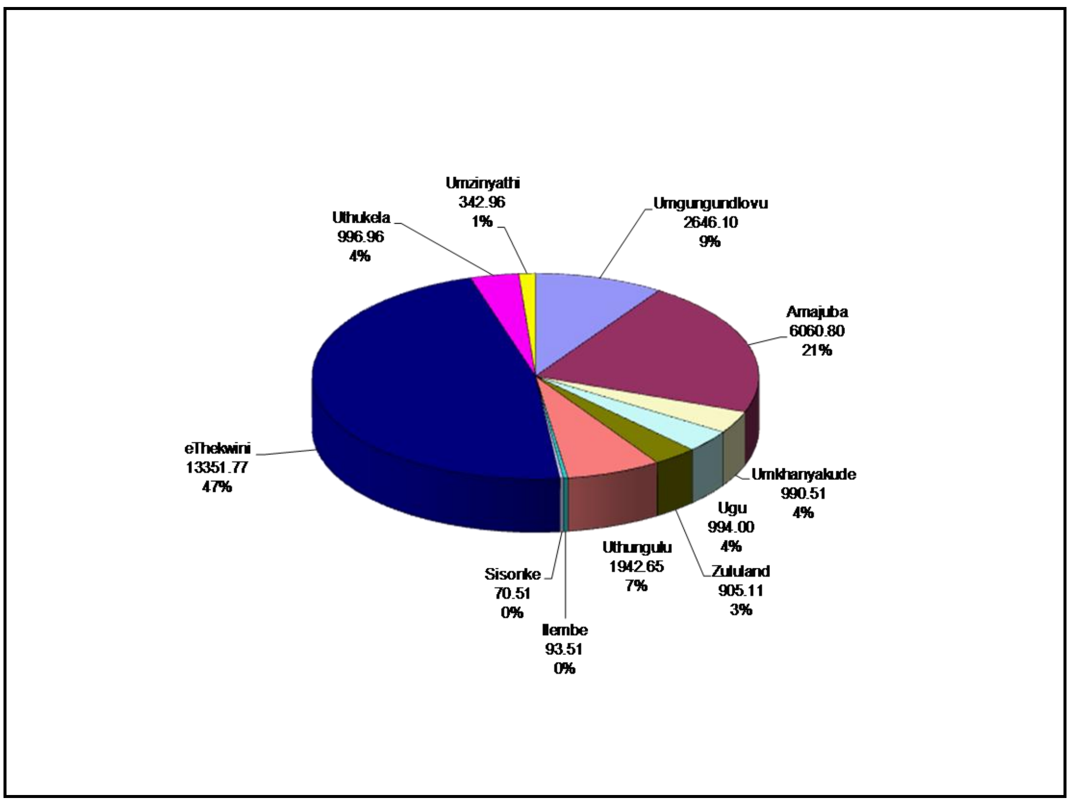


Figure 10: Sulphur dioxide emissions from vehicles in KZN per district municipality

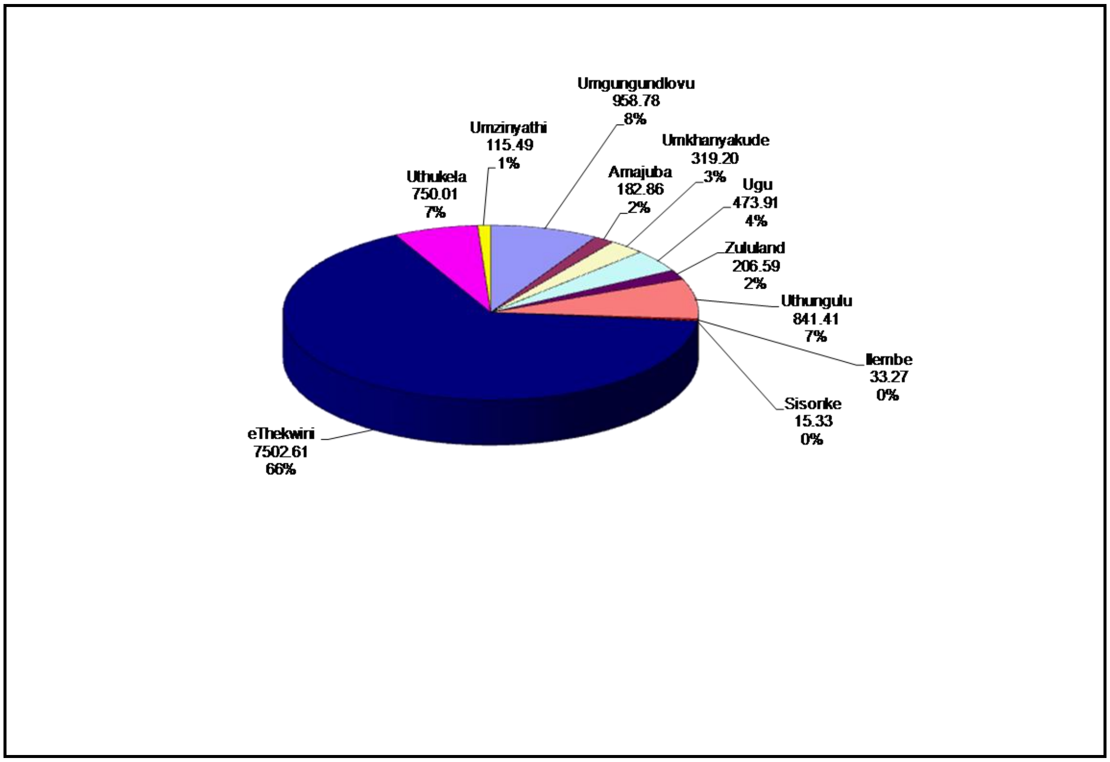


Figure 11: Nox emissions from Vehicles in KZN per district municipality

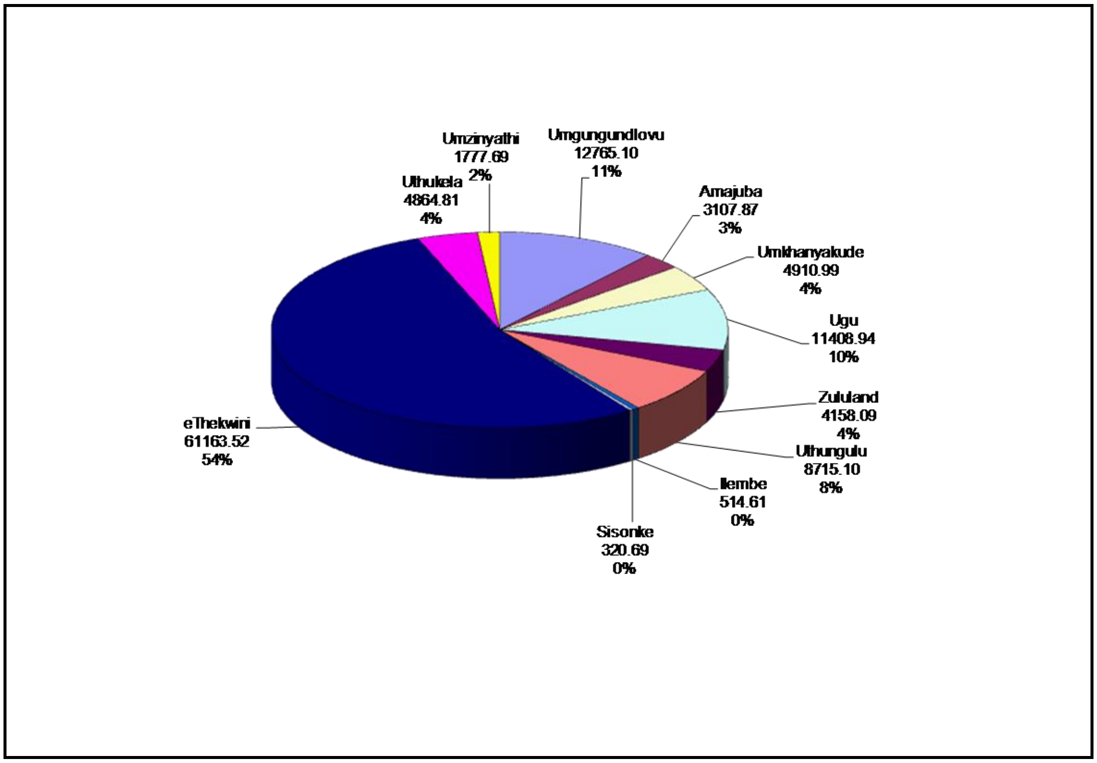


Figure 12: CO emissions from vehicles in KZN per district municipality

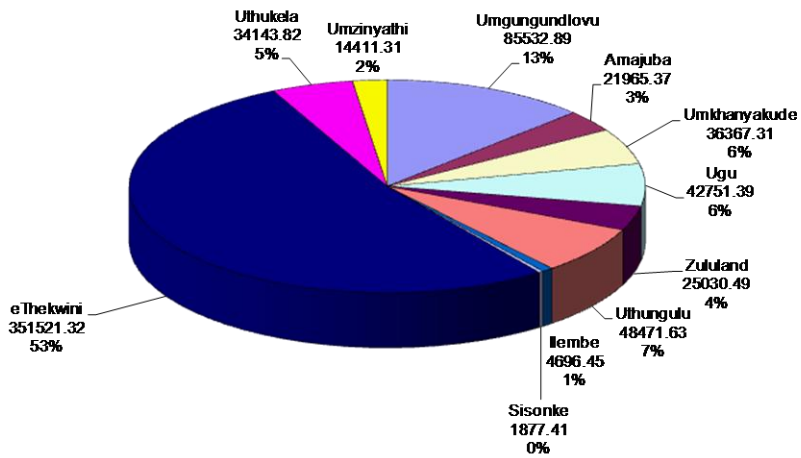
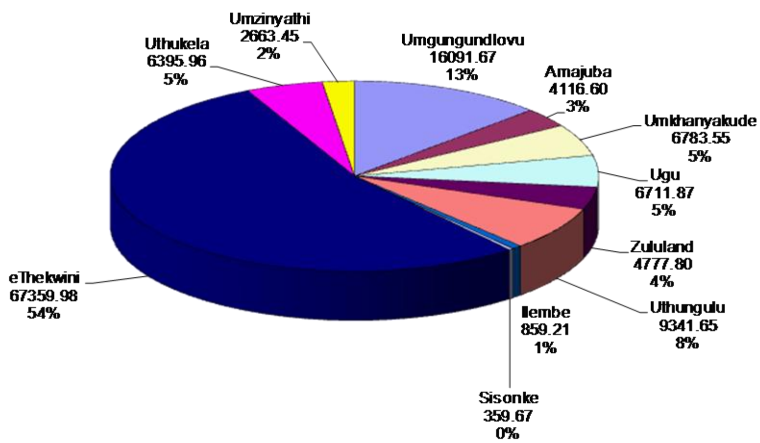


Figure 13: VOC emissions from Vehicles in KZN per district municipality



2.2.3 Aircrafts

Introduction

The emission inventory for aircrafts was compiled using 2006 data supplied by Durban International Airport (DIA). Data from other airports such as Richards Bay and Pietermaritzburg was not retrieved.

Methodology

The approach taken by ZES is based on the NPI Technique. Essentially this uses International Civil Aviation Organisation (ICAO) Data Bank emissions for aircraft engines, and then calculates total emissions based on the number of engines, number of (Landing and Take-Off) LTO cycles, and the Times in Mode (TIMs). These calculations are open to some uncertainty due to the integrity of the base data provided by DIA, and that some aircraft emissions have not been fully accounted for.

Durban International Airport confirmed that the Taxi-in and Taxi-out times are 4 minutes each. The total Taxi time per LTO cycle is taken as 8 minutes in the calculations.

A significant constraint with the calculations was that DIA had not fully identified some of the aircraft types e.g. there are 2847 McDonnell Douglas LTOs, but it is not clear whether these are DC-8, DC-9, DC-10, or MD-80 aircraft. The emissions from different aircraft types can vary considerably. It was therefore been necessary to make assumptions on which aircraft type is used.

The calculation also took account of reverse thrust on landing, and emissions from the Auxiliary Power Units.

Calculation of Aircraft Emissions

Air Quality Consultants Ltd (AQC) peer reviewed the data and performed a quality control check on the results. They used the base data provided by DIA to re-calculate aircraft emissions. Essentially the methodology used, was the same calculation approach of ZES, but took into account more pollutants, and included reverse thrust and Auxiliary power units (APUs) emissions.

The emissions arising from each aircraft movement was calculated as the sum of the emissions for each part of the landing and take-off (LTO) cycle. Records of aircraft mix and numbers of aircraft movements were supplied by DIA. Where specific aircraft types were not nominated, an assumption was made.

For each type of aircraft, emissions per aircraft movement were calculated using emission factors in grams of pollutant per kilogram of fuel burnt, together with fuel flow in kilograms per second.

These were extracted from the Federal Aviation Agency (FAA) EDMS model and the ICAO Engine Exhaust Emissions Data Bank.

Emission factors are provided for 'take-off' (100% thrust), 'climb out' (85% thrust), 'approach' (30% thrust) and 'idle' (7% thrust). It was assumed that all jets that have reverse thrust capabilities use a 60% reverse thrust for 15 seconds on landing. Emission factors for 60% thrust settings were derived by linear interpolation between the settings for which emission factors are available.

Emission factors within the EDMS and ICAO databases are usually stated for new engines. To account for engine deterioration, nitrogen oxide emissions were increased by 4.5%, while for all other pollutants the fuel flow and subsequent calculation of emissions was increased by 4.3%.

In the absence of specific data for DIA, times-in-mode for take-off, approach and climb-out were based on experience gained from other studies. These were:

- Take off (start of roll to wheels off): 50 seconds
- Climb out (wheels off to 100m altitude): 12 seconds
- Approach (decent from 100 altitude to wheels down): 30 seconds

Taxi (ground idle) times were assumed to be 8 minutes per LTO cycle, based on information provided by DIA

Data related to emissions of PM from aircraft are relatively sparse, and where they do exist, the data are quite old. It is possible to define a relationship between the Smoke Number (SN), which is commonly reported, and the mass of particulate material, and this can be used to estimate PM emissions for each mode of engine operation. Smoke Number data are not available for all aircraft, and where necessary, estimates were applied. Emissions of PM from the smaller aircraft, where no data are available, were disregarded, but these are considered to be negligible.

Estimates of carbon dioxide emissions were calculated from total fuel use.

Brake and tyre wear

An allowance has also been made for PM emissions arising from brake and tyre wear based on the observed relationship to maximum take-off weight (MTOW)[4]. Emissions were calculated for

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[4] Personal Communication with Chris Eyres, Aviation Emissions, Gas Turbine Technologies, QinetiQ. PM^{10} emission (kg) = 4.76×10^{-7} (MTOW) – 0.00874.

all large aircraft types. The relationship is not applicable to smaller aircrafts, below 55,000 kg, and it was assumed the PM emissions from these sources are negligible.

Auxiliary power units

Auxiliary power units (APUs) are used to provide power to the larger aircraft when the main engines are not running, e.g. whilst the aircrafts are parked at the stand or on the apron. Emissions for APUs have been calculated on the basis of emission rates published in the EDMS model. APU running times was assumed to be 20 minutes for each passenger aircraft LTO cycle, i.e. 10 minutes per passenger aircraft movement.

Table 7: Types of aircraft inventoried

TYPES OF AIRCRAFTS			
Models of Aircrafts	**Model No.**	**Times landed**	**No. of Engines per model**
Airbus	319	3894	2
Airbus	310	1	2
Airbus	340	18	4
Boeing	707	1	2
Boeing	727	130	2
Boeing	737	6521	2
Boeing	747	9	4
Boeing	757	1	2
Cessna		1212	2
Douglas	DC3	1915	2
Dash	8	1298	2
Embraer		366	2
Fokker	28	7	2
Gulf stream		30	2
Hawker Siddeley		162	2
Illushin	IL76	4	2
Lockhead	LOH	12	2
Mc Donald Douglas		2847	2
British Aerospace		1450	2
Fairchild Metro		224	2
Piper Light Aricrafts		108	2
Helli/piper		4820	2
TOTAL LANDINGS		**25030**	**48**

Some of the aircraft information provided by Durban International Airport was ambiguous. For example, data for 2847 McDonnell Douglas flights was supplied but was not clearly marked as either DC8, or DC9, DC10, MD-80, likewise for Embraer, British Aerospace. Emissions from these aircraft are excluded from the report..

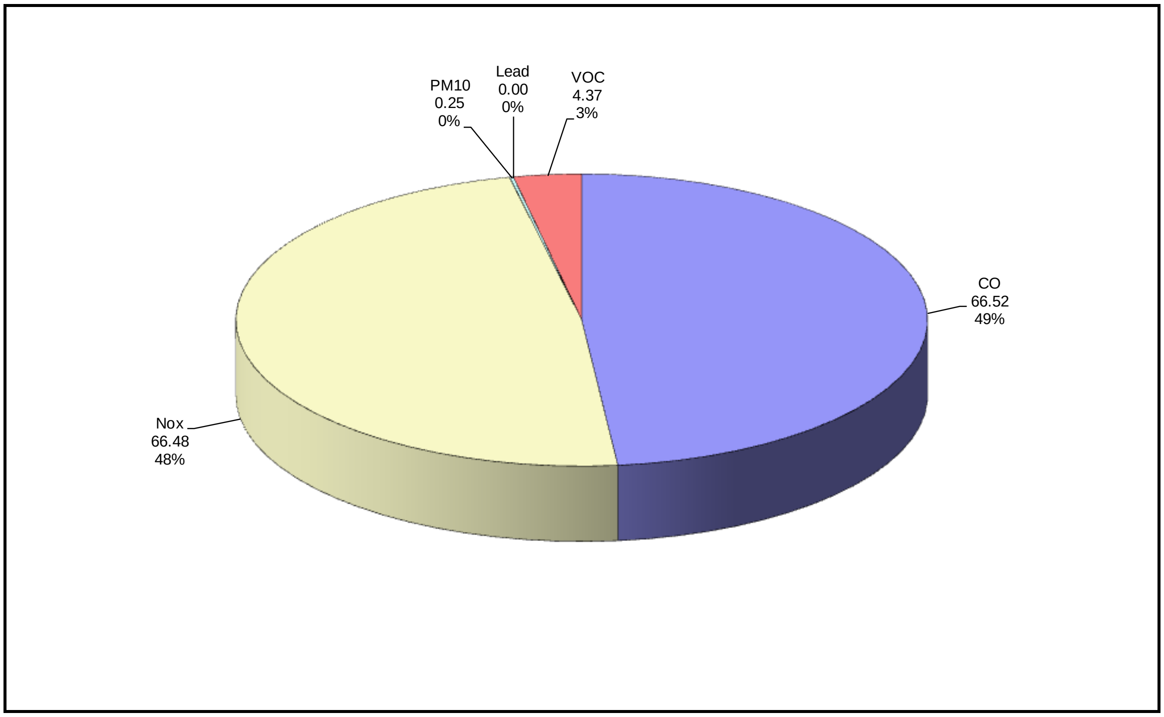
Results

The calculated emissions are summarised in the table below.

Table 8: Aircraft emission results based on aircraft movement from DIA

Mode	HC t/yr	NOx t/yr	CO t/yr	PM10 t/yr	CO2 Kt/yr
Take Off	0.36	44.38	2.70	0.12	
Climbout	0.08	6.86	0.57	0.03	
Approach	0.14	2.98	2.73	0.01	
Idle	3.38	9.12	53.31	0.06	
APU	0.41	3.14	7.21	0.03	
Total	**4.37**	**66.48**	**66.52**	**0.25**	**17.80**

Figure 14: Aircraft emissions



2.3 Non-Point Sources

2.3.1 Sugarcane Burning

Introduction

Non-point source emissions means a source of atmospheric emissions which cannot be identified as having emanated from a single identifiable source or fixed location, and includes veld, forest and open fires, mining activities, agricultural activities and stockpiles. In this study, only sugarcane burning has been inventoried.

According to the information received from the South African Sugar Association, KwaZulu-Natal has four regions under sugarcane cultivation. These regions include Zululand, Midlands, North Coast and the South Coast with a total area of 377 000 hectares under sugarcane cultivation.

The process of Sugarcane Burning

The process of sugarcane production comprises sugarcane plantation and milling and refining. During the harvest season sugarcane is burnt before it is taken to the mills. There are several reasons why sugarcane growers and millers burn the sugarcane; almost 20-25% of the plant consists of leafy material, including tops, from which little or no sugar is produced. Therefore sugarcane is burnt to reduce the amount of leafy unwanted material (trash), including stalk tops to make it easier for processing. Burning sugarcane before harvest removes most of the trash that would not contribute to sugar production. Burning sugarcane also reduces the production costs and improves the quality of the product delivered to the factory or mill for processing. . Furthermore, sugarcane industries have estimated that, by not burning the trash, the industry would spend more in transportation and processing costs. Thus there is currently no cost effective alternative to deal with this large volume of trash by mechanical means.

The burning of sugar cane fields and other types of veld burning can cause visibility problems as well as health problems to people in the surrounding residential areas during harvest season. Sugarcane burning also causes nuisance to communities adjacent to fields i.e. smoke and ash fall-out. Due to air pollution associated with cane burning during the harvest season, the sugar industry is under increasing pressure from environmental groups and urban dwellers who have raised concerns about the nuisances and health impacts caused by sugarcane burning (especially around the North and South Coast cane-growing regions of South Africa). (SASA, 2002)

There is a further challenge to the South African sugar industry in that the topography of many of sugarcane growing areas limits the use of machinery for harvesting, for example in areas where there is steep terrain farm layout or rocks in the fields.

As a result of these challenges and the health impacts, the South African sugar industry has established industry codes of practice and best management practices (BMP) for sugarcane burning. The South African Environmental Protection (EPA) agency regularly monitors sugar-industry burning practices and fines are issued for breaches of government legislation. (SRDC Project Final report, 2005).

Methodology

To obtain data for the sugarcane burning process, communication with the South African Sugar Association (SASA) in KZN was conducted. SASA provided ZES with year 2006 data. The data provided is as follows:

- KZN total amount of 377 000ha is under sugarcane cultivation
- 75% of the total area is harvested
- 90% of the harvested is burnt and
- 60.42 tons per ha was harvested

This data was used to calculate sugarcane burning emissions by applying emission factors obtained from the Australian National Pollutant Inventory (NPI) Emission Inventory Technique Manual.

The main pollutants from the process of sugarcane burning are PM_{10}, CO, NOx and VOCs. The process of sugarcane burning may be seasonal, but contributes a high percentage of emissions.

Calculations

Emission estimates based on the area of sugarcane burning were calculated according to Equation2 of the NPI technique.

Calculation of material burned in agricultural burning in a SLA (statistical local area) for sugarcane: Given Mc = Hc * Rc * Fc

The equation above was used to calculate the emissions where

Mc is the fuel consumed in a SLA burning the crop,

Hc determines the total harvest of crop type,

Rc stands for the residue fraction for the crop type and the

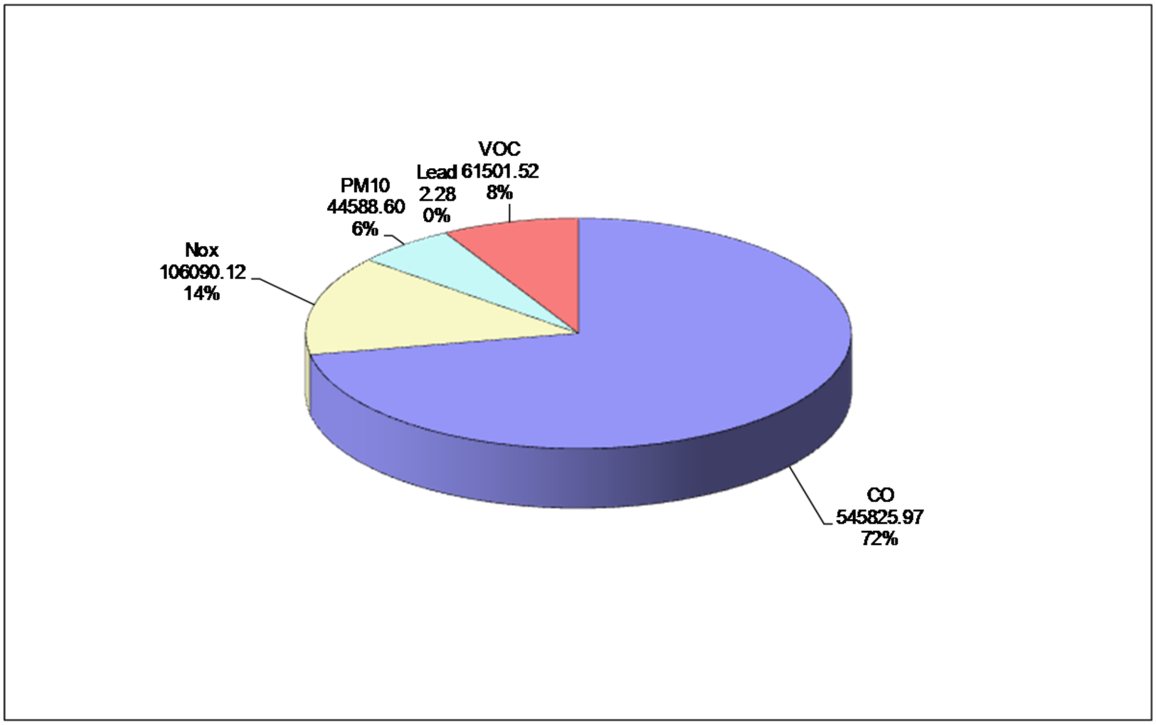
Fc determines the total harvest of the crop.

The detailed layout of emission factors used and calculations are given in Appendix 2

Results

The results for sugarcane burning emissions could not be represented spatially using the GIS map since the information obtained was provided for the total area under sugarcane cultivation. It was not subdivided into individual cane growing areas or per district municipality.

Figure 15: Emissions from sugar cane burning



Burning of sugarcane produces excessive smoke. Pollutants such as Carbon monoxide, oxides of nitrogen, particulate matter, volatile organic compounds and lead are released into the atmosphere.

Figure 16 shows that CO emissions are the largest contributor in sugarcane burning, followed by NOx and VOCs. In addition, aerosols are emitted during cane burning, and these particles can affect human health. Furthermore small PM (PM_{10}, $PM_{2.5}$) particles appear to have the greatest potential for damaging health since they can penetrate deep into the lungs and reach the lower respiratory system if inhaled. Studies have shown that the concentrations of PM_{10}, $PM_{2.5}$, are higher during the burning period compared with the non-burning period.

2.4 Overall results

This section presents combined results from point, non-point and mobile sources as overall provincial air emission estimate results. These results are still considered as not a true indication of the emissions in the province since not all emitters returned their questionnaires.

Further to this, if all waste treatment and disposal, domestic and commercial combustion processes, including landfill and sewage, veld fires, mining, agricultural and construction activities had been included in the study, the results may be considerably higher.

Table 9: Overall result in tons per annum

Districts	CO2	CO	SO2	NOX	PM	LEAD	VOCs	OTHERS
Umgungundlovu	114747.33	89030.52	1593.16	13281.12	4655.99	0.00	16092.34	0.00
Amajuba	36197.00	22045.40	2756.55	3351.73	9091.20	0.00	4117.83	0.00
Umkhanyakude	20890.00	51341.31	319.62	4910.99	2872.51	0.00	6783.55	0.00
Ugu	208674.00	44017.25	500.82	11920.30	1339.74	0.03	6748.69	0.00
Zululand	7154.00	25952.49	206.75	4158.09	1299.11	0.00	4777.80	0.00
Uthungulu	103395.00	183156.67	27629.36	9417.30	4045.17	0.94	9595.49	1309.70
Ilembe	0.00	7845.67	2525.37	1586.61	1054.98	1.03	873.84	0.00
Sisonke	0.00	1937.41	15.33	620.69	70.51	0.00	359.67	0.00
Ethekwini	3747.17	368544.69	34309.67	84250.69	16679.08	1.25	67610.10	6226.50
Uthukela	0.00	35117.08	1296.43	5045.97	1652.62	0.00	6501.20	0.00
Umzinyathi	0.00	14411.34	117.14	1778.19	343.22	0.00	2663.45	0.00
TOTAL	494804.50	1389292.32	71270.21	246478.28	87692.98	5.53	187629.84	7536.20

Table 9 above includes all collected emission results such as industrial and vehicle emissions, sugar cane burning and aircraft results.

Figure 16: Overall emissions per pollutant for KZN province

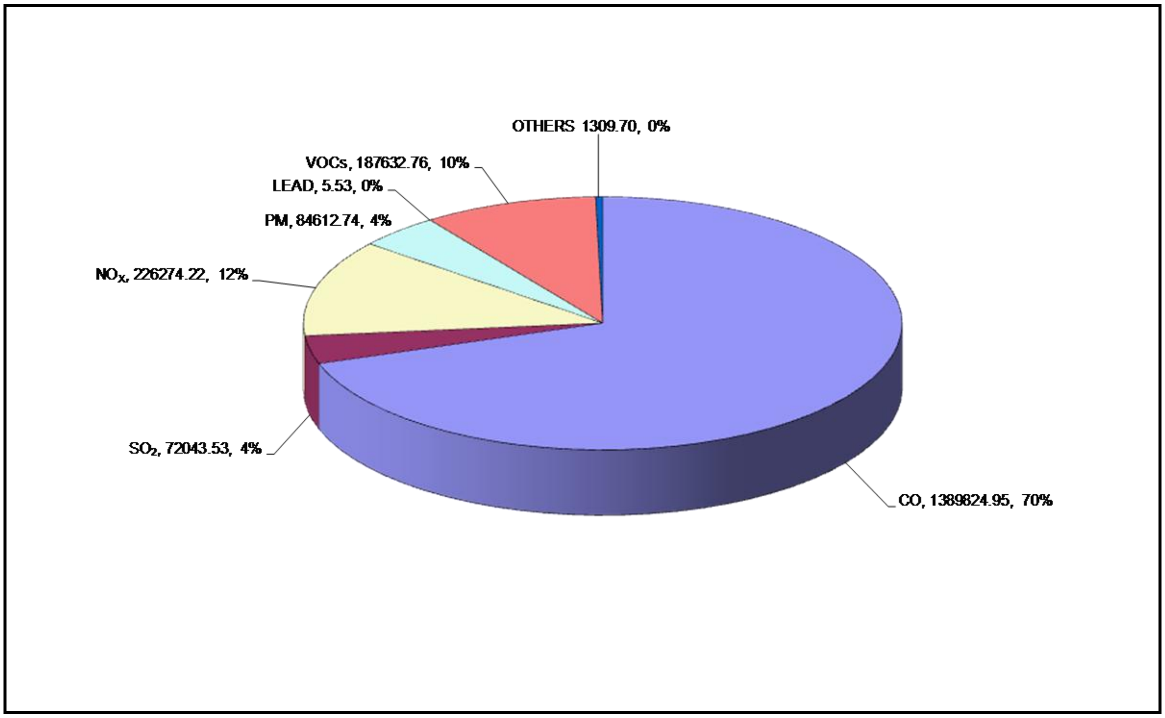


Figure 17: Comparison of particulate emissions from different sources

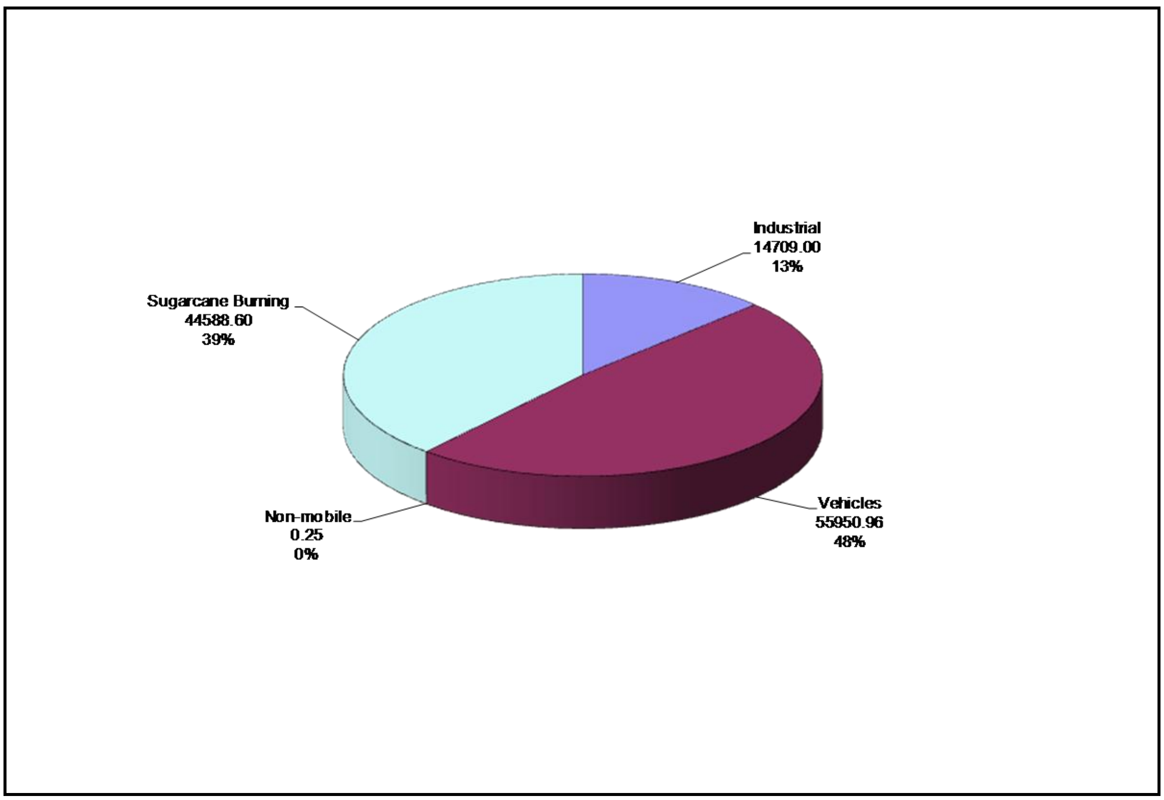


Figure 18: NOx comparison between vehicles, point sources and agricultural activities

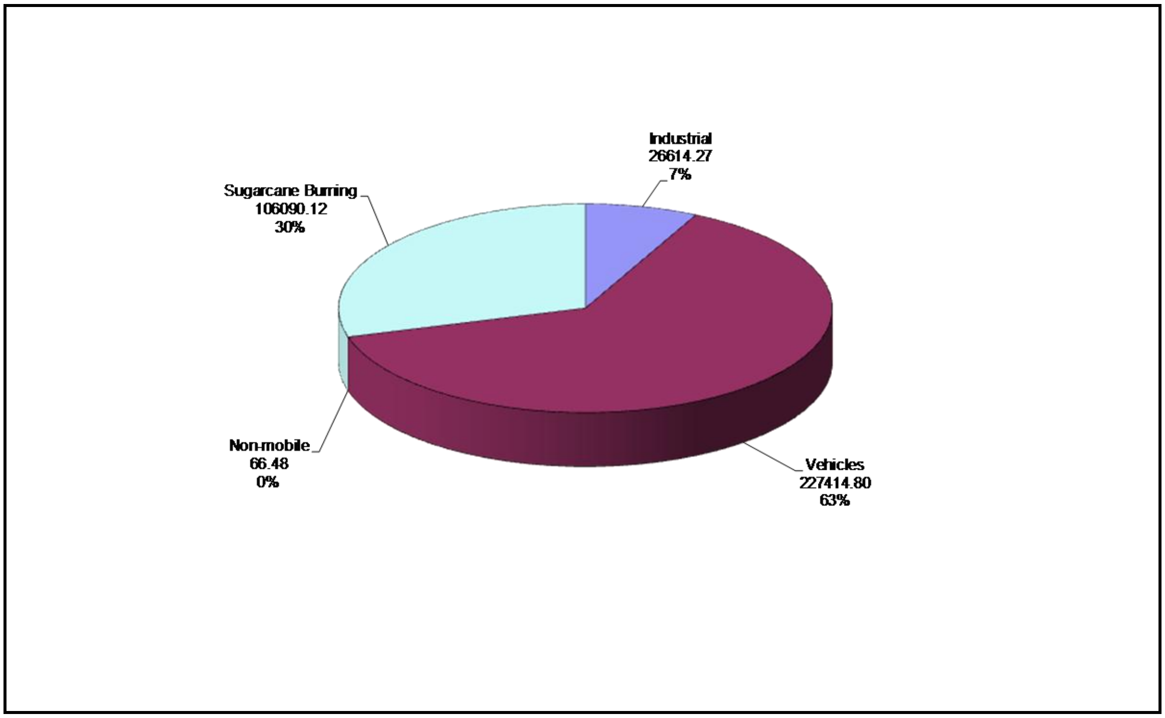


Figure 19 Sulphur dioxide emissions comparison

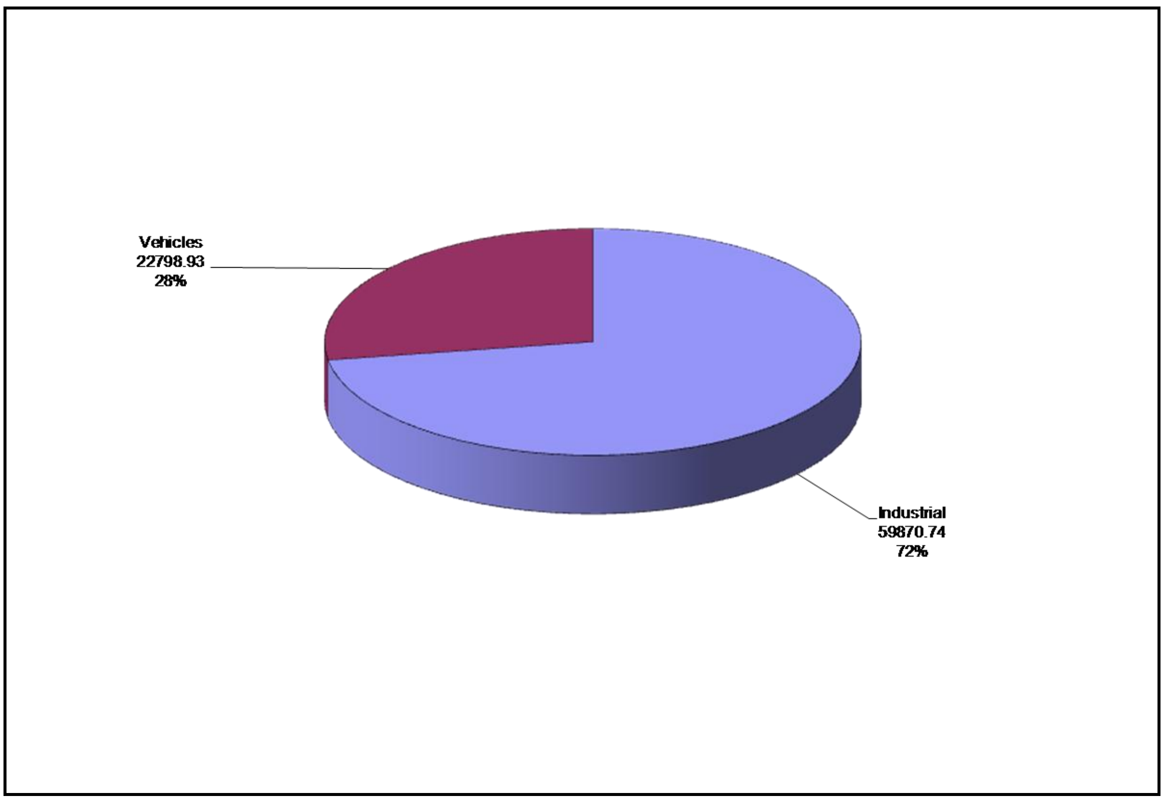


Figure 20: Overall carbon monoxide emissions comparison

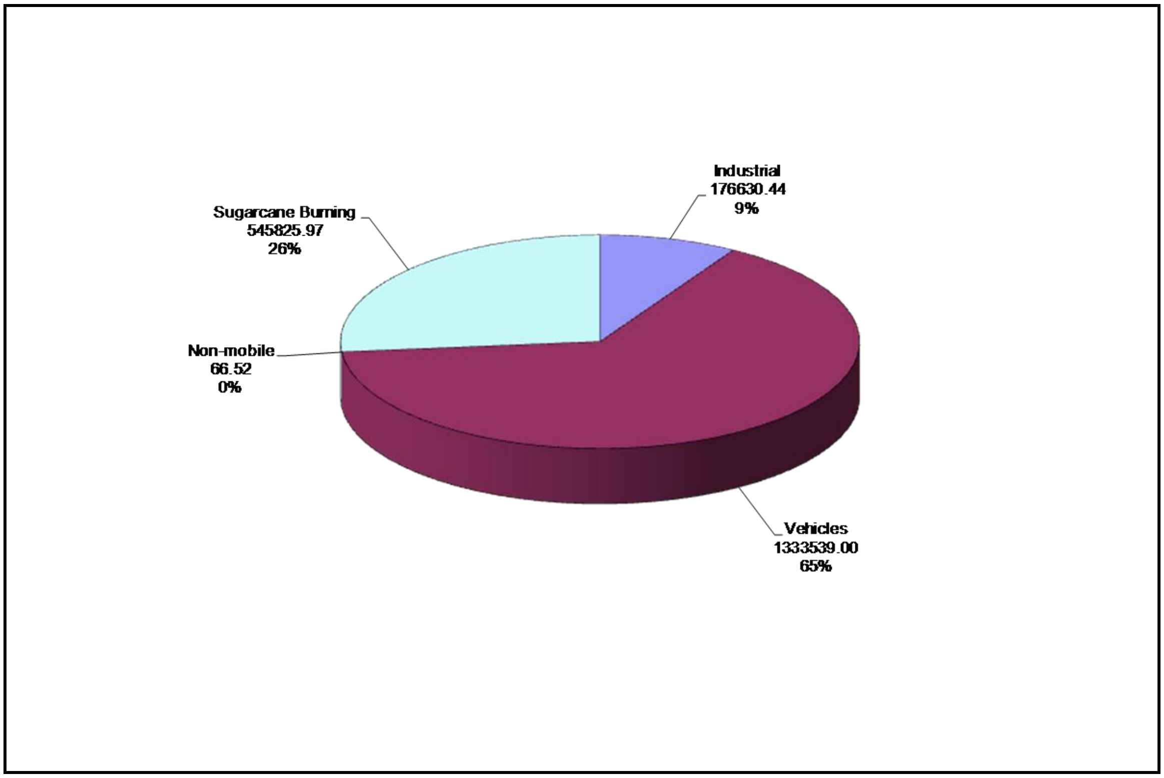


Figure 21: VOC overall emissions comparison

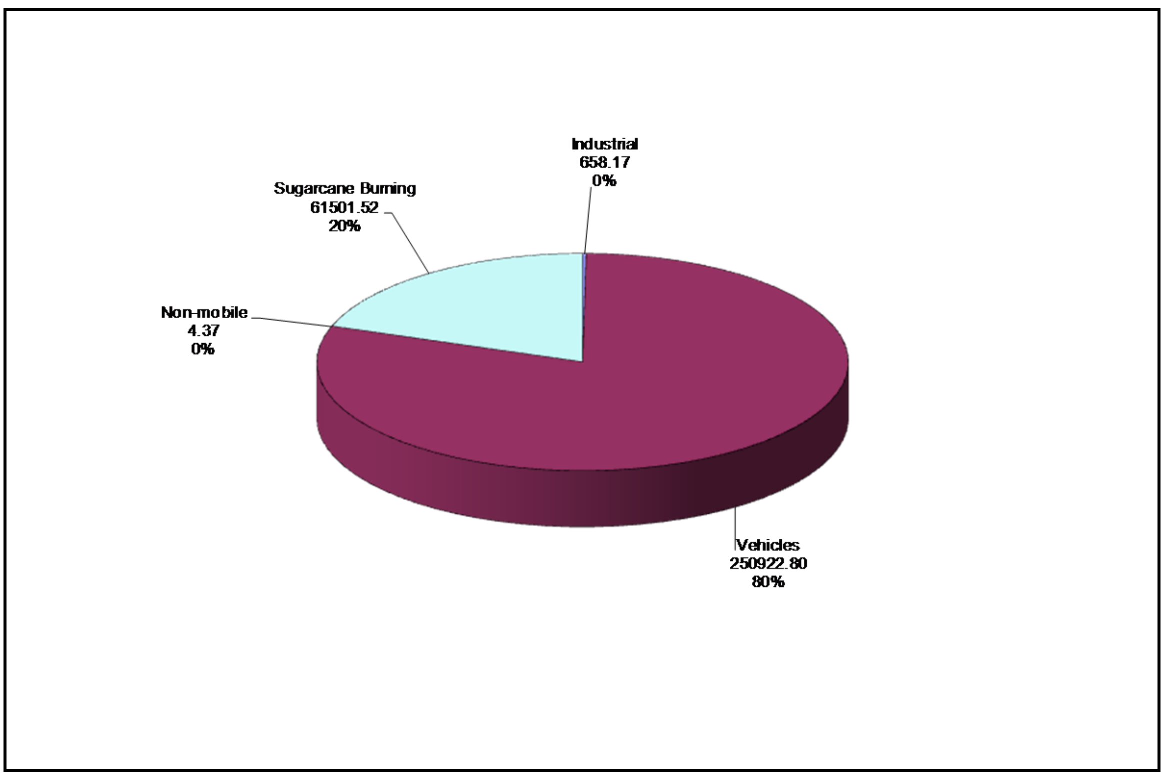


Figure 22: Lead

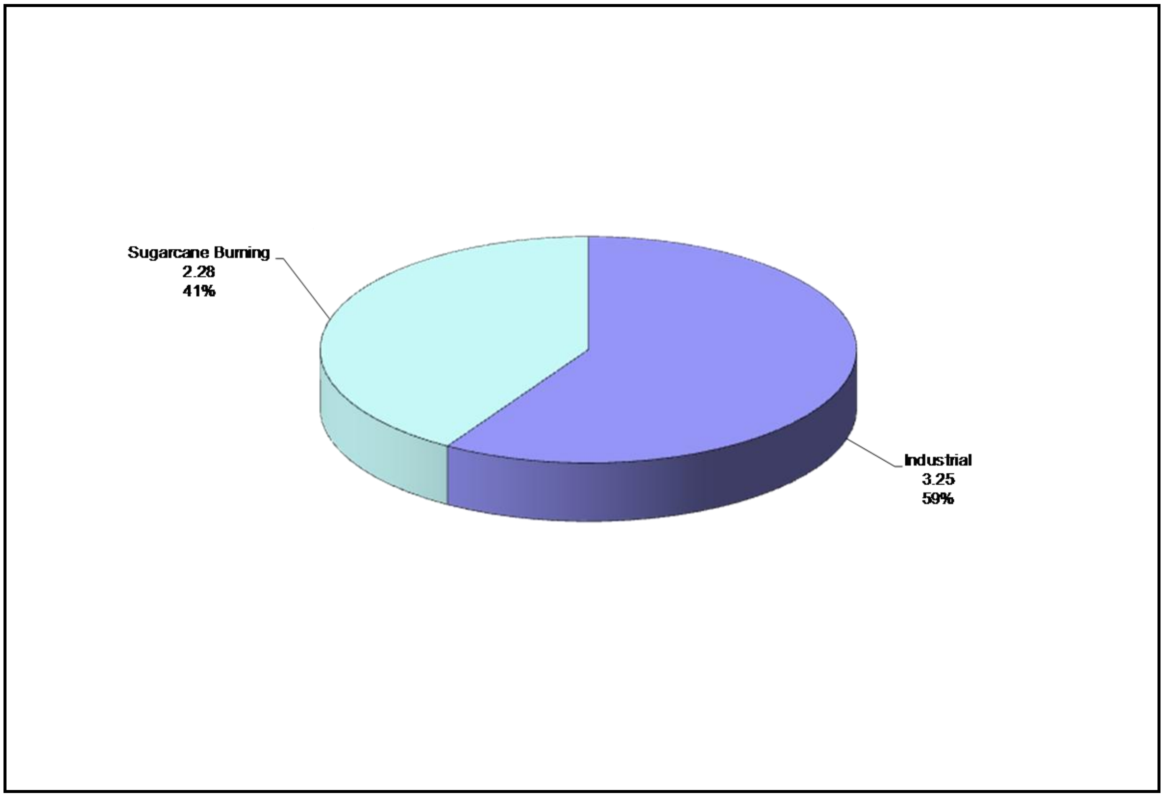


Figure 17 illustrates total emissions in KwaZulu-Natal per pollutant. The highest emissions in the province are carbon monoxide (70%) followed by 12% from oxides of nitrogen and 10% from volatile organic compounds. Vehicles are the major contributor of carbon monoxide followed by sugar cane burning.

Figure 18 presents total particulate emissions in KwaZulu-Natal. The highest contribution of 49% is vehicles followed by 40% from sugar cane burning. In figure 19 it is evident that vehicles remain the major contributor to the oxide of nitrogen emissions in the province followed by a 31% contribution from sugar cane burning. Industries are estimated to contribute only 2% of the oxide of nitrogen emissions.

73% of sulphur dioxide emissions are attributed by industries within the province, with only 23% from vehicles. Industries did not submit significant information on lead and figure 23 shows that 80% of lead is due to vehicle emissions followed by 20% from sugar cane burning. Although sugarcane contributes a significant amount of emissions, this report does not draw any conclusion regarding emissions from sugarcane burning since this source only contributes during a certain period of the year.

3. RECOMMENDATIONS AND CONCLUSION

1. It is recommended that vehicle emissions be modelled, although a fuel based approach was used. The principal concern of this approach is whether the emission factors calculated for the Brown Haze study accurately represent the current vehicle fleet composition in the KZN region. In particular it is important to take account of the emission class of vehicles e.g. whether 3-way catalysts are fitted to petrol-driven cars, and whether diesel vehicles have particle traps. In the absence of fleet composition data it is recognised that no other approach can be taken, but the limitations and uncertainty of the selected method should be clearly set out.

2. It is also important to recognise that the approach only takes account of hot exhaust emissions. Other road traffic sources of emissions include:

    - Cold start emissions – when the vehicle's engine is cold is emits pollutants at a higher rate then when it reaches operational temperature. This is particularly the case for vehicles equipped with catalytic reduction technologies;
    - Evaporative emissions – these include emissions of petrol vapour from the fuel tanks, which can represent a significant fraction of the total NMVOC emissions;
    - Particle emissions from brake and tyre wear, and road re-suspension – emissions from these sources may be equivalent to PM emissions from the tail pipe.

3. The province should systematically continue to improve emission inventories by applying sensitivity and uncertainty analyses and by comparing them to independent sources of measured data. Such comparisons will help identify subsequent improvement priorities.

4. In addition, the province should:

- Put pressure to those industries that did not submit returns to comply so that emissions can be more accurately quantified.
- Update this report once outstanding emission data is submitted.
- Consider the inclusion of veld fires, mining (quarrying), dirt roads, off-road sources, wind erosion, smaller facilities and agricultural activities in the second phase report.
- Define and implement standards for emission inventory structure, data documentation, and data reporting for local municipality emission inventories.

5. The emission inventory database should be constantly reviewed and updated.

4. REFERENCES

Calculating air emissions for the Michigan Air Emissions Reporting System (MAERS), Clean Air Assistance Program: Environmental Science and Services Division Michigan Department of Environmental Quality, January 2004

COEX Environmental Planners, Vehicular emissions for Kwazulu Natal

Durban Metro Emission Inventory (Results and Methodology), February 1988

Emission Inventory Spreadsheet, EThekwini Metro, 2004

EThekwini Metro, Air Quality Management Plan, April 2007-06-14

Newcastle Emission Inventory Report, February 2004 prepared by Newcastle City Council

RBCAA Emission Inventory Executive Summary, 2004 by ECOSERV

US EPA AP42 and Australian NPI Emission Estimation Techniques Manual

National Pollutants Inventory Emission Estimates Technique Manual for aggravated emissions from prescribed wildfires, September 1999 available at: http://www.npi.gov.au/handbooks/aedmanuals/pubs/burning_ff.pdf

http://en.wikipedia.org/wiki/KwaZulu-Natal_Province)

(http://www.kzntopbusiness.co.za/2005) for Sisonke, Umzinyathi, Zululand, Uthukela, Ilembe, Amajuba, Ugu and Umgungundlovu District Municipalities.

Umkhanyakude District Municipality Local Economic Development Initiative, May 2003 (http://devplan/kzntl.gov.za/idp_reviewed/IDPS/DC27/LED_REPORT.pdf))

Ugu District Municipality Integrated Development Plan 2004/2005

http://www.brabys.com)

RBCAA Annual Technical Report: 2005; Prepared by ECOSERV AQ002, 28 February 2006 (http://live.ecoserv.com) on (http://www.rbcaa.co.za)

Umhlathuze Municipality, Umhlathuze IDP REVIEW 2005/2006:)

Ethekwini Air Quality Monitoring Network Annual Report 2006 (http://www2.nilu.no/AirQuality/data/reports)