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A bottom-up air pollution emission inventory for Dakar

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Summary

Financed by the Nordic Development Fund (NDF), the Norwegian Institute for Air Research (NILU) has supported the Conseil Exécutif des Transports Urbains de Dakar (CETUD) in establishing the Centre de Gestion de la Qualité de l'Air (CGQA) with an Air Quality Monitoring and Management System for Dakar. This project is part of the component entitled as "Amelioration de la qualité de l'air en milieu urbain" (QADAK) of the "Programme d'Amélioration de la Mobilité Urbaine" (PAMU) operated by the Conseil Exécutif des Transports Urbains de Dakar (CETUD).

The current report summarises the contents of the bottom-up emission inventory developed for and by the CGQA for air pollutants in Dakar. The collection of emission data started in 2006 and continued until 2010. The identification of air pollutant sources in Dakar and the collection or estimation of their emission data have been a continuous work. Most of the collection work was carried out by CGQA, under the guidance and supervision of NILU. As data was collected, quality was controlled, gaps identified and gap filling work was defined by NILU for CGQA to undertake. Updating and gap filling of a bottom-up air emission inventory is a continuous task, which CGQA will continue to carry out based on the training and experience that they have developed during the last 4 years of the project.

1 Introduction

Emission inventories for air pollution sources are in many cases the basis for air quality assessment and management in cities. The spatial and temporal distribution of the emission sources is estimated as accurate as possible in the inventories. Atmospheric emissions are usually estimated either on the basis of emission measurements, or estimated based on fuel/product consumption or production data and emission factors for a specific activity or industrial process. The quality of the inventory is of great importance, since the data on emissions and emission conditions is used for air quality assessment and management of air pollution problems.

A bottom-up atmospheric emission inventory was developed for Dakar. It contains detailed information on emissions to air and on emission conditions (like stack heights, diameters, exhaust temperature, time variation, etc) for the main sources of air pollution in Dakar. The inventory was developed to meet the information needs of the air pollution dispersion models concerning emission to air. Dispersion models need detailed information on emissions to air and its sources and that is the reason why national top-down emission inventories cannot be used for modeling of air quality within a city or region.

2 Methodology

The atmospheric emissions inventory for Dakar was structured in order to enable all sources of air pollution within Dakar, Pikine and part of Rufisque to be included. An inventory typically includes information about the emissions from major industrial sources, estimates from smaller sources and from the various types of transport sources. In addition, common data for the emission inventory module of AirQUIS are included like fuels, source sectors and time variation for each emission.

The reference year for this emission inventory is 2005, as the work on emission data collection started in 2006 and the most updated data existent at the time was for the year 2005. Where available, data on activity projections for years after 2005 was also collected, in order to know of planned or projected activity developments. Unfortunately, projections on activity data were not available for most sources.

NILU has defined the structure of the emission inventory and delivered the AirQUIS emission module. The AirQUIS emission module contains the emission database and emission models for the storage and estimation of emission data, respectively. The collection of the necessary data for the emission inventory was designed and supervised by NILU and executed for the most by the CGQA experts. NILU has formed the CGQA experts on emission inventorying, including emission data collection and emission data estimates, gap analysis, gap filling and emission inventory update. Under the supervision of NILU, the CGQA has developed a quality manual for the emission inventorying (Ndiaye, 2007) and has written a detailed report on the emission data collected and its references, which wasn't complete at the date of the present report.

The main steps of the emission inventory work undertaken were:

- Identification of main sources in Dakar;
- Design of questionnaires for emission data collection;
- Preparation of a quality manual for the emission data collection;
- Data collection;
- Review and analysis of the collected data;
- Import of quality controlled data into the emission database;
- Identification of gaps;
- Fill in the gaps (by further data collection and/or by estimates);
- Compilation of documents collected and the sources of the collected emission data.

2.1 Geographical coverage

The current atmospheric emission inventory for Dakar was developed to cover Dakar city, the municipality of Pikine and part of the municipality of Rufisque. The area indicated in Figure 3 is the area covered by the air quality dispersion model and it is therefore the area for which air emission data was collected. The delimitation of this area was conditioned by factors like where the population density is the highest and how big the modeling domain can be contra the modeling resolution needed for air quality assessment and management in the Dakar area (Guerreiro and Dam, 2010).

2.2 Components included

The emission inventory was developed to cover the main air pollutants, used as indicators for the air monitoring network, for which there was some reliable emission data. The following components were included in the emission inventory:

- Nitrogen oxides (NO_x);
- Nitrogen dioxide (NO_2)
- Nitrogen monoxide (NO);
- Sulphur dioxide (SO_2);
- Particulate matter with diameter inferior to 10 µm (PM10);
- Carbon monoxide (CO);
- Volatile Organic Compounds (VOCs).

For more information on the criteria of choice of indicators for the air monitoring network see Sivertsen (2006). Note that ozone (O_3), measured by the monitoring network, is not included in the emission inventory. Ozone is not directly emitted by anthropogenic sources but formed in the atmosphere by the chemical reactions induced by anthropogenic pollutants such as NOx and VOCs in the presence of sun light.

2.3 Source sector classification

The source sector classification used in the emission inventory is based on the source sector classification developed by the DEEC (DEEC, 2007) and presented in Appendix 3.

The emission data collected for Dakar belonged to the following source sectors (in French):

- Agroalimentaire
- Industrie de boissons
- Industrie du Tabac
- Industrie Textile
- Industrie du Carton et du papier
- Materiaux, mineraux et metaux
- Raffinage de Pétrole
- Chimie, Parachimie, Caoutchouc
- Production d'electricité et de vapeur
- Engrais simples solides à base de nitrates
- Produits combustibles
- Gestion de déchets
- Émissions d'habitations privées

2.4 Types of sources

The emission inventory is divided into three types of sources, namely point, area and line sources:

<u>Point sources</u> - emission estimates are provided on an individual plant or emission outlet in conjunction with data on location, capacity or throughput, operating conditions etc. Typically industrial stacks are considered as point sources.

<u>Line sources</u> - vehicle emissions from road transport are provided for sections along the line of the road.

Area sources - smaller or more diffuse sources of pollution (home heating, public services, etc.) are provided on an area basis either for administrative areas, such as counties, municipality etc, or for regular grids.

3 Emission Inventory

This chapter gives an overview over the emission data collected, how it was collected and how it was organised in the emission inventory database of the AirQUIS emission module (Laupsa, H., 2008).

3.1 Point sources

Sources identified on an individual facility basis, emitting through stacks are called point sources. Refineries and industrial plants are examples of point sources. For the collection of the necessary emission data for the point sources, a questionnaire was developed (Appendix 2) and sent to the industries listed in Appendix 1. The CGQA experts visited the industries in order to:

- establish a direct contact between the CGQA experts and the industry,
- assure the good understanding of the questionnaire,
- assure an answer from the industries,
- collect information on stack coordinates and height,
- learn about the industrial processes and emission conditions,
- fill in gaps in the first collected data.

The visits started in the end of 2006 and continued until 2008. Some industries were visited or contacted more than once, in order to fill in identified gaps or clarify questions.

The list of main industries targeted by the emission inventory questionnaire developed by this project is presented in the Appendix 1. The list is based on the main industries with emissions to air extracted from the Annexe F – Fiches d'entreprise complétées of the "Étude sur la gestion de la pollution industrielle dans la baie de Hann (Base de données)". Direction de l'Environnement et des Etablissements Classés, 2005.

Unfortunately many industries did not answer the questionnaire. Since the CGQA has no legal mandate to compel the industries to report to CGQA on their emission data and emission conditions, the point source emission inventory was limited to the industries that voluntarily answered to the questionnaire.

3.1.1 Point sources database structure

The point sources emission database organises the necessary emission data in four information levels: industry, stack, cleaning device and process. The industries are connected to regions and sources sectors, previously defined for the region covered by the inventory. Figure 1 shows how the emission database for point sources is organised in the AirQUIS emission module.

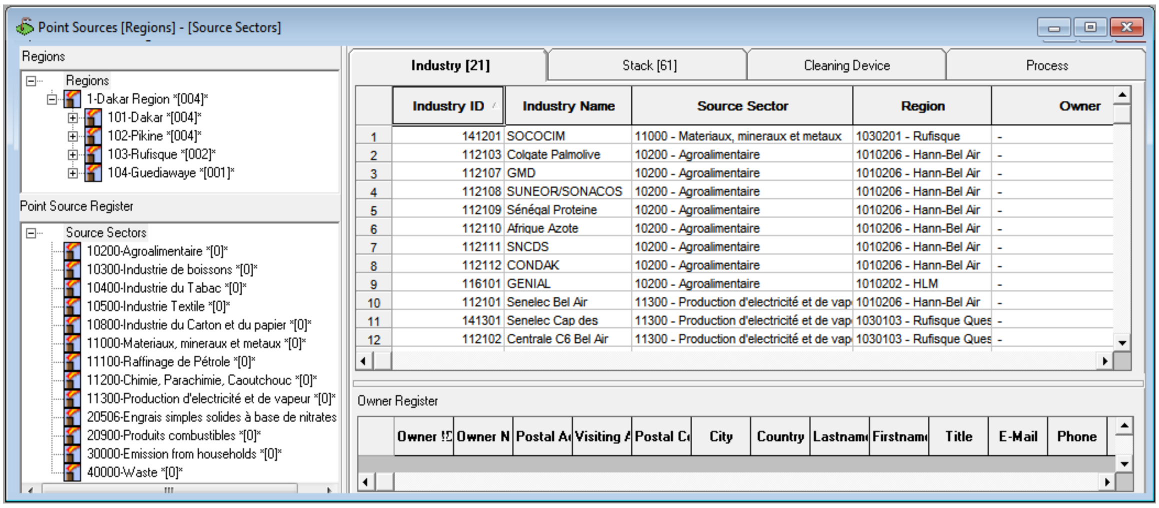


Figure 1: Structure of point sources emission data in AirQUIS.

<u>Regions</u>

Point source data is organized geographically i.e., industry data are connected to defined geographical regions. Regions can be used as a geographical filter, when searching for industries. By selecting a region in the point source emission module, all the industries belonging to the selected region (or sub-regions defined under that region) will be listed.

<u>Point source register</u>

The point source register organizes the industry data according to the source sector classification. Point source register uses source sector as a searching tool for industries and stacks or other point source properties. Thirteen source sectors were defined for Dakar, as explained in Chapter 2.3 and listed in Table 1.

Table 1: Defined source sectors for Dakar in AirQUIS

ID	Source Sector Name
10200	Agroalimentaire
10300	Industrie de boissons
10400	Industrie du Tabac
10500	Industrie Textile
10800	Industrie du Carton et du papier
11000	Materiaux, mineraux et metaux
11100	Raffinage de Pétrole
11200	Chimie, Parachimie, Caoutchouc
11300	Production d'electricité et de vapeur
20506	Engrais simples solides à base de nitrates
20900	Produits combustibles
30000	Émissions d'habitations privées
40000	Gestion de déchets

Industry

The industry register gives the overview of the industries covered by the emission inventory. Table 2 shows an extract from the database industry register. An industry, as defined here, can be any type of factory or group of factories that have some sort of process emissions to the air. 21 industries, in different source sectors, were registered in the database for Dakar. Each industrial plant has a unique ID and is located in a defined Region.

Table 2: Extract from the Industrial Register data in the Dakar emission database

Industrial Plant Register							
Industrial Plant ID	Name of Industrial Plant	Source sectors ID	Region ID	Owner ID	Source sectors Name	Region Name	Owner Name
112101	Senelec Bel Air	11300	1010206	1	Production d'electricité et de vapeur	Hann-Bel Air	Senelec
141301	Senelec Cap des Biches	11300	1030103	1	Production d'electricité et de vapeur	Rufisque Quest	Senelec
112102	Centrale C6 Bel Air	11300	1030103	2	Production d'electricité et de vapeur	Rufisque Quest	Senelec
141302	GTI Cap des biches	11300	1010206	3	Production d'electricité et de vapeur	Hann-Bel Air	Senelec
112103	Colgate Palmolive	10200	1010206	10	Agroalimentaire	Hann-Bel Air	Colgate Palmolive

Stack

The physical characteristics and geographical information of each stack within an industry, such as coordinate, height, diameter, gas temperature, velocity and gas flow, were collected or estimated for each stack registered in the emission inventory. The required stack data (Table 3) is necessary for the air pollution dispersion model and had therefore to be collected or estimated in order to have the necessary input emission data for the air quality modelling.

A total of 61 stacks, with the required data, were registered in the emission database. For the stacks which lacked information on gas velocity and gas flow rate, typical default values were assumed for the type of industry in question.

Table 3: Required stack data in the emission database

Stack data														
Stack ID	Stack name	X Co-ordinate	Y Co-ordinate	Stack height (m)	Stack Diameter (m)	Gas Temperature (C)	Gas Velocity (m/s)	Gas Flow Rate (m^3/s)	Building Height	Building Width	Industrial Plant ID	Time of Inventory	Note
11210101	105 CI	237688	1625460	16	0.85	480	20	23			112101	01.01.2007	2005 années des données
11210102	106 CII	237688	1625460	16	0.85	480	20	23			112101	01.01.2007	2005 années des données
11210103	TAG2	237686	1625455	16	2	575	20	23			112101	01.01.2007	2005 années des données
14130101	C3	252225	1628556	35	3	250	20	23			141301	01.01.2007	2005 années des données

Cleaning device

For the industries with cleaning devices, data about the type of cleaning device and on its efficiency have to be entered into the database. At the moment there is no data on cleaning devices included in the database for Dakar, as industries did not report the existence of cleaning devices in their facilities.

Processes

Each industry has usually several industrial processes generating air pollutants, that are then emitted through stacks. As most industries in Dakar did not have emission measurement data, the estimate of emissions from each process was based on the reported fuel consumptions.

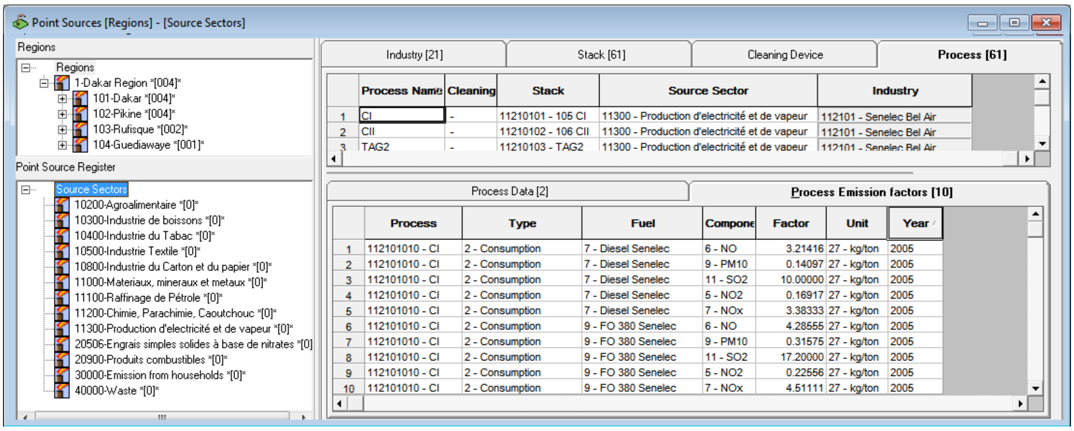


Figure 2 : Point sources - Process and process data register

In figure 2 the process data is displayed, as fuel consumption amount for each fuel type and for each process. The process data table is used for registration of the fuel consumption or emission data, including validity period, fuel consumed (i.e. the amount and unit), and finally a time variation.

Emission factors

Emission factors are ratios that relate emission of a specific component/pollutant to an activity such as fuel combustion. In the emission factors register, specific emission factors are defined for each type of process, each type of fuel and for each pollutant.

Point source time variation

A time variation for the point source emissions has been defined for each process, where data was available. Weekly, daily and hourly time variation data was imported into the database as an input for the emission model calculation.

3.1.2 Point sources emission data

In total, 21 industries answered the questionnaire, but only 15 of them provided valid data for the estimation of their emissions. Of these 15 industries, data for 61 stacks and processes was collected and included in the emission database. For each process, one may either enter directly emission data, usually based on emission measurements, or one may enter fuel consumption data and the correct emission factor for that fuel and process. Emissions for that process will be then calculated by multiplying the fuel consumption and the emission factor for that process and fuel.

For all the processes in Dakar included in the database, the emissions were estimated based on fuel consumption data reported by the industries, and an emission factor from the U.S. Environmental Protection Agency AP 42 Compilation of Air Pollutant Emission Factors (U.S. EPA, 1995). The reason for this is that in the great majority of the cases there were no certified emission measurement data available. In one case certified emission measurement data was available. However, the quality control of the emission data indicated that the emission measurements had been done under production conditions of about 10% of the normal process production.

Figure 3 shows the industries included in the emission inventory and their stack heights.

Table 4 shows the fuel types and their total yearly consumption used by different industrial processes and reported by the industries.

Table 4: Type of fuel and total fuel consumption by the industrial plants registered in the emission database for the reference year of 2005.

Fuel ID	Fuel Name	Using by industrial processes (%)	Consumption used by industry (tonnes/year)
1	Gasoil	15	7607
6	Diesel	8	4014
7	Diesel Senelec	6	23303
8	Fuel 380	14	2420
9	FO 380 Senelec	45	519277
10	FO 380 Senelec and Fuel Gaz	8	23651
18	Houille	5	167300

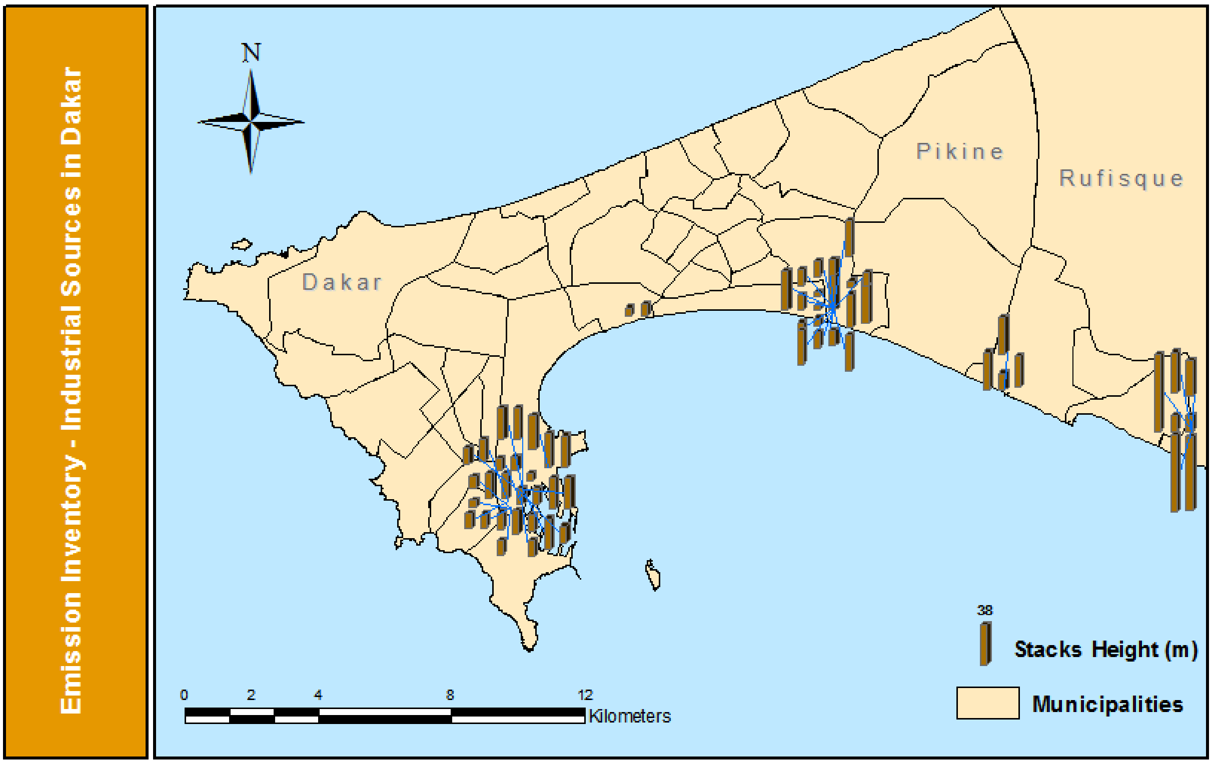


Figure 3: Emission Inventory in 2005- Industrial Sources in Dakar

In order to calculate the emission of SO_2, the most reliable method is to estimate the emission factor based on the sulphur content of the consumed fuels. The CGQA has therefore collected information on the sulphur content of the fuels used in Dakar, summarised in the Table 5.

Table 5: Sulphur content in percentage of weight collected by the CGQA for the types of fuels used in Dakar.

Fuel name	Sulphur content in % of weight
1. GASOIL	0.5
2. ESSENCE	0.15
3. SUPER	0.15
4. JETA1/PETROLE	0.15
5. Mélange 2T	0.15
6. Diesel	0.5
7. Fioul 180	3.5
8. Fioul 380	0.86

The emissions were calculated based on the above described method and are summarised in Table 6 for each industry and component. There are only two industries with CO emission data available and no data on VOC emissions is available for the industries.

Table 6: Total emissions for each component for each industry in the database.

Name	Emission (tonnes/year)					
	NOx	NO_2	NO	PM10	SO_2	CO
Senelec Bel Air	1051	52.5	998.2	49.7	2428	missing
Colgate Palmolive	12	0.6	11.1	0.7	106	missing
MTOA	1	0.1	1.3	0.1	14	missing
SAF	10	0.5	9.4	0.6	104	missing
GMD	14	0.7	13.5	0.6	42	missing
SUNEOR/SONACOS	27	1.3	25.5	1.7	284	missing
Sénégal Proteine	2	0.1	2.3	0.2	25	missing
SNCDS	1	0.1	1.4	0.1	16	missing
CONDAK	1	0.1	1.0	0.1	11	missing
SOTIBA	13	0.6	12.0	0.7	98	missing
La Rochette	3	0.2	3.3	0.2	37	missing
SAR	389	22.6	366.5	1.8	43	24
ICS	33	1.7	31.5	2.1	350	25
SOCOCIM	335	16.7	318.0	1.0	47	missing
Senelec Cap des Biches	2399	119.9	2278.9	114	6255	missing
Total Industry	**4291**	**218**	**4074**	**173**	**9859**	**49**

3.1.3 Point sources inventory main gaps

The main gap of the point sources emission inventory is the lack of emission data for CO and VOCs from the industries. In addition, only 15 out of the 48 target industries by the questionnaire have responded with acceptable quality data, which leaves a significant number of industries that still have to be covered by the inventory. As a next step, the CGQA should coordinate their inventory work with the DEEC, in order to assure a better response from the industries and avoid demanding from the industries to respond to different questionnaires and requests on related data.

The CGQA is applying for financing to develop competences and buy instrumentation to do emission measurements on stacks. Stack emission measurements would improve the inventory considerably, if done under average production conditions and by the internationally defined standards, for example the U.S. EPA Promulgated Test Methods (published between 1996 and 2009, available at http://www.epa.gov/ttn/emc/promgate.html).

3.2 Line sources

Line sources cover typically vehicle emissions from road transport and are provided for sections along the line of the road. Also included as line sources are emissions from fuel powered trains, like the "Petit Train Bleu de Banlieue" in Dakar, and emissions from maritime transport routes. All these emission should be handled as line sources in the AirQUIS emission inventory module.

The traffic data used to estimate the emissions from the road traffic in Dakar was generated by the GMAT Canadian consultancy company, using the EMME2 traffic model and based on traffic countings executed by GMAT to generate the necessary input data to the traffic model (GMAT, 2006). The reference year of the modelled traffic date was 2003. NILU has updated GMAT's traffic volume estimates to the emission inventory reference year of 2005, based on the 4% increase of petrol sold in petrol stations in Dakar between 2003 and 2005.

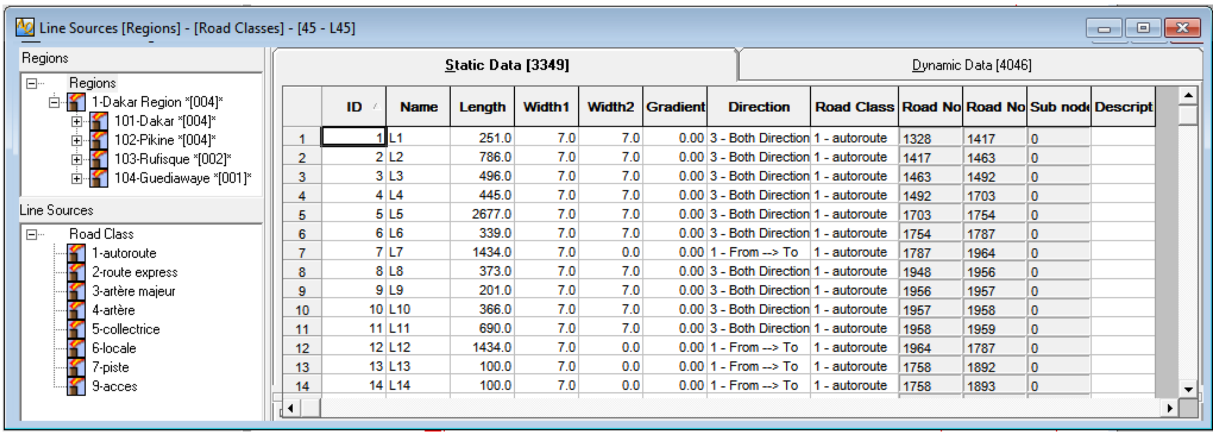
Data on vehicle fleet composition in Dakar was extracted and provided by the Direction des Transports Terrestres (DDT, 2004).

3.2.1 Line sources database structure

This chapter summarises the structure and contents of the emission database developed for Dakar. For more detailed information on the structure and data required in the AirQUIS line sources emission database, see the AirQUIS Emission Module User's Manual (Laupsa, 2008).

The line sources emission database organises the necessary traffic data in two main levels for each road link as static data and dynamic data. The road links are connected to regions and road classes, which have previously been defined. Figure

4a shows how the emission database for line sources is organised in the AirQUIS emission module.



	ID	Name	Length	Width1	Width2	Gradient	Direction	Road Class	Road No	Road No	Sub node	Descript
1	1	L1	251.0	7.0	7.0	0.00	3 - Both Direction	1 - autoroute	1328	1417	0	
2	2	L2	786.0	7.0	7.0	0.00	3 - Both Direction	1 - autoroute	1417	1463	0	
3	3	L3	496.0	7.0	7.0	0.00	3 - Both Direction	1 - autoroute	1463	1492	0	
4	4	L4	445.0	7.0	7.0	0.00	3 - Both Direction	1 - autoroute	1492	1703	0	
5	5	L5	2677.0	7.0	7.0	0.00	3 - Both Direction	1 - autoroute	1703	1754	0	
6	6	L6	339.0	7.0	7.0	0.00	3 - Both Direction	1 - autoroute	1754	1787	0	
7	7	L7	1434.0	7.0	0.0	0.00	1 - From --> To	1 - autoroute	1787	1964	0	
8	8	L8	373.0	7.0	7.0	0.00	3 - Both Direction	1 - autoroute	1948	1956	0	
9	9	L9	201.0	7.0	7.0	0.00	3 - Both Direction	1 - autoroute	1956	1957	0	
10	10	L10	366.0	7.0	7.0	0.00	3 - Both Direction	1 - autoroute	1957	1958	0	
11	11	L11	690.0	7.0	7.0	0.00	3 - Both Direction	1 - autoroute	1958	1959	0	
12	12	L12	1434.0	7.0	0.0	0.00	1 - From --> To	1 - autoroute	1964	1787	0	
13	13	L13	100.0	7.0	0.0	0.00	1 - From --> To	1 - autoroute	1758	1892	0	
14	14	L14	100.0	7.0	0.0	0.00	1 - From --> To	1 - autoroute	1758	1893	0	

Figure 4a: Line sources data in the AirQUIS emission database. More specifically an extract of the static data for the road links in the Dakar database.

<u>Regions</u>

Line sources are organized geographically, e.g. coordinates define the road links. The regions are used as a geographical filter searching for road links in the line source window. By selecting a region in the line source emission module, all the road links belonging to the selected region (or sub-regions defined under that region) will be listed.

<u>Road Classes</u>

The line source register organizes the road links according to the road classification, previously defined. Line source register uses road class as a searching tool for road links in the line source window.

The road classes used for Dakar are the same as defined in GMAT's traffic study (GMAT, 2006) (in French):

1. autoroute
2. route express
3. artère majeur
4. artère
5. collectrice
6. locale
7. piste
8. acces

Road nodes

Road nodes define the start and end point for a road link. In the present emission inventory the same road nodes identification numbers were used as defined in GMAT's traffic study (GMAT, 2006). The determination of the road nodes coordinates was done using ArcGIS and the road nodes maps produced by GMAT, sometimes supported by a satellite picture of Dakar. For a full description of the used procedures for georeferencing and for adding road nodes see Randall (2008).

Static traffic data

A road link is a segment between two road nodes, where the static classification and dynamic traffic data are homogenous for the length of the segment connecting a start and end node. The static road data define the static properties of the road link like length, width, gradient, etc. Figure 4a shows an extract of the static data included in the AirQUIS database.

Dynamic traffic data

The dynamic traffic data describes the traffic flow in each driving sense of the road links, like traffic volume (i.e. annual daily traffic; ADT) and average driving speed. Figure 4b shows an extract of the dynamic data included in the AirQUIS database.

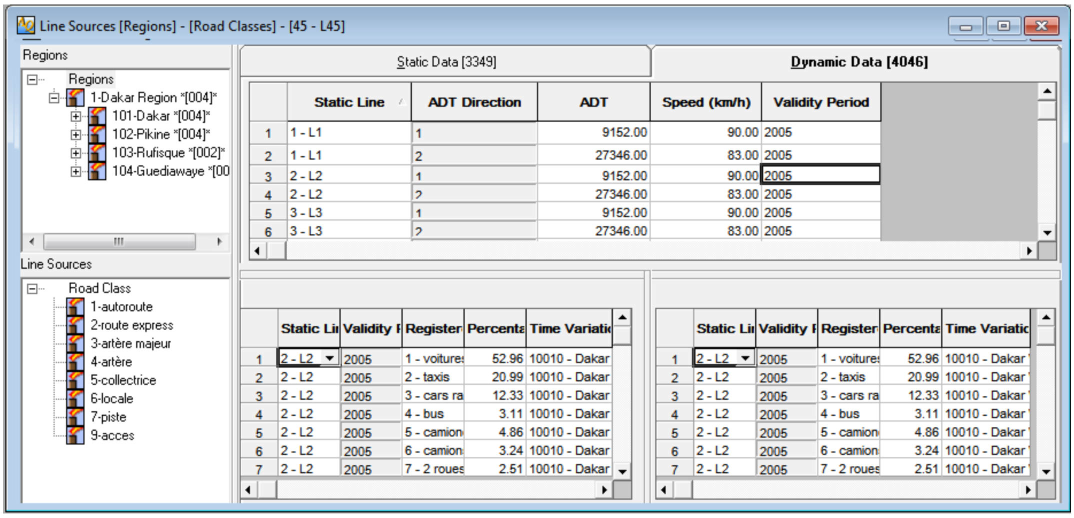


Figure 4b: Line source database - an extract of the dynamic data for the road links in the Dakar database.

Vehicle distribution

Road link vehicle distribution defines the percentage (%) of Registered Vehicle Classes (RVC) and time variation on each road link.

Vehicles in Dakar were divided into seven classes, as shown in Table 7. The vehicle distribution data for Dakar (presented as Vehicle Class Fraction % in Table 7) is based on the data available in Simon & Christiansen (2000).

Table 7: Vehicle classes defined for Dakar and the percentage of each vehicle class circulating in Dakar's roads.

ID number	Road Vehicle Class (RVC) Name	Vehicle Class Fraction %
1	voitures particulieres (VP)	53,0
2	taxis	21,0
3	cars rapides et minicars	12,3
4	bus	3,1
5	camionettes	4,9
6	camions	3,2
7	2 roues motorisés	2,5

Traffic emission factors

The emission factors are specifically defined for the different factors affecting the emissions, such as components, each vehicle class, fuel type; and speed. An example from the AirQUIS database is shown in Figure 4c.

The traffic emission factors for Dakar were defined based on emission factors available in the literature and taking into account the age and type of vehicles in Dakar. This approach was necessary as specific emission factors for the vehicle fleet in Dakar are not available. The CGQA is planning to undertake vehicle emission measurements, which will allow them to estimate specific emission factors for the traffic in Dakar and update the current database.

The current emission factors in the database are extracted from COPERT III (Ntziachristos and Samaras, 2000). The highest emission factors were assumed for the vehicle categories in Dakar, like Pre-ECE for light gasoline vehicles (VP) or EURO I for heavy duty vehicles. Still the emission factors for exhaust particles are probably underestimated, as many vehicles in Dakar emit notorious amounts of black carbon particles, rarely observed in the European car fleet.

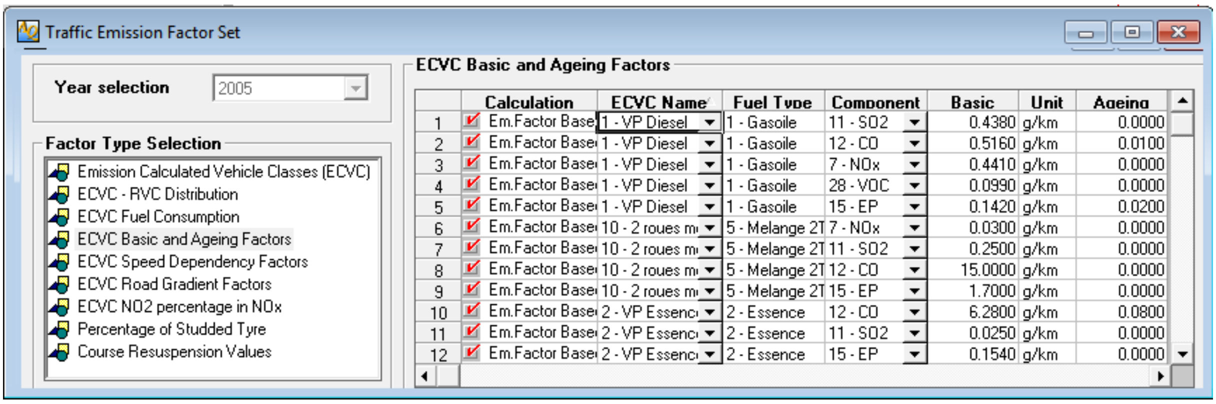


Figure 4c: Extract of traffic emission factors for the vehicle categories in AirQUIS database.

3.2.2 Line sources emission data

Calculations of emissions from road traffic are based on sets of emission factors for each component and for each vehicle class, as explained in the previous chapter. The emission factors are dependent of several parameters, like for example fuel (typically diesel or gasoline), traffic speed, road slope and average age of the vehicle fleet.

The emission of the different components from the traffic flow on each road link is a function of:

- traffic volume for each vehicle category;
- driving speed on each road link;
- road gradient of each road link;
- average age of vehicles for each vehicle category;
- the percentage of each vehicle class on the road links.

Traffic emissions were calculated by the AirQUIS emission model for each road link and for the components NO_x, NO_2, NO, EP (Exhausted Particles), CO and VOCs, as:

$$Q_1 = \frac{ADT\,[vehicle/day]}{86400\,[s/day]} \times \frac{\%\,ECVC\ of\ RVC}{100} \times BF\,[g/km \times vehicle] \times \frac{1km}{1000m}$$

Where:

Q_1	= Emission [g/s*m]
ADT	= Annual Daily Traffic
% ECVC of RVC	= Percentage Emission calculation vehicle class (ECVC) of a Registered Vehicle classes (RVC)
BF	= Basic Emission Factor

The emission from a vehicle will normally change with the age of the vehicle. Therefore an ageing factor must be specified in the AirQUIS database. The ageing factor is defined as "change per accumulated driving distance" and the age corrected emission factor is estimated as:

$$Q_2 = Q_1 * (1 + S * AgeingF)$$
$$S = (ECVC_{Year} - ECVC_{Average\ Model\ Year}) * ECVC_{Average\ Driving\ Distance} / 10000$$

Where:

Q_2	= Emission from vehicle, with total driving distance S
Q_1	= Emission from new vehicles
S	= Number of 10 000 km (S=8 corresponds to 80 000 km)
AgeingF	= Factor which represents the increase emission with increasing driving distance.

Table 8 shows the average vehicle model year and average driving distance assumed for each Emission Calculated Vehicle Class (ECVC) in Dakar. The data was estimated based on the available data (i.e. Simon & Christiansen, 2000) and corrected for the reference year of the emission inventory, 2005.

Table 8: Average vehicle model year and average driving distance assumed for each Emission Calculated Vehicle Class (ECVC) in Dakar.

ID	Name	Average Model year	Average Driving Distance (km/year)	Vehicle Class ID	Fuel Type ID
1	VP Diesel	1988	14228	1 - voitures particulieres (VP)	1 - Gasoile
2	VP Essence	1988	14228	1 - voitures particulieres (VP)	2 - Essence
3	Taxis Diesel	1988	60000	2 - taxis	1 - Gasoile
4	Taxis Essence	1988	60000	2 - taxis	2 - Essence
5	cars rapides et minicars Diesel	1989	73000	3 - cars rapides et minicars	1 - Gasoile
6	cars rapides et minicars Essence	1989	73000	3 - cars rapides et minicars	2 - Essence
7	bus	1985	72000	4 - bus	1 - Gasoile
8	camionettes	1985	12977	5 - camionettes	1 - Gasoile
9	camions	1985	12977	6 - camions	1 - Gasoile
10	2 roues motorisés	1998	9606	7 - 2 roues motorisés	5 - Melange 2T

In general, the vehicles in Dakar are quite old. Most of the vehicles were produced in 1980s. Taxis, "cars rapides" and "minicars" have very large average driving distances per year.

The traffic emissions depend on the road gradient, for road links where the start and end nodes are not at the same altitude, as shown by the formula:

$$Q_3 = Q_2 * Road\ Gradient\ Factor$$

If the road link is flat, the road gradient factor is set to 1. As Dakar is a rather flat city, and no road gradient data was available for each road link, a road gradient of 1 was assumed for all road links.

The traffic emissions are dependent on the driving speed, as shown by the formula:

$$Q_4 = Q_3 * Speed\ Dependency\ Factor$$

A speed dependency factor is defined for each component and each ECVC. For the Dakar database, the speed dependency factors extracted from COPERT III (Ntziachristos and Samaras, 2000) were used. Figure 5 shows, as an example, the speed dependency factors used for the vehicle category "voitures particulieres" for NOx, SO_2 and CO.

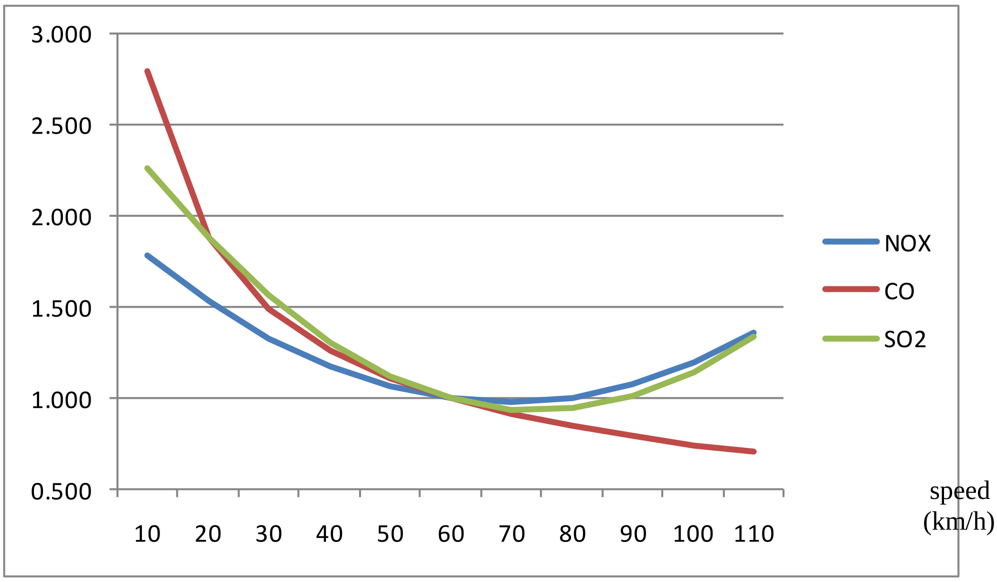


Figure 5: Speed dependency factor for "voitures particulieres" (VP). On the vertical axis the speed dependency factor, on the horizontal axis the average driving speed expressed in km/hour.

Time dependency

In order to account for the time variation of the traffic flow, time variation factors have to be inserted in the database for traffic. Based on the time variation factors, the traffic emissions are calculated for each specific hour of the year, as described by:

$$Q = Q*TV_{hour}*24*TV_{day}*7*TV_{week}*52$$

Where:

Q = Emission
TV_{hour} = Time variation for the hour
TV_{day} = Time variation for the day
TV_{week} = Time variation for the week

Since each time variation sum up to one, we have to multiply the hourly time variation with 24, the daily time variation with 7 and the weekly time variation with 52 in above equation.

The time variations assumed for the traffic in Dakar are shown in Figures 6a, 6b and 6c for weekly, daily and hourly variations, respectively. The time variation factors are based on traffic countings from 2002 and seasonability data for Dakar extracted from "Recensement de la Circulation 2002 - Rapport de AATER".

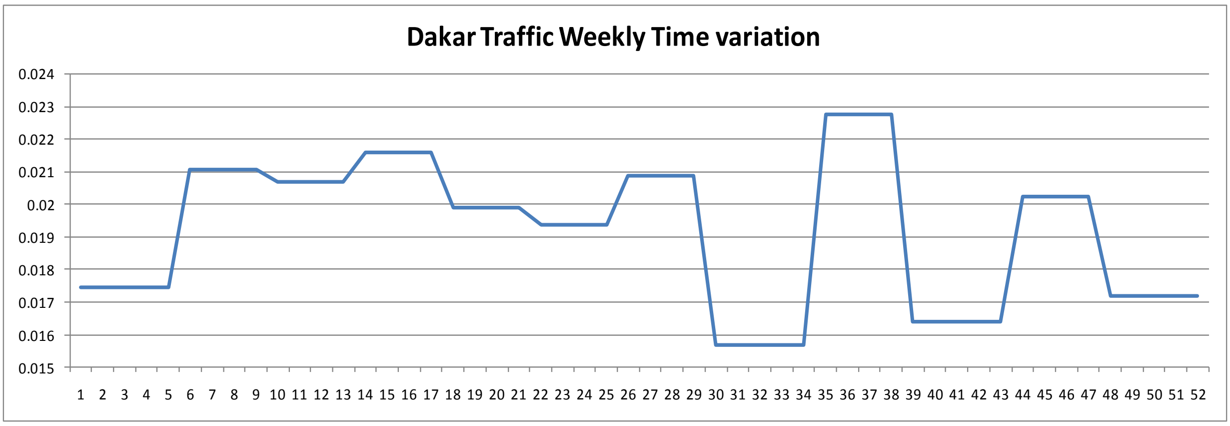


Figure 6a: Dakar traffic volume weekly variation. The horizontal axis refers to the 52 weeks of the calender year. The vertical axis is the calculated AirQUIS weekly factor.

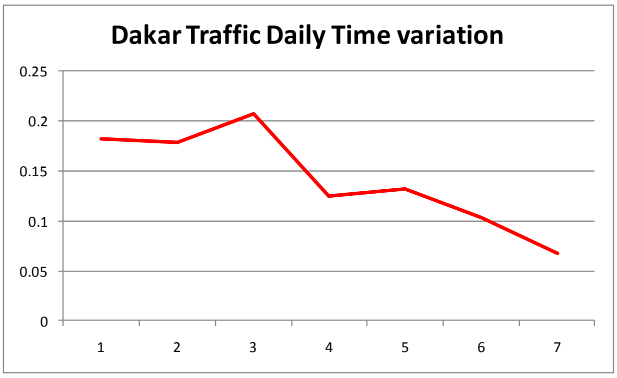


Figure 6b: Dakar traffic average daily time variation, The horizontal axis shows days of the week; day 1 corresponds to Monday and day 7 corresponds to Sunday. The vertical axis is the calculated AirQUIS daily factor.

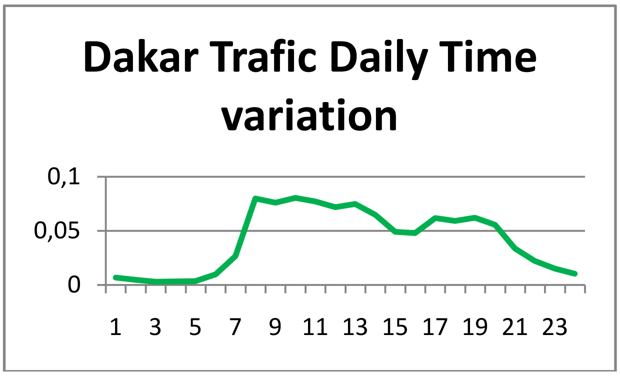


Figure 6c: Dakar traffic average hourly time variation for the hours of the week (in the horizontal axis). Day 1 corresponds to Monday and day 7 corresponds to Sunday.

In summary, Figure 7 shows the road network built in the AirQUIS emission database and GIS for Dakar. The Figure shows the total traffic volumes (as annual daily traffic) for each road link of the road network. Table 9 summarises the total number of road links in the road network and the number of road links with available ADT data.

Table 9: Number of road links and Annual Daily Traffic (ADT) available.

Road links data in Dakar	Value	
Number of links	3349	
Number of links with traffic volume data (ADT) available	2785	
Average ADT in a road link	4183	
Number of links which have ADT < 500 and percent of total	470	17%
Number of links which have 500 < ADT < 3000 and percent/total	1038	37%
Number of links which have ADT > 3000 and percent of total	1277	46%

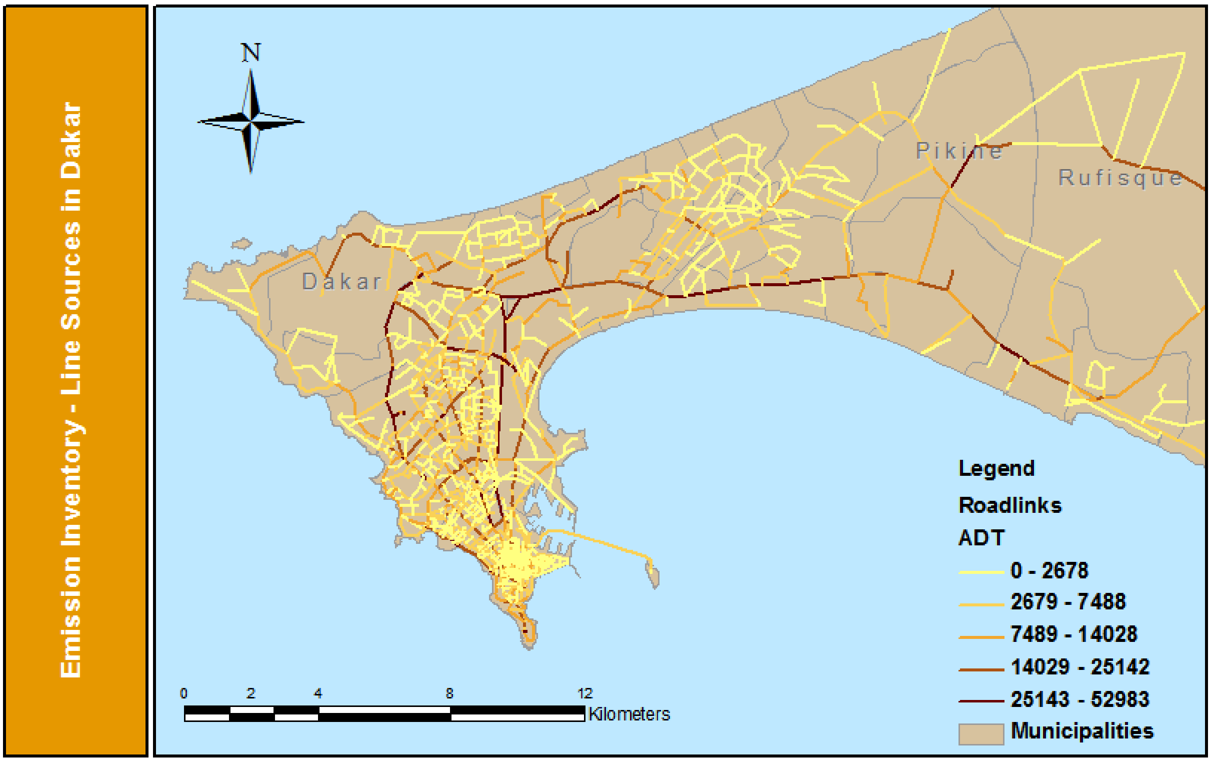


Figure 7: Visualization of annual daily traffic (ADT) on each road link of the road network in Dakar.

The total emissions from the traffic sources in Dakar are presented in Table 10 for all the components included in the emission inventory, and for the inventory reference year of 2005. They were calculated by the AirQUIS emission model, based on the data described in this chapter.

Table 10: Total traffic emissions in Dakar calculated by the AirQUIS emission model for components included in the emission inventory and for the reference year of 2005.

Source	Emission (tonnes/year)						
	NOx	NO_2	NO	PM10	SO_2	VOC	CO
Traffic	8920	1025	7895	976	1030	2232	51263

3.2.3 Line sources inventory main gaps

The current line sources emission inventory only covers road traffic at the present date. Activity data and fuel consumption data for the Petit Train Bleu de Banlieue and the regular maritime traffic within the modelled region will have to be included in the database as the next step in the CGQA's emission inventory work.

Concerning the road traffic emissions, the update of the road network (road nodes and road links) in currently being done by the CGQA, but the CGQA will also need to update the dynamic traffic data, as soon as updated traffic countings or/and traffic model results are available. As earlier stated, if the CGQA gets the necessary financing to do vehicle emission measurements, it will be able to update the traffic emission factors for the specific vehicle classes in Dakar.

3.3 Area sources

Area sources are usually smaller or more diffuse sources of pollution. Emissions from area sources are associated to an area, typically either to defined administrative areas, such as counties, municipality etc, or to regular grids.

3.3.1 Area sources database structure

The required data for area source includes:

- The definition of area source data sets;
- For each defined dataset, the emission rates or consumption values and an emission factor;
- Each defined dataset has associated emissions to defined geographical regions or grid cells.

Figure 8 shows an example of the area source sets defined for Dakar. Each area source set is defined by an ID number and a name and is related to a predefined source sector and emitted component. Then for each sub-region (in Dakar's case, "commune d'arrondissement") or for each grid cell it has attributed an emission rate (or consumption rate and an emission factor) and a time variation for that specific source.

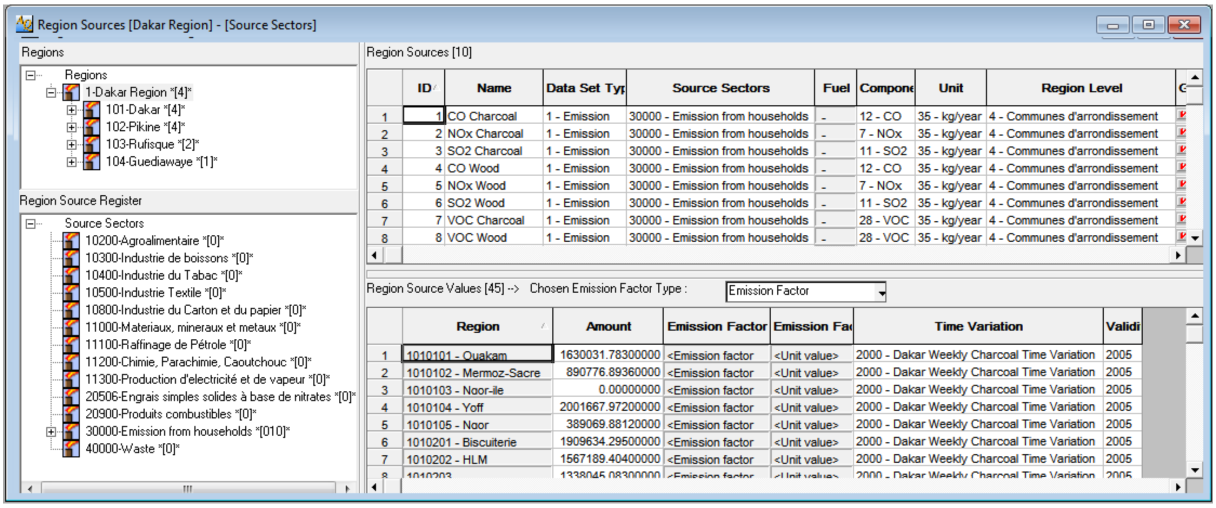


Figure 8: Dakar area emission in AirQUIS database

Consumption from region/area sources is used to calculate emissions from the region sources of the chosen component, according to:

Q = Consumption x "Consumption Emission Factor"

The area emissions are then converted from the regions (polygons) values into grid cell (field) values, as part of the preparation of emission input data for the dispersion model. For instance the emission calculated in region A will be distributed between all the grid cells that are in contact with region A (e.g. marked with • in Figure 9), according to the equation:

$$Value\,in\,Grid\,cell = \frac{Total\,emission\,in\,region\,A \times Area\,of\,grid\,cell\,inside\,region\,A}{Area\,of\,region\,A}$$

It is assumed that the total emission from the region sources in a region is homogeneous distributed within that region.

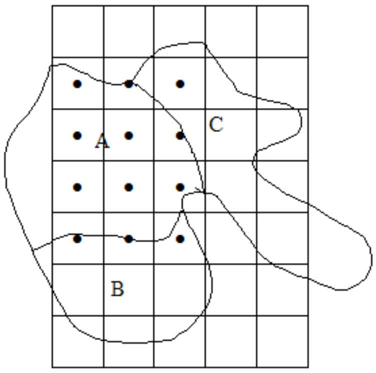


Figure 9: The region emission values are converted into model grid cell values. A, B and C are different regions, each with an attributed homogenous emission rate (in g/s).

3.3.2 Area sources emission data

The two area emission sources included in the database for Dakar are:

- Emissions from charcoal consumption in households and artisanal activities;
- Emissions from wood burning in households and artisanal activities.

For both sources, the emissions were calculated based on population data for each "commune d'arrondissement" and consumption of charcoal and wood in Dakar.

Based on data from Caho (1993), a charcoal consumption of 0,51 kg/day/person for the Dakar city and of 0,62 kg/day/person for the sub-urban areas of Dakar "banlieu" were estimated. The wood consumption per capita was estimated based on the data in the report "Consommation de bois de chauffe et de charbon de bois" (from Statistique DRS P). One third of the total wood consumption in the great Dakar region was attributed to Dakar city and two thirds to Dakar sub-urban areas/"Banlieu". The wood consumption was then attributed to each "commune d'arrondissement", based on population distribution.

The emission factors used to estimate emissions of charcoal and wood consumptions were extracted from Bhattacharya et at (2002), with the exeption of the emission factor for SO_2 emissions from wood burning, which was extracted from Environment Australia (2002).

After the calculation of the area emissions of NOx, NO_2, NO, SO_2, CO and VOCs, as described previously, the emissions were imported into the AirQUIS area sources database, linked to the geographical regions "commune d'arrondissement". Figure 10 shows, as an example, the CO emissions from charcoal consumption in Dakar.

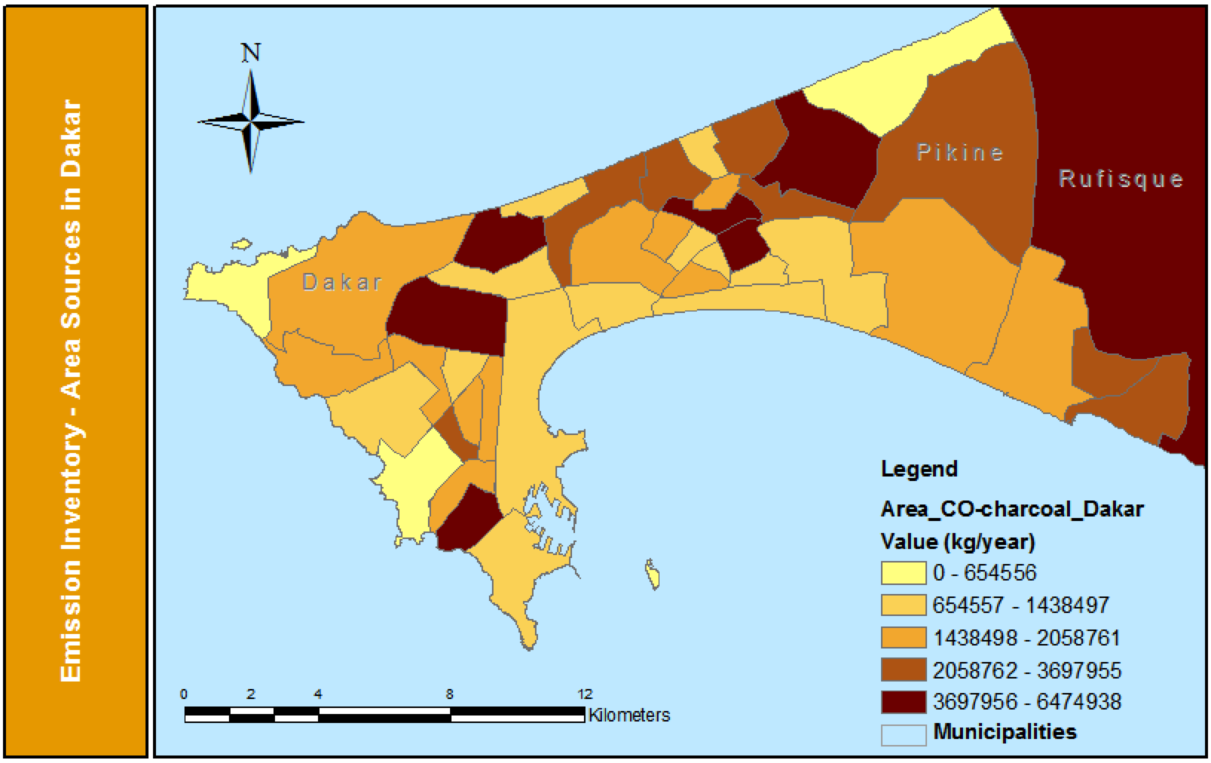


Figure 10: CO emissions from charcoal consumption in Dakar.

Table 11: Total emission from the area sources included in database for Dakar.

Source	**Emission (tonnes/year)**						
	NOx	**NO_2**	**NO**	**PM10**	**SO_2**	**VOC**	**CO**
Wood Burning	7.6	0.8	6.84	missing	7.6	731	1717
Charcoal Burning	107.0	10.7	96.34	missing	97.4	8612	96340
Area	114.6	11.5	103.18	missing	105	9343	98057

Area sources contribute a large amount to the CO emissions in Dakar with 98057 tonnes/year, which double the amount of CO emission emitted by traffic (i.e. 51263 tonnes/year of CO).

3.3.3 Area sources inventory main gaps

The main identified gaps of the area sources emission inventory are:

- Emissions from waste burning in Dakar, including from spontaneous combustions at the waste landfill of Mbeubeuss;
- Emissions from Dakar's harbour activities;
- Emissions from Dakar's airport;
- Diffusive emissions of VOCs from petrol stations;
- Diffusive emissions of VOCs from storage tank fields;
- Emissions from private electricity generators.

The gaps listed above have been identified in 2008, and the CGQA has undertaken several actions to collect the necessary data to include the above mentioned sources in the emission inventory as area sources. Unfortunately at this date some necessary data is still missing and these sources could therefore not be included. The collection and review of the remaining necessary data will be the next task for the CGQA emission experts in order to complete the area sources emission inventory. In addition, the PM10 emissions from the already defined area sources must be estimated.

3.4 All sources

Table 12 shows the total emissions by source type for all the sources included in the AirQUIS emission database. It is important to note that the database does not contain emission information for all the industries operating in Dakar, but it is estimated that the majority of the industrial emissions of NOx, NO_2, NO and SO_2 are included, as the most important industries in Dakar have provided data for those components. The area sources inventory has also important gaps, as several important sources aren't yet included in the inventory.

Nevertheless, from the figures presented in Table 12 and from the known emission conditions for the different types of sources, it can be concluded that traffic is the anthropogenic source with the most important impact on ground level ambient concentrations of NOx, NO and NO_2 and probably particulate matter. Traffic emissions occur at ground level and have therefore a direct impact on ground level air pollutant concentrations and population exposure to those air pollutants.

Area emissions, for instance from combustion of charcoal and wood in households and from open waste burning, are important sources of CO and particulate matter and have an important impact on ground level air concentrations, both ambient and indoor (as the wood and charcoal are often burned indoors). Emissions from area sources give therefore an important contribution to the population exposure to air pollutants.

Table 12: Main sources of air pollution in Dakar

Source	Emission (tonnes/year)						
	NOx	NO_2	NO	PM10	SO_2	VOC	CO
Industry	4291	218	4074	173	9859	missing	49*
Traffic	8920	1025	7895	976	1030	2232	51263
Area	115	11.5	103.5	missing	105	9343	98057
Total	**13326**	**1254**	**12072**	**1150**	**10994**	**11575**	**149369**

(*) Data from 2 of 15 main industries in Dakar, missing data for the others

The industrial sources are the major source of SO_2 in Dakar, and an important source of NOx, including NO_2 and NO. The diffusive emissions of VOCs in the Bel Air industrial area are also expected to be significant, but they are yet not integrated in the emission inventory, due to very little reported data on VOC emissions from industries.

Most industrial sources are favourably located concerning population exposure, as they are placed south of the populated areas and the wind blows predominantly from the North, North-east and North-west directions in Dakar (Sivertsen et al, 2006). Besides most of the air pollutants are emitted by stacks resulting in a lower contribution to the population exposure to air pollution, compared to the other source types with low emission heights within the population agglomerations. Nevertheless, industry still has a significant contribution to air pollution in Dakar. It is necessary to complete the emission inventory with all the industrial emission in order to develop good air quality management strategies and air pollution abatement measures.

4 Conclusion

A bottom-up atmospheric emission inventory was developed for Dakar. It contains detailed information on emissions to air and on emission conditions (like stack heights, diameters, exhaust temperature, time variation, etc) for the main sources of air pollution in Dakar. The inventory was developed to meet the information needs of the air pollution dispersion models concerning emission to air. Dispersion models need detailed information on emissions to air and its sources and that is the reason why national top-down emission inventories cannot be used for modeling of air quality within a city or region.

Several emission data gaps have been identified for the different type of sources in the emission database, namely point, line and area sources. Updating and gap filling of a bottom-up air emission inventory is a continuous task, which CGQA will continue to carry out based on the training and experience developed during the last 4 years of the QADAK project.

Based on the emission data in the inventory, it can be concluded that traffic is the anthropogenic source with the most important impact on ground level ambient concentrations of NOx, NO and NO_2 and probably particulate matter. The main reason is that traffic emissions are emitted at ground level and have therefore a direct impact on ground level air pollutant concentrations and on population exposure to those air pollutants.

Area emissions (e.g. emissions from combustion of charcoal and wood in households and from open waste burning) are important sources of CO and particulate matter and have an important impact on ground level air concentrations, both indoors and ambient. Emissions from area sources give therefore an important contribution to the population exposure to air pollutants.

The industries are the major sources of SO_2 in Dakar, and an important source of NOx, including NO_2 and NO. Most industrial sources are favourably located, in relation to the prevailing winds and geographical distribution of the population agglomerations, and most of its air pollutants are emitted by stacks. These two facts result in a lower contribution to the population exposure to air pollution, when compared to the other source types, with low emission heights within the population agglomerations and similar emission rates. Nevertheless, industry still has a significant contribution to air pollution in Dakar.

It is necessary that the CGQA completes the emission inventory with respect to all the major identified sources in this report, in order to develop good air quality management strategies and air pollution abatement measures.

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Appendix 1

List of main industries in Dakar initially targeted by the current emission inventory

The list of main industries targeted as a first step by the emission inventory questionnaire, developed by this project, is presented in the table below. The list is based on the main industries with emissions to air extracted from the Annexe F – Fiches d'entreprise complétées of the "Étude sur la gestion de la pollution industrielle dans la baie de Hann (Base de données)". Direction de l'Environnement et des Etablissements Classés, 2005.

Industries	**Sector**
1. Afric Azote	Agro-alimentaire
2. SNCDS	Agro-alimentaire
3. CONDAK	Agro-alimentaire
4. Sénégal Proteines	Agro-alimentaire
5. Colgate Palmolive/NSOA	Agro-alimentaire
6. Grands Moulins de Dakar	Agro-alimentaire
7. SOBOA	Agro-alimentaire
8. SENELEC Cap des biches	Centrale Electrique
9. SENELEC Bel Air	Centrale Electrique
10. GTI	Centrale Electrique
11. ICS	Chimie (engrais)
12. FUMOA	Plastique
13. NESTLE	Agro-alimentaire
14. SAR	Raffinerie
15. MTOA	Tabac
16. FAKHRY	Détergent et savon
17. SHEL Sénégal	Groupe Pétrolier
18. TOTAL Sénégal	Groupe Pétrolier
19. Mobil Oil	Groupe Pétrolier
20. Elton	Groupe Pétrolier
21. SIPS	Papeterie
22. SOCOCIM	Cimenterie
23. SOTIBA	Textile
24. CARNAUD METAL BOX	Emballages Métalliques
25. SOSENAP	Plastique
26. DIPROM	Parfumerie
27. SEGOA	Oxygène et Acétylène
28. La Rochette	Emballage cartons

As a second step in the emission inventory data collection, the CGQA extended the number of industries targeted from 28 to 48, in order to have an inventory as complete as possible. The table here under shows the total amount of industries visited by the CGQA experts by type of industrial activity.

Sector	**Nombre d'entreprises**
Agroalimentaire	**19**
Industries de Boisson	**01**
Industries de Tabac	**01**
Industrie textile	**02**
Industrie du papier et carton	**02**
Raffinage du pétrole	**01**
Chimie, parachimie, caoutchouc	**07**
Production d'électricité et de vapeur	**05**
Engrais simples solides à base de nitrates	**02**
Stockage de combustibles	**04**
Métallurgie	**01**
Fabrication d'emballages métalliques	**01**
Production de médicaments	**02**

Appendix 2

Questionnaire sent to the industries

Centre de Gestion de la Qualité
De l'Air à Dakar

ENR/CGQA/01
IR : 00

INVENTAIRE DES EMISSIONS POUR L'AIR DANS L'INDUSTRIE

1ère Partie - PRESENTATION GENERALE DE L'ENTREPRISE

Dénomination ou raison sociale de l'entreprise:
....
Nom de l'usine :..
Forme juridique : ....
Adresse de l'usine
Code postal : ....**Commune :** ....
Téléphone : ....**Fax :** ....
Personne de contact
NOM : ....**Prénom :** ....
E-mail : ....@ ....
Fonction: ....

2eme Partie - PRESENTATION DES ACTIVITES

1. Quelles sont les différentes activités de production dans votre usine ?

Types d'activités (Description des procédés industriels	Produits	Volume annuel de production	Année
1.			
2.			
3.			
4.			
5.			
6.			

2. Détermination de la durée des activités, pour l'année 2005 si possible?

Activités	Début et fin de production journalière	Jours ouvrés hebdomadaire	Mois ouvrés annuels, variation mensuelle	Année
1.			Jan- %, Fev- %, Mar- %, Avr- %, Mai- %, Jun- %, Jul- %, Aou- %, Sep- %, Oct- %, Nov- %,	
2.				
3.				
4.				
5.				
6.				

Ministère de l'Environnement et de la Protection de la nature
Direction de l'Environnement et des Etablissements Classé

Centre de Gestion de la Qualité
De l'Air à Dakar

ENR/CGQA/01
IR : 00

3. Description des cheminées existantes et du débit annuel moyen

	Numéro et/ou nom de la cheminée	Coordonnées géographiques de la cheminée X,Y (UTM)	Hauteur (m)	Diamètre interne du débouché (m)	Température des gaz à la sortie cheminée (°C)	Débit total des gaz secs (Nm^3/h)	Vitesse de sortie des gaz (m/s)	Numéro de l' activité lié à l'émission (tableau 1)
1								
2								
3								
4								
5								
6								
7								
8								

4. Description du bâtiment ou structure d'où s'échappent des polluants à travers le toit ou system de ventilation

	Nom du bâtiment ou structure d'où s'échappent les polluants	Dimensions du bâtiment/structure (m):			Hauteur des émissions (m)	Description de l'endroit de sortie	Température des gaz à la sortie (°C)	Numéro de l'activité lié à l'émission (tableau 1)
		Hauteur	Longueur	largeur				
1								
2								
3								
4								
5								
6								
7								

5. Quelles sont la nature et la quantité des différents combustibles utilisés par votre installation?

Nr. Combustible	Nom du combustible utilisé	Consommation (Quantité en m^3, tonne, litre par an)	PCI	Teneur en soufre %	Teneur en cendres
1					
2					
3					
4					
5					
6					
7					

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6. Listez les différentes installations dans votre usine ?

Nr de l'activité	Désignation de l'installation*	Description (type et technologies)	Consommation moyenne de combustible (t/an ou m3/an) pour chaque type de combustible (défini dans le tableau 5)	Nr de la cheminée d'émission (Tableau 3)	Nr de bâtiment d'émission (Tableau 4)
1			Nr ... Nr ...		
			Nr ... Nr ...		
			Nr ... Nr ...		
			Nr ... Nr ...		
2			Nr ... Nr ...		
			Nr ... Nr ...		
			Nr ... Nr ...		
			Nr ... Nr ...		
3			Nr ... Nr ...		
			Nr ... Nr ...		
			Nr ... Nr ...		
			Nr ... Nr ...		
4			Nr ... Nr ...		
			Nr ... Nr ...		
			Nr ... Nr ...		
			Nr ... Nr ...		
5			Nr ... Nr ...		
			Nr ... Nr ...		
			Nr ... Nr ...		
			Nr ... Nr ...		

* Exemples : Chaudières, Turbines, Fours, etc.

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7. Existe-t-il des systèmes d'épuration en place et en fonctionnement? Dans ce cas préciser à quelle cheminée (n° et/ou nom) le système d'épuration est lié et les caractéristiques suivants pour chaque système :

Nr du système	Nom du système	Numéro de la cheminée à laquelle est liée le système	Polluants épurés*	Rendement d'épuration pour chaque polluant (%)
1				
2				
3				
4				
5				
6				
7				

*** Exemples : Sox, Nox, PM10, PM ; COV**

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3eme Partie – INVENTAIRE DES SOURCES D'EMISSION

8. Si vous faites des estimations de vos émissions dans l'air, quels sont les Facteurs d'Emission (FE) que vous utilisez pour chaque activité (par unité de production ou par unité de consumation de combustible)?

Numéro Activité	Facteurs d'Emission (kg/tonne de combustible ou produit)						Type de combustible ou produit au quel les FE s'applique	Provenance des Facteurs d'Emission
	SOx	NOx	COV	partic ules	PM10	autre s		

9. Si vous faites des estimations de vos émissions dans l'air, veuillez ajouter à cette enquête de résultat de ces estimations pour chaque cheminée et chaque polluant en annexe. Dans le cas où les émissions diffuses (par les canaux de ventilation ou toit de l'usine) seraient estimées, veuillez indiquer la hauteur, et de taux d'émission moyen (t/an) par polluant.

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10. Avez vous mesuré vos émissions pour l'air ? - Dans ce cas préciser pour chaque cheminée les paramètres suivants :

Nr. de la cheminée où la mesure est faite	Polluants mesurés	Débit des effluents pendant la période de mesure (Nm3/s)	Concentration moyenne de polluant à l'émission (g/m3 ou ppm)	% activité/ production par rapport à la moyenne annuelle	Date de la mesure
	CO				
	NOX				
	SOX				
	PM10				
	COV				
	Autres à préciser				
	CO				
	NOX				
	SOX				
	PM10				
	COV				
	Autres à préciser				
	CO				
	NOX				
	SOX				
	PM10				
	COV				
	Autres à préciser				
	CO				
	NOX				
	SOX				
	PM10				
	COV				
	Autres à préciser				
	CO				
	NOX				
	SOX				
	PM10				
	COV				
	Autres à préciser				

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Appendix 3

Source sector classification

Nomenclature Sénégalaise des Installations classées pour la Protection de l'Environnement

NOMENCLATURE ACTIVITES

Rubrique	INSTALLATION OU ACTIVITE
A100	ACTIVTES AGRICOLES, AMENAGEMENT HYDROAGRICOLE, ELEVAGE, PECHE, EXPLOITATIONS FORESTIERES
A 200	AGROALIMENTAIRES
A 300	INDUSTRIE DE BOISSONS
A 400	INDUSTRIE DU TABAC
A 500	INDUSTRIE TEXTILE
A 600	INDUSTRIE DU CUIR ET DE LA CHAUSSURE
A 700	TRAVAIL DU BOIS ET FABRICATION D'ARTICLES EN BOIS
A 800	INDUSTRIE DU PAPIER ET DU CARTON
A 900	IMPRIMERIE ET REPRODUCTION
A 1000	MATERIAUX, MINERAIS ET METAUX
A 1100	EXPLORATION PETROLIERE
A 1200	RAFFINAGE DE PETROLE
A 1300	CHIMIE, PARACHIMIE, CAOUTCHOUC
A 1400	PRODUCTION ET DISTRIBUTION D'ELECTRICITE, DE GAZ, DE VAPEUR ET D'EAU CHAUDE, COMBUSTION, COMPRESSION ET REFRIGERATION
A 1500	FABRICATION DE MACHINES, EQUIPEMENTS DE TRAVAIL ET APPAREILS
A 1600	CONSTRUCTION, ASSEMBLAGE DE VEHICULES AUTOMOBILES, REMORQUES ET SEMI-REMORQUES
A 1700	FABRICATION D'AUTRES MATERIELS DE TRANSPORT
A 1800	COMMERCE ET REPARATION DE VEHICULES AUTOMOBILES ET DE MOTOCYCLES
A 1900	COMMERCE DE GROS ET DEPOTS DE PRODUITS
A 2000	HOTELS, RESTAURANTS, RESIDENCES HOTELIERES, AUBERGES, CAMPINGS ET CARAVANES
A 2100	ASSAINISSEMENT ET TRAITEMENT DES EAUX
A 2200	GESTION DES DECHETS
A 2300	ACTIVITES RECREATIVES, CULTURELLES ET SPORTIVES

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ABSTRACT
The current report summarises the contents of the bottom-up emission inventory developed for and by the CGQA for air pollutants in Dakar. The collection of emission data started in 2006 and continued until 2010. It has been a continuous work to identify air pollutant sources in Dakar and collect or estimate their emission data. Most of the collection work was carried out by CGQA, under the guidance and supervision of NILU. As data was collected, quality of the data was controlled, gaps identified and gap filling work was defined by NILU for CGQA to undertake. Updating and gap filling of a bottom-up air emission inventory is a continuous task, which CGQA will continue to carry out, based on the training and experience they have developed during the last 4 years of the project.

NORWEGIAN TITLE

KEYWORDS		
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