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Air Pollution Sources

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1 Introduction

Air pollution is generated from a number of different sources. The concentrations of air pollutants that are measured in the ambient air will always be a sum of the interactions from different sources. It is therefore important to have some basic knowledge about the characteristics of the sources in the different areas.

Emissions of air pollutant are related to socio-economic activities such as:

- Combustion of fossil fuels (power production),
- Industrial processes of various kinds,
- Road transport,
- Waste burning, open air and in incinerators,
- Solvent use,
- Agricultural activities.

Substances emitted into the atmosphere by human and natural activities are the cause of many current and potential environmental problems, including:

- Acidification
- Air quality degradation
- Global warming/climate change
- Damage and soiling of buildings and other structures
- Stratospheric ozone depletion
- Human and ecosystem exposure to hazardous substances.

It is necessary to have quantitative information on these emissions and their sources in order to help:

- Inform the policy makers and the public
- Define environmental priorities and identify the activities and actors responsible for the problems
- Set explicit objectives and constraints
- Assess the potential environmental impacts and implications of different strategies and plans
- Evaluate the environmental costs and benefits of different policies
- Monitor the state of the environment to check that targets are being achieved
- Monitor policy action to ensure that it is having the desired effects
- Ensure that those responsible for implementing the policies are complying with their obligations.

The knowledge of sources and emissions of air pollutants in a specific area will also together with knowledge about prevailing winds support the planning of measurement programmes. A detailed survey of the sources and the emissions compiled into an emission inventory will be the most important basis for air quality planning and reduction of air pollution impacts.

2 Many different sources

In cities and urban areas air may be severely polluted from a variety of sources such as transportation and by burning of fossil fuels (oil and coal) in generating stations, factories, office buildings, and homes and by the incineration of garbage. The massive combustion produces tons of ash, soot, and other particulates responsible for the grey smog over the cities along with enormous quantities of sulphur oxides and nitrogen oxides. These oxides rust iron, damage building stone, decompose nylon, tarnish silver, and kill plants. Air pollution from cities also affects rural areas for many miles downwind.

Every industrial process exhibits its own pattern of air pollution. Petroleum refineries are responsible for extensive hydrocarbon and particulate pollution. Iron and steel mills, metal smelters, pulp and paper mills, chemical plants, cement and asphalt plants all discharge vast amounts of various particulates, toxic elements as well as organic and inorganic gases.

The combustion of gasoline and other hydrocarbon fuels in automobiles, trucks, and jet airplanes produces several primary pollutants: nitrogen oxides, gaseous hydrocarbons, and carbon monoxide, as well as large quantities of particulates, containing elements such as lead. In the presence of sunlight, nitrogen oxides combine with hydrocarbons to form a secondary class of pollutants, the photochemical oxidants, among them ozone and the eye-stinging peroxy-acetylnitrate (PAN).

Nitrogen oxides also react with oxygen (ozone) in the air to form nitrogen dioxide, a foul-smelling brown gas. In urban areas like Los Angeles where transportation is the main cause of air pollution, nitrogen dioxide tints the air, blending with other contaminants and the atmospheric water vapour to produce brown smog. Although the use of catalytic converters has reduced smog-producing compounds in motor vehicle exhaust emissions, recent studies have shown that in so doing the converters produce nitrous oxide, which contributes substantially to global warming.

The many types of sources of atmospheric emissions create different types of pollutants. A main stream of sources can be identified to classify pollutants, for example:

- Power plants
- Refineries
- Incinerators
- Factories
- Domestic households
- Cars and other vehicles
- Animals and humans
- Fossil fuel extraction and production sites
- Offices and public buildings
- Trees and other vegetation
- Distribution pipelines
- Fertilised land
- Land with biological decay.

It is not possible to measure emissions from all of the individual examples of these sources or, in the short term, from all the different source types. In practice, atmospheric emissions are estimated on the basis of measurements made at selected or representative samples of the (main) sources and source types.

3 Some major pollutants (Indicators)

It is normally not possible to measure all the air pollutants present in the atmosphere. We therefore have to choose some indicators that should represent a set of parameters selected to reflect the status of the environment. They should enable the estimation of trends and development, and should represent the basis for evaluating human and environmental impact. Further, they should be relevant for decision-making and they should be sensitive for environmental warning systems.

The most commonly selected air quality indicators for urban air pollution are:

- Nitrogen dioxide (NO_2),
- Sulphur dioxide (SO_2),
- Carbon monoxide (CO),
- Particles with aerodynamic diameter less than 10 μm (or 2,5 μm), PM_{10} ($PM_{2,5}$),
- Ozone.

Nitrogen oxides (NO_x) belongs to a family of highly reactive gases. These gases form when fuel is burned at high temperatures, and come principally from motor vehicle exhaust and stationary sources such as electric utilities and industrial boilers. A suffocating, brownish gas, nitrogen dioxide is a strong oxidizing agent that reacts in the air to form corrosive nitric acid, as well as toxic organic nitrates. It also plays a major role in the atmospheric reactions that produce ground-level ozone (or smog).

Sulphur dioxide belongs to the family of gases called sulphur oxides (SO_x). These gases are formed when fuel containing sulphur (mainly coal and oil) is burned, and during metal smelting and other industrial processes.

Particulate matter is the term for solid or liquid particles found in the air. Some particles are large or dark enough to be seen as soot or smoke. Others are so small they can be detected only with an electron microscope. Because particles originate from a variety of mobile and stationary sources (diesel trucks, woodstoves, power plants, etc.), their chemical and physical compositions vary widely. Particulate matter can be directly emitted or can be formed in the atmosphere when gaseous pollutants such as SO_2 and NO_x react to form fine particles. Particles up to about 100 micrometer in diameter are measured as Total Suspended Particles (TSP), while presently the most significant parameter for suspended particles in the air (thoracic particles) are those with aerodynamic diameter less than 10 micrometer.

Carbon monoxide is a colourless, odourless, poisonous gas formed when carbon in fuels is not burned completely. It is a by-product of highway vehicle exhaust,

which contributes about 60 percent of all CO emissions worldwide. In cities, automobile exhaust can cause as much as 95 percent of all CO emissions. These emissions can result in high concentrations of CO, particularly in local areas with heavy traffic congestion. Other sources of CO emissions include industrial processes and fuel combustion in sources such as boilers and incinerators. Despite an overall downward trend in concentrations and emissions of CO, some metropolitan areas still experience high levels of CO.

Volatile organic compounds (VOC) are emitted into the atmosphere from petrochemical factories, oil based activities, automobiles and other chemical plants. The VOCs also plays a major role in the atmospheric reactions with NO_x and in the present of sun light to produce ground-level ozone (or smog).

Different activities and different type of sources emit different type of pollutants to the atmosphere. Some relevant emission compounds given by source categories are presented in Table 1 below. The number of x-s indicated the important of the type of sources for each of the selected indicator.

Table 1: The importance of emitted compounds for 11 selected types of pollution sources. (The number of x indicate importance)

Source category	SO_x	NO_x	CO	VOC	TSP/PM_{10}
Power generation	xx	xx	x	x	x
Residential, commercial combustion	x	x	xx	x	xx
Process industry with combustion	xx	xx	x	x	xx
Non-combustion industry	x	x	(xx)	xx	x
Extraction and distribution of fuels	x	x	x	xx	
Solvent use				xx	
Road transport	x	xx	xx	xx	xx
Other transport	x	(xx)	x	x	x
Waste disposal and treatment	x	x	xx	xx	xx
Agricultural activities				x	x
Natural sources				x	x

It is possible to estimate the emission rate when activity, production numbers and consumption of fuels are given. The basic model for an emission estimate is the product of (at least) two variables, for example:

- An activity statistic and a typical average emission factor for the activity, or
- An emission measurement over a period of time and the number of such periods emissions occurred in the required estimation period.

For example, to estimate annual emissions of sulphur dioxide in grams per year from an oil-fired power plant you might use, either:

- Annual fuel consumption (in tonnes fuel/year) and an emission factor (in grams SO_2 emitted/tonne fuel consumed), or
- Measured SO_2 emissions (in grams per hour) and number of operating hours per year.

4 Emission inventories

Emission estimates are collected together into inventories or databases which usually also contain supporting data on, for example: the locations of the sources of emissions; emission measurements where available; emission factors; capacity, production or activity rates in the various source sectors; operating conditions; methods of measurement or estimation, etc.

To identify the characteristics of different sources the different air pollution sources are normally divided into:

- Point sources (emissions from stacks, e.g. power plants and industries),
- Line sources (emission from traffic along a road or a street),
- Area sources (e.g. residential heating and other small sources distributed over an area),

4.1 Point sources

The point sources are normally linked to individual well-defined stacks. Emission estimates are provided on an individual plant or emission outlet (usually large) usually in conjunction with data on location, capacity or throughput, operating conditions etc.

The tendency is for more sources to be provided as point sources as legislative requirements extend to more source types and pollutants as well as more openness provides more such relevant data.

Point sources include industrial and non-industrial stationary equipment or processes considered significant sources of air pollution emissions. A facility is considered to have significant emissions if it emits about one ton or more in a calendar year.

Examples of point sources include industrial and commercial boilers, electric utility boilers, turbine engines, wood and pulp processors, paper mills, industrial surface coating facilities, refinery and chemical processing operations, and petroleum storage tanks. Area sources that may fall under the point source definition are piping leaks, industrial wastewater treatment ponds, rock and quarry operations, and tank farms. Insignificant point sources are included by category in the area source inventory

4.1.1 Emission from stationary point sources

Point sources may be tall stacks emitting pollution from industrial processes or from burning of fossil fuels. When estimating the emission rate, either for statistical reasons or as input to dispersion models, activity data should be linked to the emission generation process as closely as possible.

For performing emission estimates two examples is presented in the following:

- For emission from power plant combustion of certain fuels; (1) fuel input instead of electricity output should be used, and (2) energy units instead of mass units should be used. Consequently, determination of appropriate heat values of fuels may be necessary where fuel data are available in mass units only;

- For combustion related emissions in general: emission characteristics vary from fuel to fuel and hence activities should be reported in this way, instead of using a total energy approach.

One must pay special attention where both combustion and fuels and processing of materials may have effects on emissions. Fuel mixture as well as specific energy demands may change over time. As a consequence, both fuel input and product output need to be accounted.

Whenever point sources are estimated individually, the estimated sum of the activity represented by these sources should be subtracted from the estimated collective activity. This is to avoid double-counting the individually considered point sources when estimating the rest of the source activity emissions (the collective approach).

As in the case of point sources treated individually in the accounting for processes with combustion, attention should be paid to avoid double counting of energy consumption statistics. Reference activity data may be available from public and private statistics, institutions or research projects. Information on fuels should include non-commercial fuels and wastes used for energy generation

4.2 Line sources

Line sources are normally composed from those emitters that are moving along roads or tracks. In some inventories vehicle emissions from road transport, railways, inland navigation, shipping or aviation etc are provided for sections along the line of the road, railway-track, canal or sea-lane.

4.2.1 Emissions from road traffic

The emissions of CO and NO_x from traffic are calculated by multiplying the traffic intensity (cars/hour) with the length of the road (km) and an "emission factor" (g/(km*car)). For CO_2, the emission factor (grams of emission per unit fuel consumption) is multiplied with the fuel consumption (kg/km).

The emission for a given road is a function of:

- Speed,
- Road gradient,
- Year of calculation (this determines the technology level of the vehicle),
- Number of cars in each vehicle class.

The emissions increase with the age of the car. There are also increased emissions from cars in cold start mode. Both of these factors can be accounted for in a model.

The total emission from the road network (tonnes/year) is estimated from the mean daily traffic parameters. The peak emission calculations utilise rush-hour parameters.

The calculation of emissions/generation of PM_{10} (road dust) is usually based on a different method than for the other components. The reason for this is that PM_{10} refers to a 24-hour average, whereas CO and NO_2 are one hour averages.

4.3 Area sources

Area sources are used to describe sources where geographical distribution is not exactly known and where emissions are small but in large numbers so that they have a significant impact on concentrations. These kinds of emissions can be from house heating, traffic or various type of land use. The emissions are normally connected to the use of different fuels in an area that is distributed according to population distribution.

Area source models are also used to estimate emissions of ammonium from agriculture. The area sources in a city have local influence, they are linked to consumption and emission factors are needed.

The area sources are most often a collection of smaller or more diffuse sources of pollution. The emission from these large number of scattered small sources are provided on an area basis either for administrative areas, such as counties, regions etc, or for regular grids (for example 1x1 km inside an urban area or 50x50 km grid on a regional scale such as in the European EMEP programme).

Area source inventories generally report emissions by categories rather than by individual source; a common method in reporting point source emissions. Area source emissions are calculated by various methods and depend on the type of data available for each category.

For example, whenever fuel use and materials data are not available, employee and county population numbers are used with established emission factors to calculate emissions. Emissions are calculated and reported on a countywide basis.

Major categories of area sources are:

- Stationary source fuel combustion such as residential fuel combustion
- Solvent use (e.g., small surface coating operations)
- Product storage and transport distribution (e.g., gasoline)
- Light industrial/commercial sources
- Agriculture (e.g., feedlots, crop burning)
- Waste management (e.g., landfills)
- Miscellaneous area sources (e.g., forest fires, wind erosion, unpaved roads)

5 Emission inventories, some examples

The **MAP emission inventory** project was designed by OECD (OECD, 1990) and covered the following pollutants:

- sulphur dioxide - SO_2,
- nitrogen oxides - NO_x, and
- volatile organic compounds - VOC, including natural emissions.

The inventory quantified point and area source emissions in nine main source sectors from 17 European OECD countries - the current 15 Member States (excluding the former German Democratic Republic) plus Norway and Switzerland.

The nine main source sectors were:

- mobile,
- power plant,
- non-industrial combustion,
- industry,
- organic solvent evaporation,
- waste treatment and disposal,
- agriculture and food industry,
- nature,
- miscellaneous.

In most but not all cases the inventory was compiled from emission estimates submitted officially by each country. OECD worked closely with each country and with the CEC (which funded activity on the inventory to regroup emission estimates into the OECD source sectors and to help countries complete their inventories

As part of the European development of emission inventories for atmospheric pollutants the **CORINAIR 1990 Inventory** recognises 11 main source sectors (as agreed with EMEP):

- Public power, cogeneration and district heating plants
- Commercial, institutional and residential combustion plants
- Industrial combustion
- Production processes
- Extraction and distribution of fossil fuels
- Solvent use
- Road transport
- Other mobile sources and machinery
- Waste treatment and disposal
- Agriculture
- Nature.

Data are provided on large point sources on an individual basis and on other smaller or more diffuse on an area basis, usually by administrative boundary at the county, department level. The sources to be provided as point sources are:

- Power plant with thermal input capacity >=300MW
- Refineries
- Sulphuric acid plant
- Nitric acid plant
- Integrated iron/steel with production capacity >3Mt/yr
- Paper pulp plant with production capacity > 100kt/yr
- Large vehicle paint plant with production capacity > 100000 vehicles/yr
- Airports with >100000 LTO cycles/yr
- Other plant emitting >=1000t/yr SO_2, NO_x or VOC or >=300000t/yr CO_2

The Goal of CORINAIR90 was to provide a complete, consistent and transparent air pollutant emission inventory for Europe in 1990 within a reasonable time scale to enable widespread use of the inventory for policy, research and other purposes. Completeness covers two aspects:

- The CORINAIR90 system is available to almost all countries of Europe and
- The SNAP90 nomenclature has been designed to provide a comprehensive list of activities generating emissions of the eight pollutants to be quantified.

Consistency will be provided by the systematic application of the CORINAIR methodology - by using the CORINAIR software and the SNAP90 nomenclature - to provide emission estimates. (See Selected References.)

Transparency is achieved through the provision within the inventory of activity statistics/data and emission factors (or details of emission measurements where available) used to calculate emissions and through the supply of full references to the sources of these data.

Initial data from CORINAIR90 became available in early 1994 and the project was completed and a series of reports prepared during 1995 and early 1996. The work was finalised and published by the EEA in 1996 and 1997.

5.1 Emission inventorying in the UK

The London studies established a general methodology now being used in preparing up-dating the London air pollution emission inventory, as well as in the Ten Cities Programme. The geographical framework for data collection and analysis is the 1 × 1 kilometre national grid. Data are collected for three types of sources:

- Line sources including roads and railways;
- Area sources including emissions from agricultural and other land, and low intensity emissions from sources such as building heating systems;

- Point sources including high intensity emissions from industrial plants.

Clearly it is impossible to measure every emission source in an area with a population of 2.5 million. The majority of emissions are therefore estimated from other information such as fuel consumption, vehicle kilometres travelled (VKT), or some other measure of activity relating to the emissions. Emission factors, derived from the results of measurements, are then applied to the activity data in order to estimate the likely emissions:
Activity rate x Emission factor = Emission rate

For many of the pollutants of concern, the major source of emissions is the combustion of fossil fuels. Consequently the collection and analysis of fuel consumption statistics plays an important part in the preparation of emission inventories.

However, it is important to consider the differences between consumption and fuel deliveries when making use of the available data. Most of the readily available statistics relate to fuel deliveries, which, in many cases, relate closely to consumption. However, in the case of fuels, which may be stockpiled, such as coal, there may be significant differences between delivery and consumption. In the case of transport fuels, there may be significant geographical differences between the point of delivery and where the fuel is used.

The pollutants and pollutant groups included in the present inventories are:

- Sulphur dioxide (SO_2)
- Oxides of nitrogen (NO_x)
- Carbon monoxide (CO)
- Methane (CH_4)
- Non-methane volatile organic compounds (NMVOC)
- Carbon dioxide (CO_2)
- Benzene
- 1,3-butadiene
- Total suspended particulate (TSP)
- Particulate matter less than 10 microns aerodynamic diameter (PM_{10})
- Black smoke

The inventories do not include all pollutants, which may be of concern for health or other reasons. Some pollutants are only emitted from a limited number of sources, or only affect specific areas. Emissions of other pollutants are in decline as a result of established policies. An example of a pollutant in this latter category is lead.

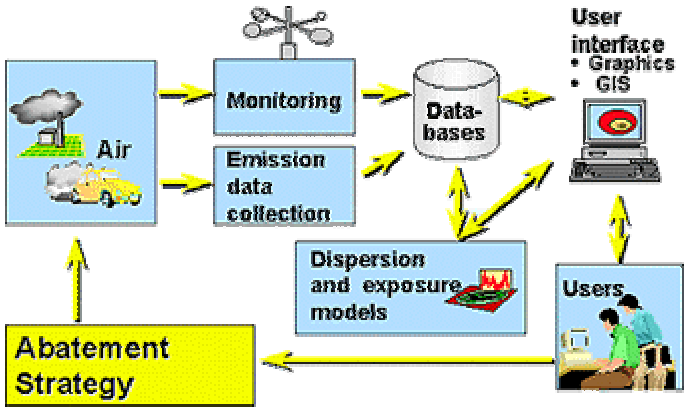
Airborne lead levels have shown a downward trend since 1981, when the amount of lead in leaded petrol was reduced from 0.45 g/l to 0.40 g/l and to 0.15 g/l in 1985. The increase in petrol consumption has offset these reductions to some extent but lead emissions from vehicles in 1994 are estimated to be 18% of those in 1980 Atmospheric concentrations are now well below the air quality limit values. The general reduction in airborne lead levels is expected to continue as

cars using leaded petrol continue to be replaced by those with catalytic converters using un-leaded petrol.

Ozone is not included in the inventory because it is not emitted directly into the atmosphere. Ozone occurs as a result of chemical reactions taking place within the atmosphere, and is therefore known as a 'secondary pollutant'. The emission factors now being used in preparing the urban emission inventories are derived from different sources.

6 The Air Emission Database in the AirQUIS planning tool

The NILU developed AirQUIS air pollution assessment and planning tool includes an emission inventory database including emission models and presentation tools.

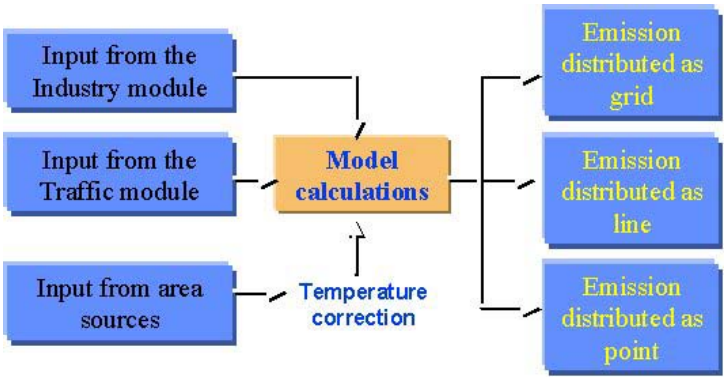


The sources of air pollution are divided in three categories.

1. Emissions from single activities of some size, like industries, energy production etc., that are linked to single stacks, are treated as point sources.
2. Emissions from road traffic are treated as line sources in the emission database.
3. Emissions from home heating, public and private services, agricultural activities etc., which cannot be represented as a point or line are treated as area sources. These may also be converted to grid.

Regardless of being point, line or area distributed, emission data can be found either as emission data for different components, or as a set consisting of consumption data and emission factors for the components for different fuels and activity types.

The emission data usually comes as yearly data, and a time factor is used to find the fraction of the yearly value that is valid for a specific period within the year. This information could relate to typical diurnal variations, weekly variations or monthly variations in emission rates. A set of these time factors is part of the emission module in AirQUIS.



The database for road traffic emissions, line sources, includes the geographical and physical description of the roads (road link definition), a system for classifying roads and traffic, dynamic traffic data, and traffic emission factors and dependencies.

Data from various traffic models such as “EMME2” can serve as a basis for the traffic data. Parameters and input, such as nodes, co-ordinates, links, and road specific properties, might have to be formatted and modified to meet the AirQUIS formats.

The traffic emissions on each road link are calculated by scaling the traffic volume for each vehicle class with a product of traffic emission dependency factors. The value of each of these factors depends on different properties of the vehicle class and the road link. The information about and connections between the different road link and vehicle class properties are defined in the module called Traffic Emission Factors.

Since the traffic emission factors and dependencies are part of the emission database, the AirQUIS system makes it possible for the user to modify the emission factors and also to have different alternative sets of factors. This makes it possible to not only study emission scenarios based on different road and traffic alternatives, but also to study effects of technology changes of the cars and to handle local conditions that affects the emissions

The dynamic traffic data describes the traffic flow and vehicle distribution on each road link. The traffic flow is given by annual daily traffic, vehicle distribution and traffic time variation for each vehicle class, in addition to free flow speed. Queue situations where traffic speed is low are described by lane capacity and volume delay functions.

The Road Link Dynamic Data form is opened from the Road Links form in AirQUIS, by selecting a road link and clicking the Data button. It is thus easy for the user to use, change or modify and to display all traffic emission data from his map-based computer screen.

The AirQUIS area sources are based on regional data set consisting of either emission data for different components or consumption data for different source categories for different fuels, with the corresponding emission factors. The area

source may even be quantified based on a regional or sub-area based data set of production data, with corresponding emission factors.

6.1 Search Criteria for Emissions

The emission data is easily accessed through search for region, field, line or point data sets. The specific industry is accessed through search criteria such as emission type/consumption type. Road links properties may also be accessed and edited easily through search criteria by using the functionality search by polygon/rectangle on geographical areas via the map, the user can find/edit information on emission sources.

6.2 Congruent with CORINAIR

The user defines the AirQUIS emission and consumption database structure. It has a hierarchical structure containing of different layers with inter relationships. In Norway, emission data is structured by the Norwegian Bureau of Statistics (SSB) and imported directly into AirQUIS by an efficient import wizard. The structure of the SSB is a simplified version of SNAP95.

6.3 Functions

The emission module can calculate all combinations of emissions in an area, such as total emissions of a component in selected areas or divided into source categories in a selected time period. The aggregation tool can also be used to obtain selected values such as maximum, minimum, average, sum and selected percentiles.

6.4 The Air Emission Model

The air emission model combines emission, consumption and production from region and point sources with traffic emissions to calculate hourly emissions distributed in fields, lines and/or points. The results may be stored as field, line and/or point data set. Before running the model the emission scenario must be defined. Here the user decides which sources to include, in the use of source selection criteria, see table below.

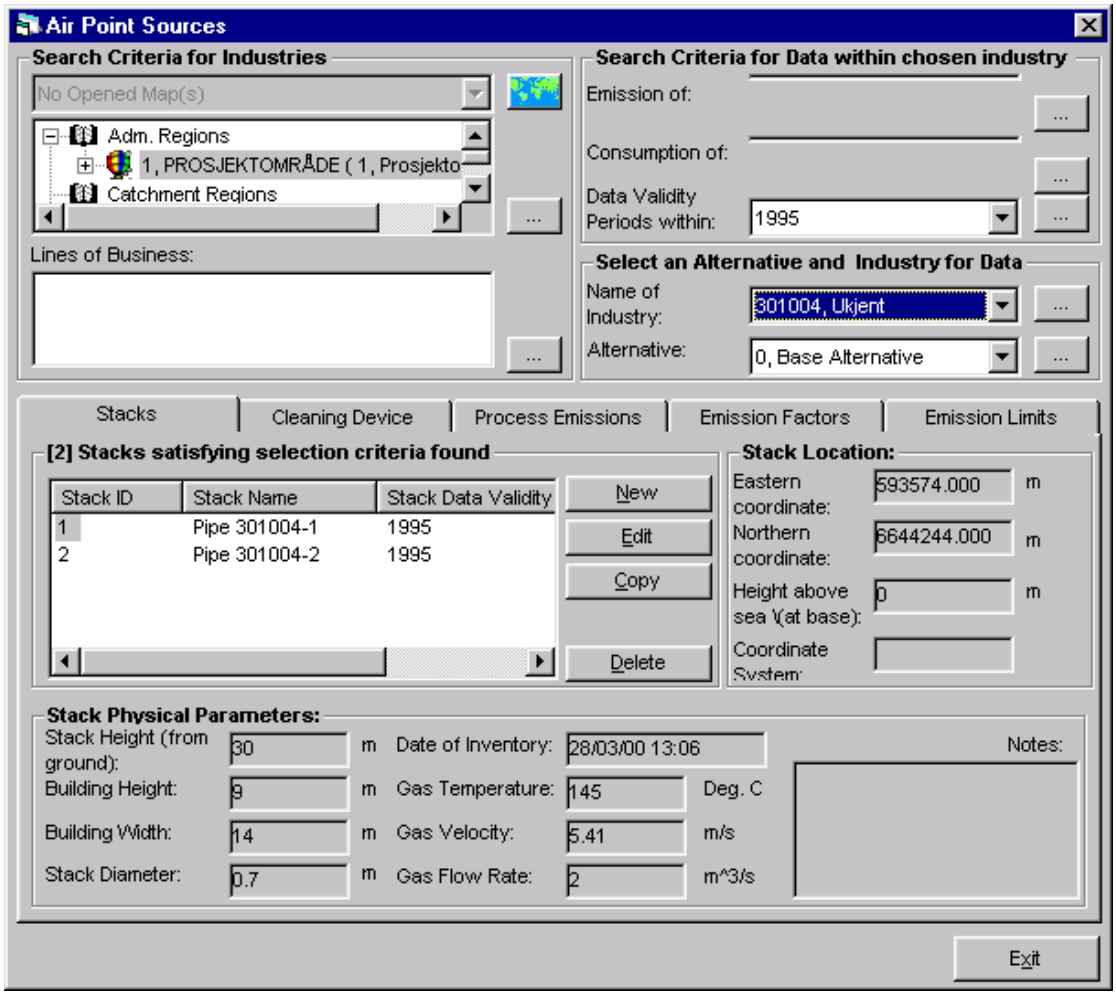
Source type	Selection choice in scenario setting
Area	Region, consumption type, activity type, product or fuel type
Line	Region, ADT limit, road classes, vehicle classes, traffic factor set
Point	Region, point source, line of business, activity type and fuel

In addition to an air emissions scenario, a meteorology scenario has to be selected in order to handle temperature dependent emission data. It is, for this purpose,

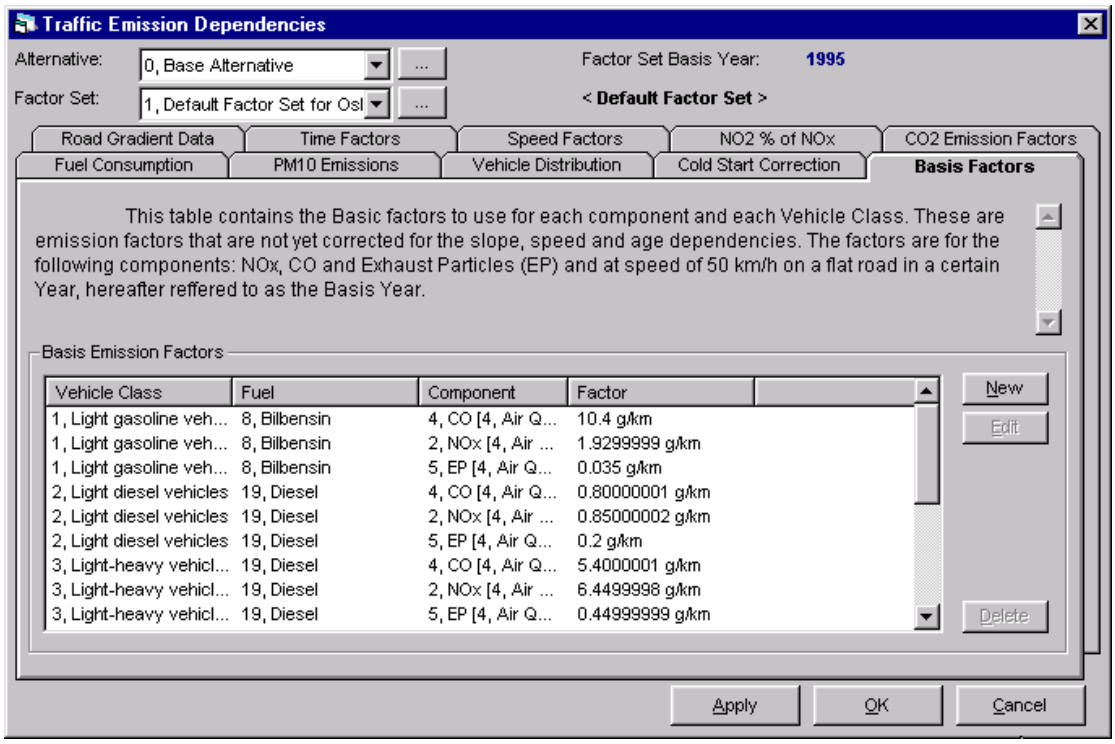
possible to use meteorological data from time periods different from the calculation period.

The different parameters and factors determining the emission are easily edited. This can be seen through the windows presented below:

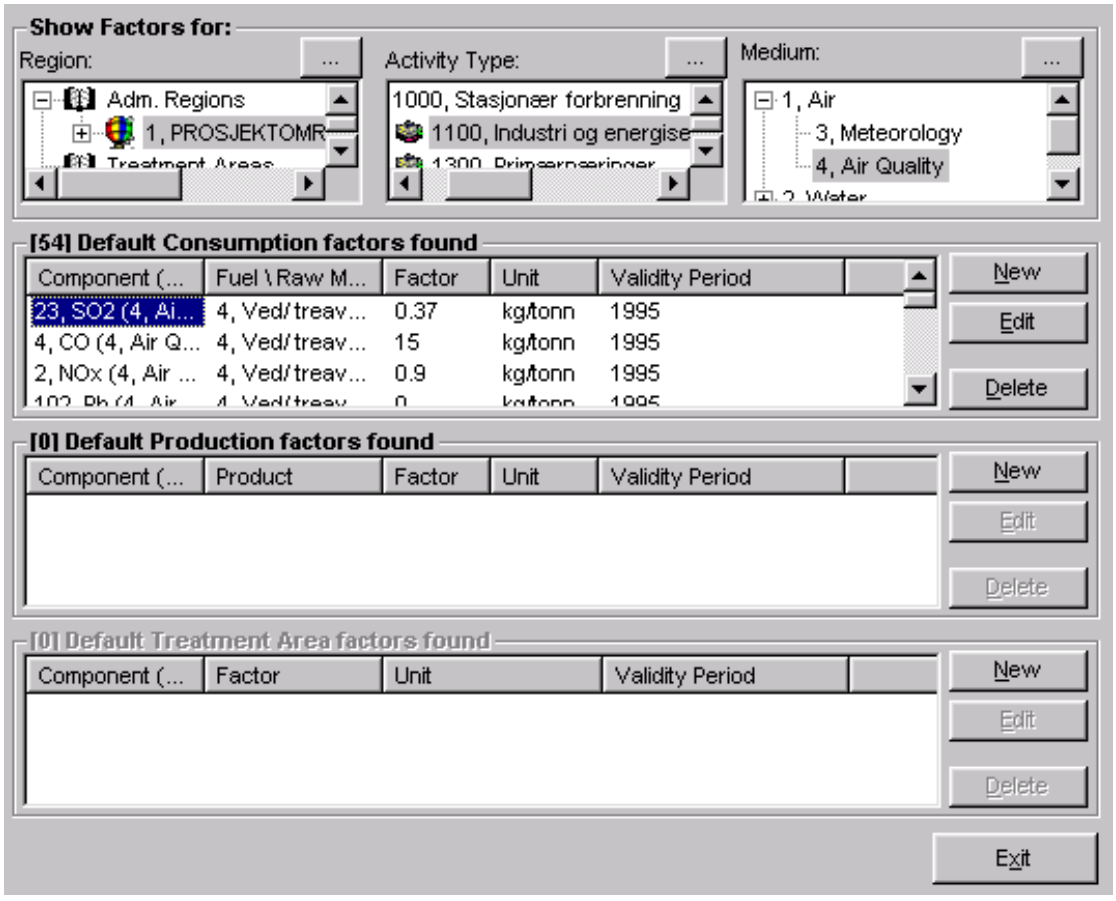
6.5 Air Point Sources



Traffic emission dependencies



Area Emission Factors



The user can set up different emission databases by selecting sources and editing the emission factors, parameters, time variations, etc. In this way a set of emission databases can be defined and adapted dependant on the work to be performed.

7 Air pollution sources in a developing country

Air pollution sources have been investigated in Egypt, which has a source profile that is typical for Developing countries. Diffusive emissions of dust from various large and small industries contribute considerably to the air pollution measured at ground level.

These diffusive emissions are normally at low levels above the surface, and will also be trapped during specific meteorological conditions in the cold stable air, giving rise to very high concentration.

Some of the typical sources found in Egypt are presented together with their related air pollutants below:

Source type	TSP/PM	SO_2	NO_2	CO	Toxins
Process Industries	XXX	XX	XX	X	XXX
Oil and fuel in:					
Industries	XX	XX	X		X
Power plants	XX	X	X		X
Commercial	X	X	X	X	XX
Transportation	XX	XX	XXX	XXX	X
Open air (waste) burning	XXX	XX	X	XX	XXX
Natural	XX		X		

Total Suspended Particulate matter (TSP), solid and liquid particles, are emitted from numerous manmade and natural sources such as open-air waste burning, industrial processes (large industries and small enterprises) and diesel-powered vehicles. Also re-suspension and wind blown dust from arid areas may create particles in the air.

Open-air burning, which starts at sunset in many settlements and residential areas of Africa, is also typical for areas in Egypt. In the Delta area for instance the smoke from open-air burning stays at the surface in the strong surface inversion that is created after sunset. These combinations of air pollution emission and adverse meteorological conditions, cause occasionally very high concentrations of inhale-able particles, unburned organic compounds, toxic metals and gases. The mixture can cause health damage to people breathing the air.

Sulphur dioxide (SO_2) is formed when fossil fuels such as coal, gas and oil are used in large and small industries and for power generation. Nitrogen oxides (NO_x) are mostly generated from automobile traffic and from burning of fossil fuels. Also some NO_x generates from natural sources such as lightning, forest fires, volcanoes and microbes in soil.

Other pollutants include carbon monoxide (CO), emitted mainly from gasoline powered motor vehicles; lead, resulting from the use of alkyl lead as an antiknock agent in gasoline, and various toxins generated from open-air burning and a numerous type of small smelters and enterprises.

The **larger industries** in Egypt are claimed to be the most important sources for air pollution. Related to the amount of emission rates (in tons per year) this may be correct, but when we measure ground level concentrations inside highly polluted areas, other sources emitting pollutants at the surface may be as important for the exposure to the population.

Some of the more important industrial sources in Egypt are given below indicating also some of the areas where these sources may be found (the list is not complete, but serve as an example):

- Cement industry Helwan, Alexandria, Assuit, ElMinya
- Metal smelters Shoubra, Tebbin, Alexandria, AbuZaabal
- Brick factories Many areas , i.e. KafrZayat, Tebbin South
- FertilisersSuez, Talkha, Alexandria ++**.**
- Aluminium Naga Hamedi
- Petrochemical Alexandria , Suez, Cairo area (north)
- Chemical KafrZayat, Alexandria, Tebbin
- Sugar factories Cairo (south), ComOmbo, Assyuit +++
- Textile ElMahalla, Damanhour, KafrDawar

8 Selected References

Over the period until 1999 the ETC/AE has prepared the following EEA reports:

Berdowski, J., Gager, M., Raberger, B., Ritter, M. and Visschedijk (1999) Overview of national programmes to reduce greenhouse gas emissions. Copenhagen (EEA Topic report 8/99).

Cirillo, M., De Lauretis, R., Del Ciello, R. (1996) Review study on European Urban Emission Inventories. Copenhagen (EEA Topic report 30/96).

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See EEA and ETC/AE web sites for more information:

- http://www.eea.eu.int/.
- http://etc-ae.eionet.eu.int/etc-ae/index.htm.