

4 Assessment of the Pollution Load and Comparison with other European Cities

The air pollution load of different land use categories was determined by classifying the diffusive sampling results. This classification results are listed in Table 4.1.

There are **three site categories in Cyprus cities** where the traffic caused pollutants **NO₂ and Benzene** reach average concentration values **higher than the Upper Assessment Threshold and even higher than the future EU limit values**. These categories are marked in Table 4.1.

- These site categories are **city areas with high traffic load**, e.g. Makarios Avenue in Nicosia and
- **Bad ventilated inner city areas** (urban background and commercial places, e.g. Municipality market in Larnaca)
- The most serious problems exists if both categories occur together:
Bad ventilated high traffic areas
- Ozone shows previously high values in high elevated background areas like in Troodos mountains. This ozone is an overall transboundary problem
- In the cities the ozone concentrations are lower than in the background because of the depletion by the primary emitted pollutants there.

Table 4.1. NO₂, Benzene, SO₂ and Ozone concentration levels at the different site categories – averages from one year diffusive sampling

Site Category	NO ₂ average in µg/m ³	Benzene average in µg/m ³	SO ₂ average in µg/m ³	Ozone average in µg/m ³
Commercial (Municipality Market, Larnaca + Armenias Street + Ezekia Papaioannou Street, Nicosia)	48,7	8,4	16,1	-
urban background	39,7	7,3	11,4	60,9
Traffic	38,9	6,7	13,2	-
recreation	32,9	-	-	-
residential	23,2	2,8	7,5	74,4
Industrial	22,7	3,5	6,6	92,7
touristic beaches	19,9	1,0	9,2	77,6
peripheral	16,8	1,7	4,2	-
Airport	15,0	1,3	5,1	-
village>700	14,0	1,7	6,9	81,0
Touristic	11,9	2,2	8,5	-
sensitive area (Akrotiri – Salt Lake)	10,7	-	-	-
village<700	8,1	1,2	4,8	78,8
agricultural	7,0	1,6	-	73,4
mountainous, forests	2,6	0,5	3,2	95,5
mountainous, no forests	2,0	1,1	2,2	102,6

The determined air pollution load in Cyprus has been compared to those of other European cities. These comparisons are depicted in the Figures 4.1. to 4.3.

- The SO₂ values are almost low in Cyprus and in most of the European cities. Only at high traffic sites SO₂ is increased due to sulphur content of Diesel and heating oil which could be further reduced.
- It can be seen that NO₂ at high traffic sites in Cyprus is not lower than in large European cities. This fact underlines the necessity for the reduction of traffic emissions in the cities of Cyprus.
- Benzene concentrations are high in high traffic areas. But, it can be seen that e.g. in Germany a consequent implementation of catalysts in cars and the reduction of benzene content in fuels lead to a distinct reduction of benzene concentrations at the same sites between 1993/94 to 2001/02.

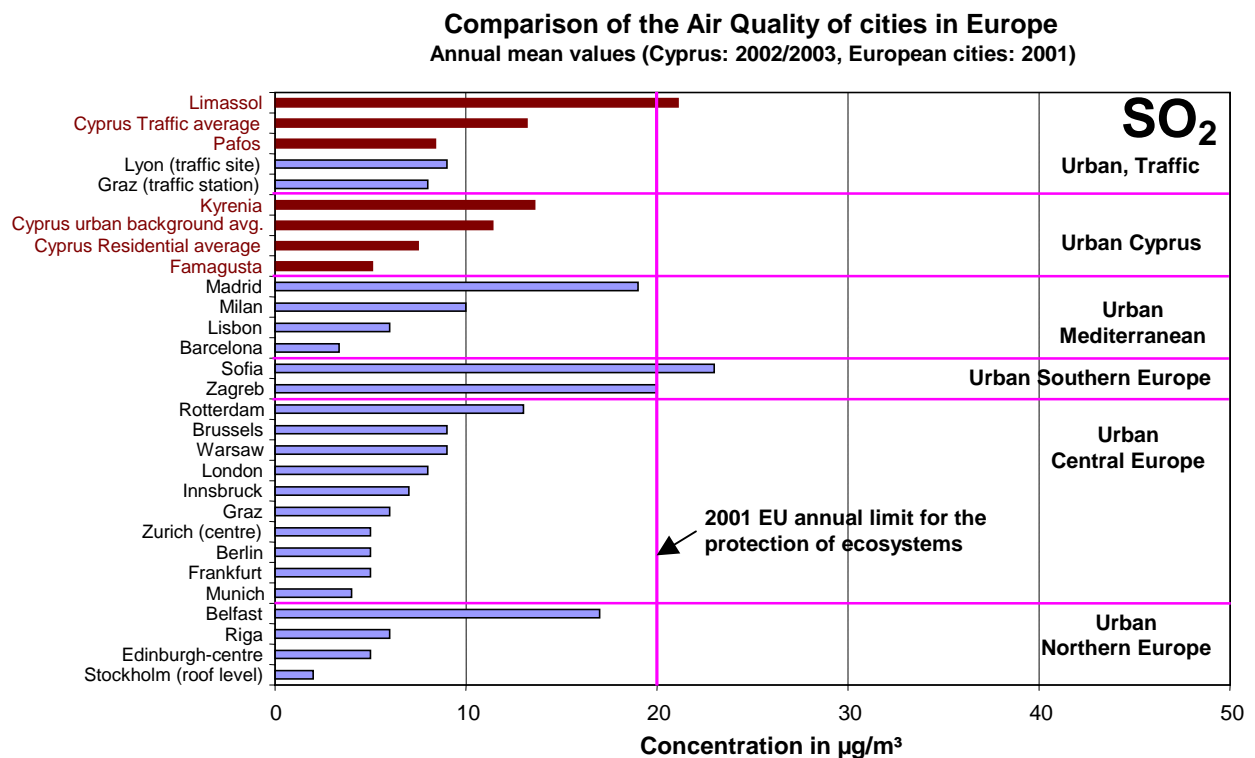


Figure 4.1. Comparison for SO₂ between Cyprus and cities of Europe

Comparison of the Air Quality of cities in Europe
Annual mean values (Cyprus: 2002/2003, European cities: 2001)

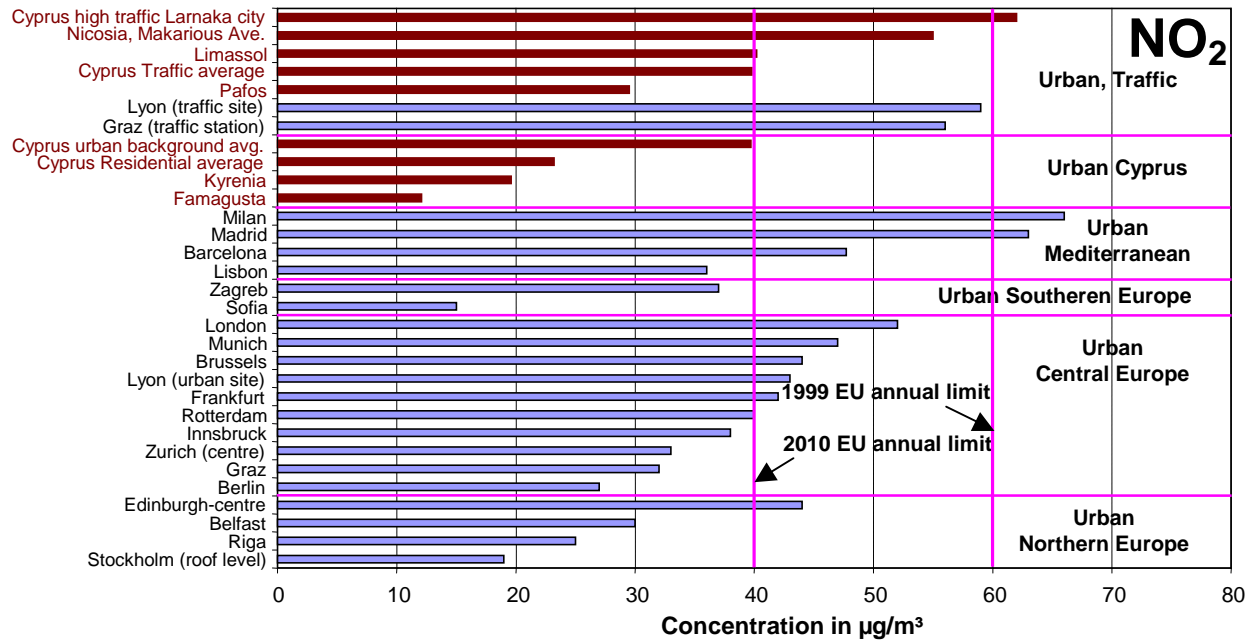
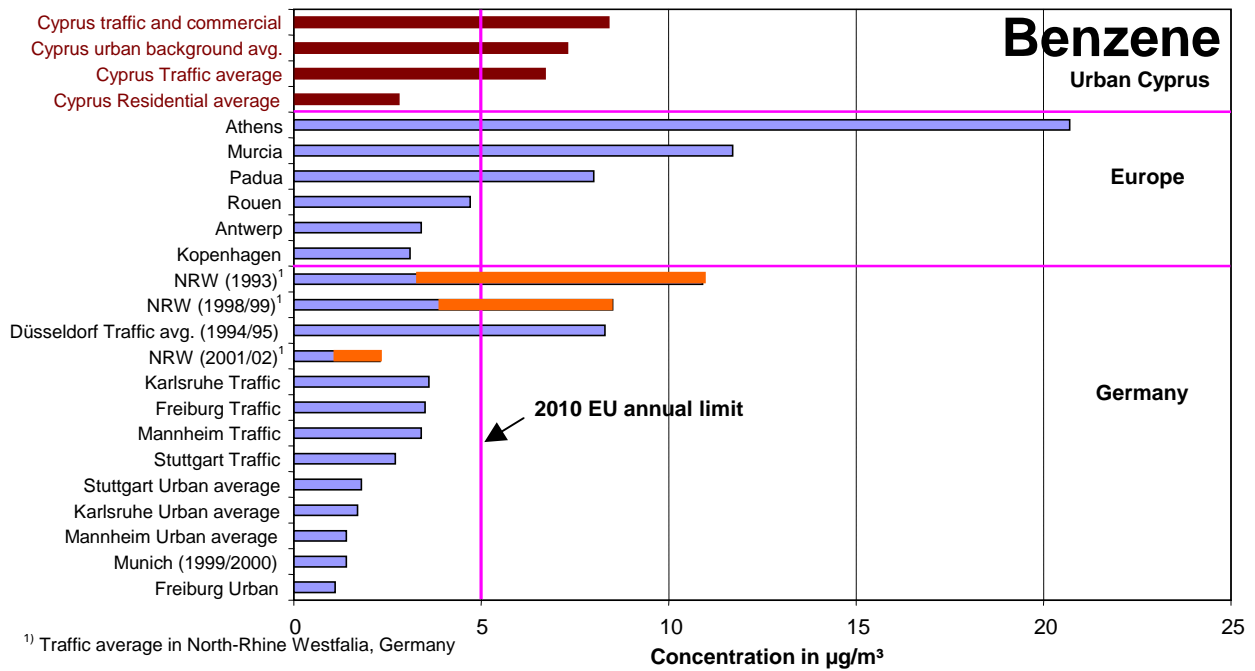


Figure 4.2. Comparison for NO₂ between Cyprus and cities of Europe

Comparison of the Air Quality of cities in Europe
Annual mean values (Cyprus: 2002/2003, European cities: 1999)



¹) Traffic average in North-Rhine Westfalia, Germany

Figure 4.3. Comparison for Benzene between Cyprus and cities of Europe

5 The Particulate Matter Problem in Cyprus

Due to the dry climate in Cyprus Particulate Matter is resuspended from soils and other surfaces. The wash out of particles from the air occurs only in winter and spring time when it is raining in Cyprus. In summer and fall time nearly no rain helps to clean the air. An illustrative overview over the PM₁₀ situation in Cyprus is given in Figure 5.1. Here the average PM₁₀ concentrations determined by particulate matter sampling during the project are depicted.

It can be recognised that at all traffic and at some residential and urban background sites the actual EU limit values for annual averages are exceeded. If the limit values of the year 2010 are considered nearly no site will have an air quality with PM₁₀ values below this strong limit.

The exceedances of 24h limit values are listed in Table 5.1 for three characteristic sites. The number and percentage of exceedances without and with Sahara dust events is shown for three different site categories:

- Nicosia General Hospital: Traffic
- Famagusta: Urban residential
- Agia Marina: Rural Background

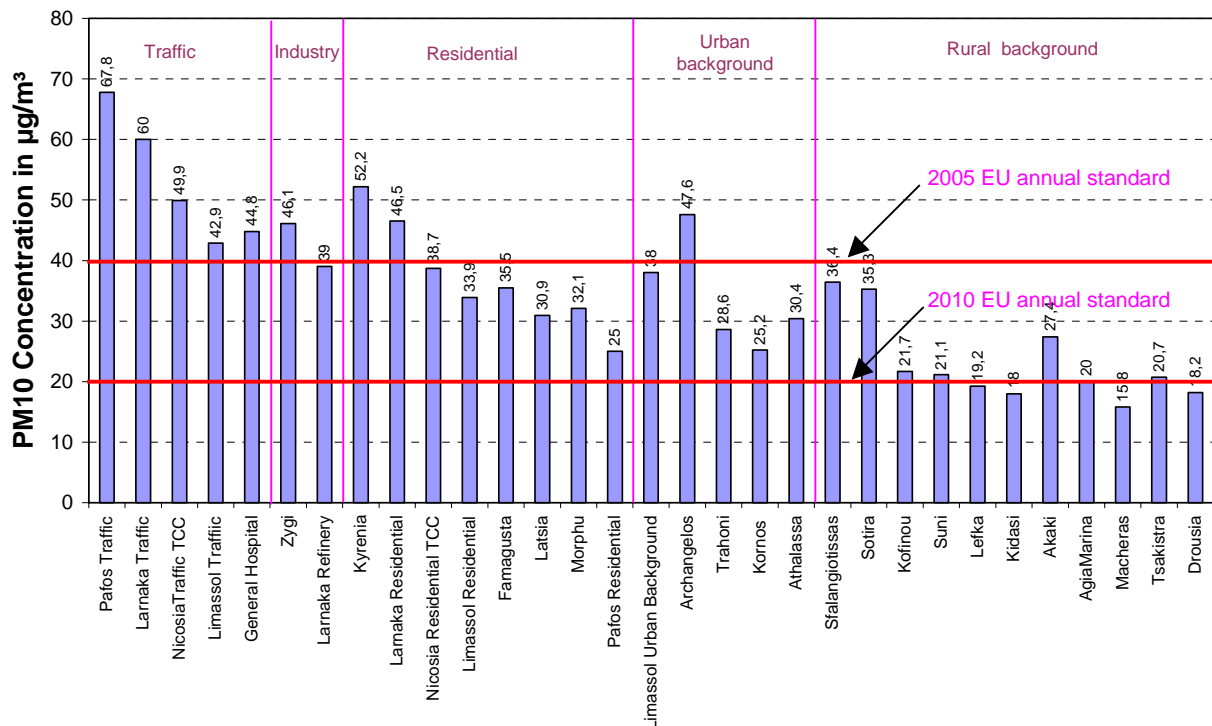


Figure 5.1. Average PM₁₀ concentrations at the different sampling points in Cyprus including Sahara dust events

Table 5.1. EU PM₁₀ 24h limit value exceedances at three different characteristic sites in Cyprus

Location	No. of exceedances (>50 µg/m ³) without Sahara dust	% of exceedances without Sahara dust events	No. of exceedances caused by Sahara dust	% of exceedances caused by Sahara dust events	No. of exceedances (>50 µg/m ³) with Sahara dust	% of exceedances with Sahara dust events
General Hospital	66	26	7	10	73	29
Famagusta	3	5	3	50	6	11
Agia Marina	7	3	5	42	12	5

Within the project the origin of the PM₁₀ load has been investigated. The results are the following:

- As an average 17% of the 24h limit exceedances are caused by Sahara dust events (at the three stations in Table 5.1 10 to 50%)
- From the remaining average PM₁₀ load (without Sahara dust) around 80% could be allocated for the three investigated sites
- At rural sites (Agia Marina as example) around 70% could be determined to be from natural origin: resuspended soil and sea salt. Around 9% could be allocated to combustion processes
- At traffic sites (e.g. General Hospital) around 60% of PM₁₀ could be allocated to traffic activities: Apart from PM exhaust emissions tire, brake and road abrasion and resuspended soil dust originally coming from fields or unpaved roads could be identified. 19% could be allocated as sea salt and traffic independent soil dust (air borne transported)
- At the residential site (Famagusta was investigated as example) 22% could be allocated as traffic induced particulate matter. The other 58% could be identified to be from soil and sea salt origin

The results of the PM investigations identified also the traffic as the main anthropogenic pollutant source. So, also from the PM₁₀ view efforts to reduce the traffic emissions have to be taken.

The comparison of the PM₁₀ concentrations in Cyprus cities with values of other European cities (Figure 5.2) demonstrate the PM₁₀ problem in Cyprus cities and underline the necessity of abatement

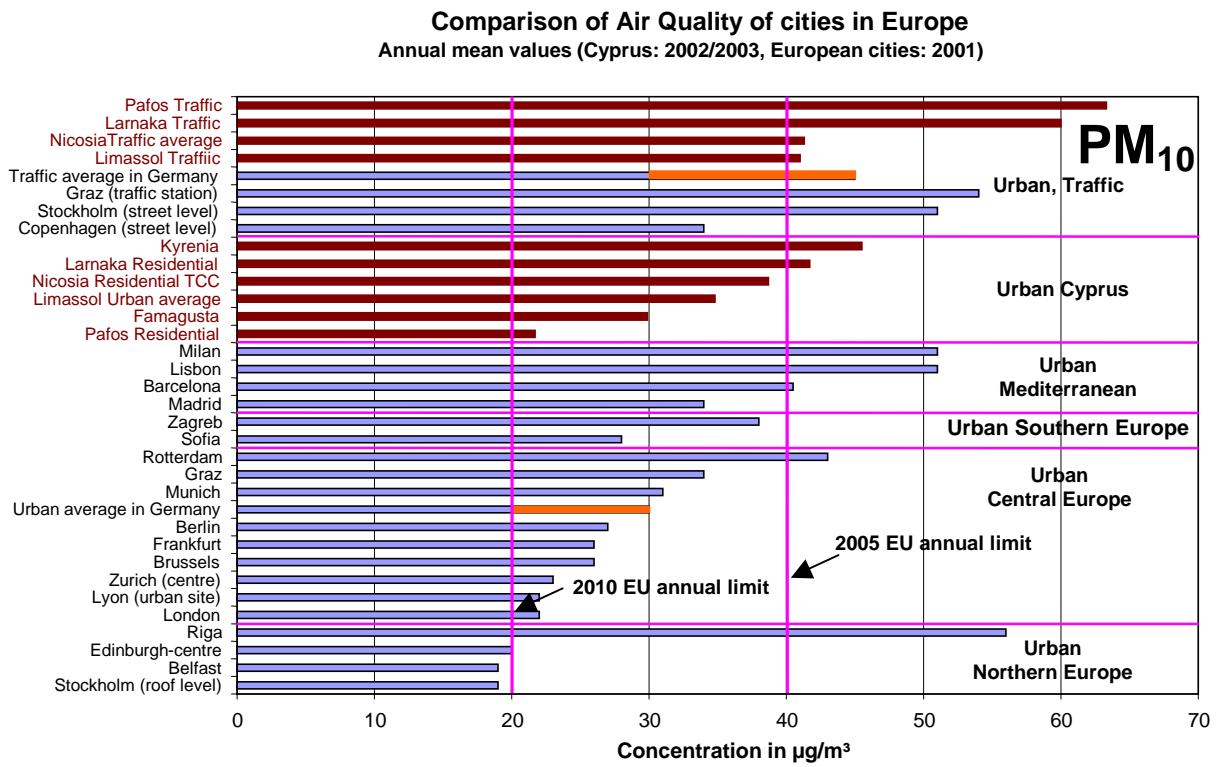


Figure 5.2. Comparison for PM₁₀ between Cyprus and cities of Europe

6 Ventilation of the cities and of traffic roads

There are two factors which influence the air quality in the cities and at high traffic roads especially:

- the emissions
- the ventilation which distributes the emissions by dilution and transporting them away.

Many investigations have shown that for the local air quality situation the ventilation is as efficient as reducing the emissions. This knowledge concerns

- high traffic roads where people are moving or living and
- cities or city areas as a whole.

Within the project the wind systems of Nicosia and Limassol were intensively investigated and the results are depicted.

Generally, TCC Nicosia is better ventilated than GCC Nicosia because of the lower building density. This is one of the reasons why the air pollution situation there is not as bad as in inner GCC Nicosia. Of course, the traffic load in GCC Nicosia is also distinctly higher but the ventilation effect is dominating. For improving the air quality in the cities the consequences of this knowledge are the following:

- Reducing the emissions at the roads
- Taking care of maintaining a good ventilation at the roads and of the cities in general.

The latter understanding is very important for the city planning! That means:

- No closed building lines at high traffic roads!

Negative examples: Makarios Avenue and Limassol Avenue in Nicosia are too poor ventilated according to their traffic load.

The recommendations for the improvement are:

- For existing bad ventilated roads the emissions have drastically to be reduced
- For new developments a good ventilation has to be considered. That means providing of enough and large building gaps considering the wind directions in this area.

The ventilation is not only an important property for the pollutants reduction on high traffic roads, but also for the improvement of the air quality of whole cities. The consequences are:

- No closed building lines with high buildings along cities or parts of cities which could block the positive ventilation effect of general wind systems, especially the sea-land breezes or the mountain-valley winds.

Negative example: The hotel line at the beach side in Larnaca. The inner city behind this line is decoupled from the sea-land breezes and therefore very bad ventilated.

The recommendations for improvement are the same as for the high traffic roads but in a larger scale:

- For existing bad ventilated city areas the emissions have drastically to be reduced
- For new developments a good ventilation has to be considered. That means, providing of open strips for the wind flows of the local wind systems, individually designed for each city. Most important is to consider the nocturnal wind direction since the nocturnal winds are slowing down and mostly weaker than the winds during the day and during night time stable meteorological conditions prevail and thus the dilution of the pollutants is inhibited. But the winds during the day shall also not to be obstructed or blocked as well. Based on the results of the project examples for some cities of Cyprus special recommendations are given in the report.

7 Recommendations for Air Quality Assessment and Improvement

7.1 General and Responsibilities

The responsibilities and concerns for air quality improvement are distributed to several groups of the society. The main responsibilities are depicted in Figure 7.1.

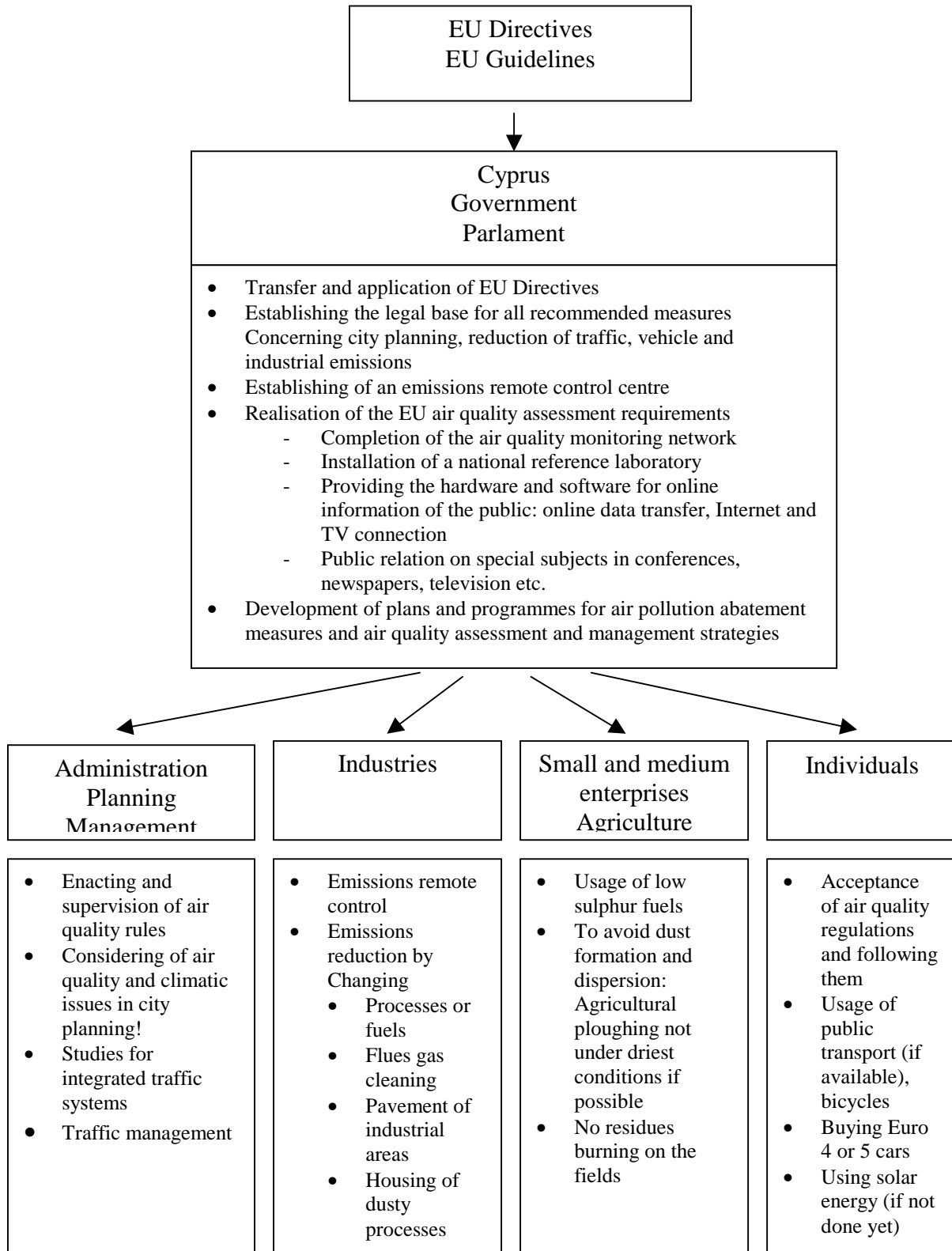


Figure 7.1. Distribution of responsibilities for air quality improvement measures

To implement air quality measures in general it has to be distinguished between

- Administrative, planning and management measures
- Technical measures to reduce the emissions at the sources
- Educational measures

The first measure for an effective improvement of the air quality is the implementation of an air quality management and control system which is hosted at the Government of Cyprus This management is responsible for:

- Transfer and application of EU Directives
- Establishing the legal base for all recommended measures
- Establishing of an emissions remote control centre
- Realisation of the EU air quality assessment requirements
 - Completion of the air quality monitoring network
 - Installation of a national reference laboratory
 - Providing the hardware and software for online information of the public: online data transfer, Internet and TV connection
 - Public relation on special subjects in conferences, newspapers, television etc.
- Development of plans and programmes for air pollution abatement measures and air quality assessment and management strategies

As results of this project proposals for the following air quality assessment items have been worked out:

- Proposal for division of Cyprus in administrative assessment zones
- Number and location of monitoring stations for an air quality monitoring network
- Need of personnel to operate the network and to manage the air quality assessment
- Requirements for a national reference laboratory and proposals for the handling of lab analyses

7.3 Proposal for zones and number of monitoring stations and personnel needed

7.3.1 Zones and monitoring stations

The zones shall be established according the six administrative districts of Cyprus, see Table 7.1. In this table the proposed number of monitoring stations is listed.

Table 7.1. Districts characterisation of Cyprus

District/Zone Number	District Name	No of monitoring stations			
		Multi compon	Mini urban/traffic	Multi compon backgrou	Mini backgrou
GCC		9	3	1	4
1a	Nicosia	2	1	1	
2	Larnaca	2	1		1
3	Limassol	2	1		1
4	Paphos	1			1
6b	Famagusta				1
	Independent, mobile	2			
TCC		2	1		1
1b	Nicosia	1			
5	Kyrenia		1		1
6a	Famagusta	1			

7.3.2 Personnel needed for quality assessment and monitoring

	GCC	TCC
Scientists	10	3
Technicians	8	3

7.4 Priorities in air quality improvement measures

As result of all the measurements carried out in the project it can be stated that the most affected sites in Cyprus are:

- High traffic zones in the cities
- Bad ventilated city areas with traffic influence
- Residential areas influenced by close traffic zones
- Surrounding areas of power plants and cement factories and some special industries
- Neighbourhood of quarries
- Sites affected by uncontrolled burning: surrounding areas of wild waste burning and of field or bush fires

To improve the air quality different measures have been recommended in the project. The realisation of such measures has different time scales. Not all measures can be realised immediately because of costs or other reasons. But some measures could be implemented at once. In the following the recommended air quality improvement measures are classified in short, medium and long term improvement activities, classified according the responsibilities. The three categories are based on the following time scales:

1. Short term measures: immediately up to one year
2. Medium term measures: one to five years
3. Long term measures: five to ten years

These time scales consider the realisation of the measures. Of course, the medium and long term measures have to be planned much earlier, even now beginning. Some measures are recommended as short term and as well as medium term measures for their continuation or as medium and long term measures respectively.

7.4.1 Short term measures

Government

- Transfer and application of EU Directives
- Establishing the legal base for all recommended measures concerning city planning, reduction of traffic, vehicle and industrial emissions
- Establishing of an emissions remote control centre
- tax reduction or tax remission for Euro 4 and Euro 5 vehicles
- Regular official emission checks for all existing vehicles
- Realisation of the EU air quality assessment requirements
 - Completion of the air quality monitoring network
 - Installation of a national reference laboratory
 - Providing the hardware and software for online information of the public: online data transfer, Internet and TV connection
 - Public relation on special subjects in conferences, newspapers, television etc.
- Regulations for:
 - Avoidance of fires and combustion on wild or controlled waste deposits
 - To avoid dust formation and dispersion: Carrying out of agricultural ploughing not under driest conditions
 - No residues burning on the fields

Administration, Planning, Management

- Introduction of air quality and urban climate aspects into the city planning of all cities in Cyprus: No development plan should be decided without an air quality and climatic experts opinion which considers the ventilation of the cities and of high traffic roads
- Studies for the design of integrated traffic systems for each major city of Cyprus including modern traffic management systems
- Initial set up of bus systems with high frequent servicing (and priority lanes and traffic lights) in the major cities and as interconnection between the cities
- Establishing of school bus systems
- Extending of pedestrian areas
- Promotion of cycle ways
- Planting of bushes and hedgerows at the edges of fields
- For existing bad ventilated roads in the cities, the traffic emissions have drastically to be reduced (by the measures mentioned above)
- Drastically emissions reduction in bad ventilated inner cities by closing them for traffic (e.g. inner cities of Larnaca, Kyrenia and Makarios Avenue in Nicosia etc.)

Small and medium enterprises, Agriculture

- Consequent extension of solar warm water systems for all buildings, also to all **hotels**
- For cases where the combustion of oil cannot be avoided (all small firings) low sulphur light oil should be required and provided in general for whole of Cyprus
- Avoidance of fires and combustion on wild or controlled waste deposits
- To avoid dust formation and dispersion: Carrying out of agricultural ploughing not under driest conditions
- No residues burning on the fields

- Planting of bushes and hedgerows at the edges of fields

Individuals

- Going by feet and bicycle for short ways
- School minibus organisation together with schools and authorities and acceptance and usage of the school bus system to avoid individual traffic
- Buying of environmental friendly Euro 4 and 5 cars
- Consequent extension of solar warm water systems for all buildings

7.4.2 Medium term measures

Administration, Planning, Management

- Further development of the bus systems with high frequent servicing (and priority lanes and traffic lights) in the major cities and as interconnection between the cities
- Extending of pedestrian areas
- Promotion of cycle ways
- Extending of the pavement of roads
- Extending of the planting of bushes and hedgerows at the edges of fields
- Realisation of the ventilation of cities: No closed building lines with high buildings along cities or parts of cities or along high traffic roads which could block the effect of cleaning wind systems, especially the sea-land breezes or the mountain-valley winds

Industries

Stepwise reduction of industrial pollution:

- Power plants: usage of better oil or flue gas cleaning by dry absorption
- Cement factories: Housing of all dust producing machines and processes and dust removal of the exhaust gases of these housings. Pavement and holding clean of all roads within the factory
- Quarries: Housing of all dust producing machines and processes and dust removal of the exhaust gases of these housings. Pavement and holding clean of all roads within the quarry area
- Installation of gas suction systems at filling stations.

Small and medium enterprises, Agriculture

- Further extension of solar warm water systems for all buildings, also to all **hotels**.
- Official regular check of combustion quality in small no permission required firings

7.4.3 Long term measures

Government, Administration, Planning, Management

- Further realisation of the ventilation of cities: No closed building lines with high buildings along cities or parts of cities or along high traffic roads which could block the effect of cleaning wind systems, especially the sea-land breezes or the mountain-valley winds
- Installation of a trolley bus system in Nicosia
- Installation of a waste incineration plant for whole Cyprus
- Extending of the pavement of roads
- Extending of the planting of bushes and hedgerows at the edges of fields

Industries

Finalisation of reduction of industrial pollution:

- Power plants: usage of better oil or flue gas cleaning by dry absorption
- Cement factories: Housing of all dust producing machines and processes and dust removal of the exhaust gases of these housings. Pavement and holding clean of all roads within the factory
- Quarries: Housing of all dust producing machines and processes and dust removal of the exhaust gases of these housings. Pavement and holding clean of all roads within the quarry area
- Installation of gas suction systems at filling stations

Individuals and persons in responsible positions

Target:

Development of an environment conscious, acceptance of air pollution prevention measures and proposals and realisation of improvement measures!