Preliminary Assessment of Ambient Air Quality in Cyprus

Executive Summary

This report contains the results of the “Preliminary assessment of ambient air quality in Cyprus” and recommendations for the implementing agencies to decide on the network to be established for the systematic monitoring of air quality in accordance to the relevant EU Directives.

1 Project Objectives and Tasks

Objectives

The main objectives of this project are:

- "Preliminary Assessment of Ambient Air Quality and Drawing Up of Zones of Pollution in Cyprus" according to the EU Framework Directive 96/62/EC on ambient air quality assessment and management.
- To assist Cyprus to optimise the ambient air quality monitoring network in order to comply with the relevant Directives of the European Union including the reporting to the commission.
- To supply the necessary input for the formulation of air pollution management policies in Cyprus including preparation of plans on how to meet the EU limits and other EU requirements.
- To increase public awareness on the issues of urban and rural air pollution.

Tasks

The air pollutants dispersion from the emission sources and their distribution in the atmosphere in time and space depends on several parameters. They are depicted in Figure 1.1. In this figure the way of pollutants from the emission to the receptors (humans, vegetation, materials) and the air quality management from monitoring to air pollution prevention measures is also shown in this Figure.

To reach the objectives of the project, to determine the temporal and the spatial distribution of the air pollutants and the assessment of its results, the total volume of work is broken down in the following main tasks:

Task 1: Emissions Inventory

Task 2: Measurements of Pollutants in Different Zones of Cyprus Using Diffusive and Active Sampling Techniques and Continuous Reference Measurements

Task 3: Determination of Pollutants Transport by Measuring the Vertical Structure of the Pollutant Plume of Nicosia and Limassol and Continuous Ground Level Wind Measurements

Task 4: Calculation of Complete Concentration Fields over Cyprus Using Measurement Results and Modelling

Task 5: Overall Evaluation and Recommendations Using the Results of Measurements and Modelling

Task 6: Future Air Quality Monitoring Network for Cyprus

Task 7: Training of the Governmental Staff, Presentation and Discussion of the Results

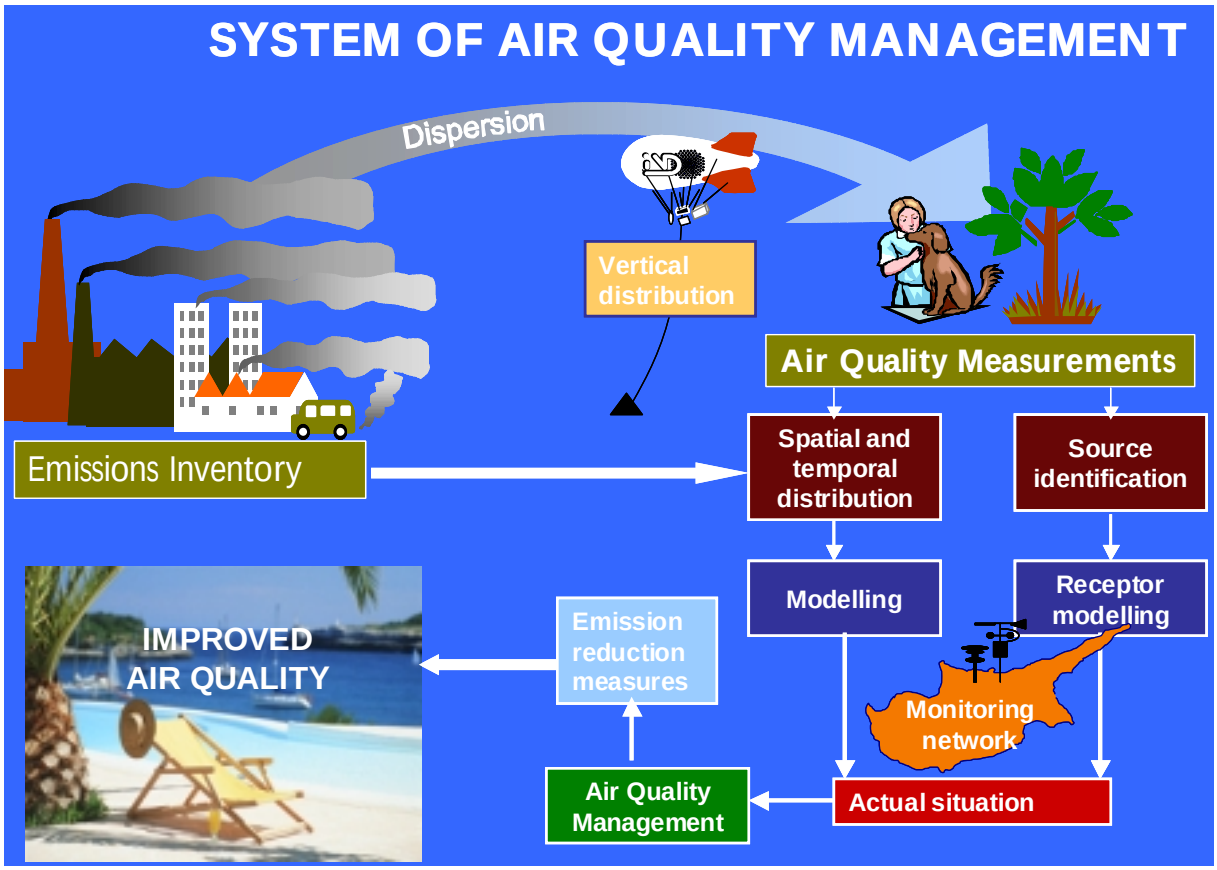

Figure 1.1. General overview of air quality assessment and management

This report describes the final results of the project. All parameters relevant for air quality issues haven been investigated:

- Emissions behaviour - emissions inventory
- The spatial distribution of air pollutants – diffusive sampling
- The temporal variation of air pollutants - continuous measurements
- Meteorology – evaluation of continuous measurements and balloon soundings
- The vertical distribution of air pollutants – balloon soundings
- Complete concentration field over Cyprus – interpolation and neural network modelling
- A preliminary assessment related to EU regulations has been carried out

2 Emissions Inventory

The results of the emissions inventory are summarized in the following tables. In Table 2.1 the calculated overall annual different air pollutants emissions due to traffic are listed for the different cities of Cyprus.

Table 2.1. Overall annual air pollutants emissions due to traffic

Region	NO_x (tns/yr)	CO (tns/yr)	VOC (tns/yr)	PM (tns/yr)	SO_2 (tns/yr)
Greek Cyprus Community (GCC)					
Nicosia urban	1776	8372	1436	86	731
Limassol urban	1773	7129	1520	143	784
Larnaka urban	531	2488	430	34	215
Pafos urban area	1032	4111	678	65	253
Highways	3545	6894	663	111	1825
Rural network	2925	5432	875	164	1866
Total GCC emissions	11677	35987	6480	540	5674
Turkish Cyprus Community (TCC)					
Nicosia urban	522	1443	252	22	525
Famagusta urban area	271	1356	251	12	171
Kerynia urban area	274	1006	184	9	153
Morphou urban area	78	393	99	3	45
Rural and high-way network	529	925	127	18	510
Total TCC emissions	1674	5123	913	64	1404
Total emissions due to traffic	**13256**	**39549**	**8271**	**667**	**7078**

The emissions of the different point sources like boilers, dry cleaners, hotels, domestic heating, agriculture, petrol stations and air crafts at the air ports are listed in Table 2.2. The boilers include the power plants which are the main sources for NO_x and SO_2. The second important source for NO_x and the main source for CO and volatile organic Compounds (VOC) is the traffic, especially in the cities.

Table 2.2. Emissions of point sources in Cyprus

Sources	NO_x (tn/yr)			CO (tn/yr)			VOC (tn/yr)			PM (tn/yr)			SO_2 (tn/yr)		
	GCC	TCC	Total	GCC	TCC	Total	GCC	TCC	Total	GCC	TCC	Total	GCC	TCC	Total
Boilers	10782	965	11747	117	104	221	509	6	515	1452	203	1655	30388	6544	39932
Dry cleaners	30,7	0,14	31	7,7	0,04	8	209	2,349	211	7,8	0,01	8	333	0,6	334
Hotels	19,4	2,2	21,6	4,9	1,4	6,3	0,2	0,05	0,25	2	0,18	2,2	82,9	5,2	91,1
Domestic heating	65,2	0,4	65,6	97,8	0,3	98,1	3,8	0,02	3,82	39,2	0,03	39,2	1666	0,3	1666
Agriculture	19,5			29,2			1,1			11,7			498		
Petrol stations							532,4	204	736,4						
Aircrafts	256,6	1,4	258	64,2	0,3	64,5	2,6	0,013	2,613	89,7	0,5	90,2	18,2	0,09	18,29

3 Spatial Pollutants Distribution – Results of Diffusive Sampling and Modelling

The spatial pollutants distribution has been determined by diffusive sampling at 250 sites in Cyprus over one year for the components NO_2, SO_2, Benzene and Ozone. The concentrations distribution over the whole island was determined by interpolation between the sites. The concentration map for the component SO_2 determined in this way is shown in Figure 3.1. On the one hand the cities can be identified in this map and on the other hand the power plants.

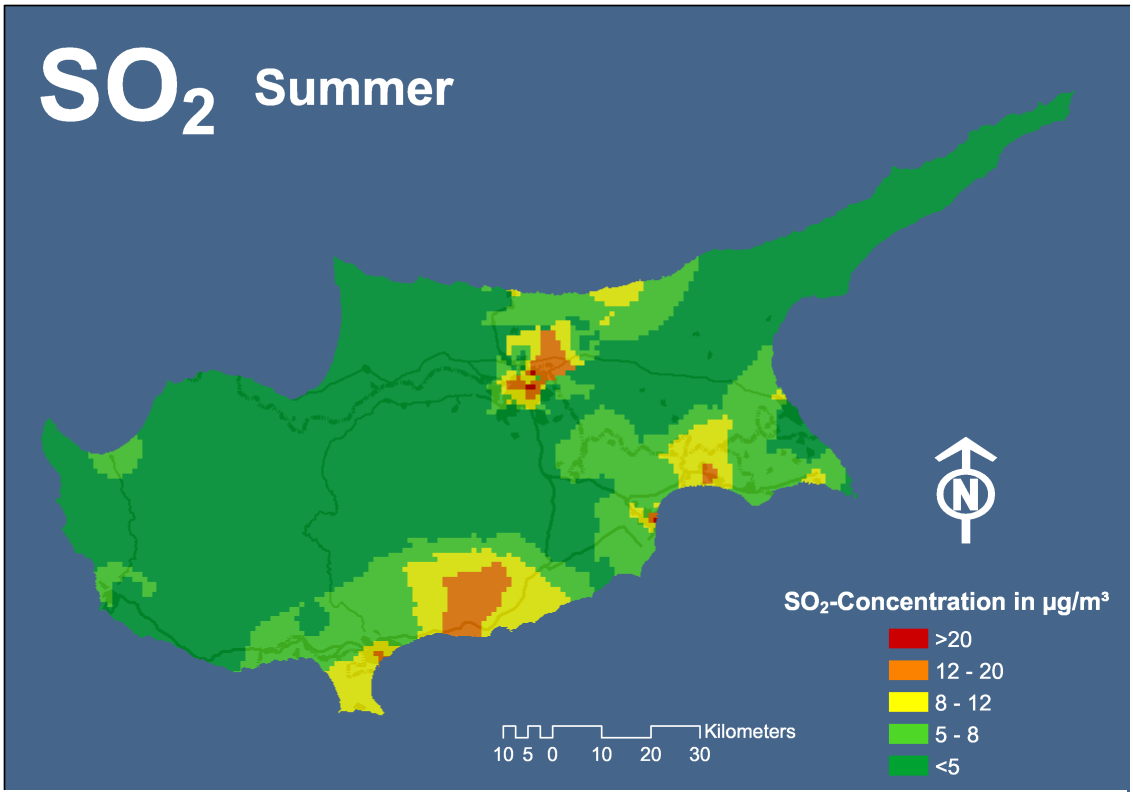

Figure 3.1. Mean interpolated SO_2 distribution over Cyprus during summer

For the component **Benzene**, emitted mainly from motor vehicles, the cities with high traffic load are mainly affected. As an example the benzene distribution over the city of Nicosia is shown in Figure 3.2. In Larnaca city the ventilation is strongly inhibited which can be seen clearly by the high Benzene concentrations there, see Figure 3.3. In the inner city or high traffic zones also high NO_2 concentrations could be recorded.

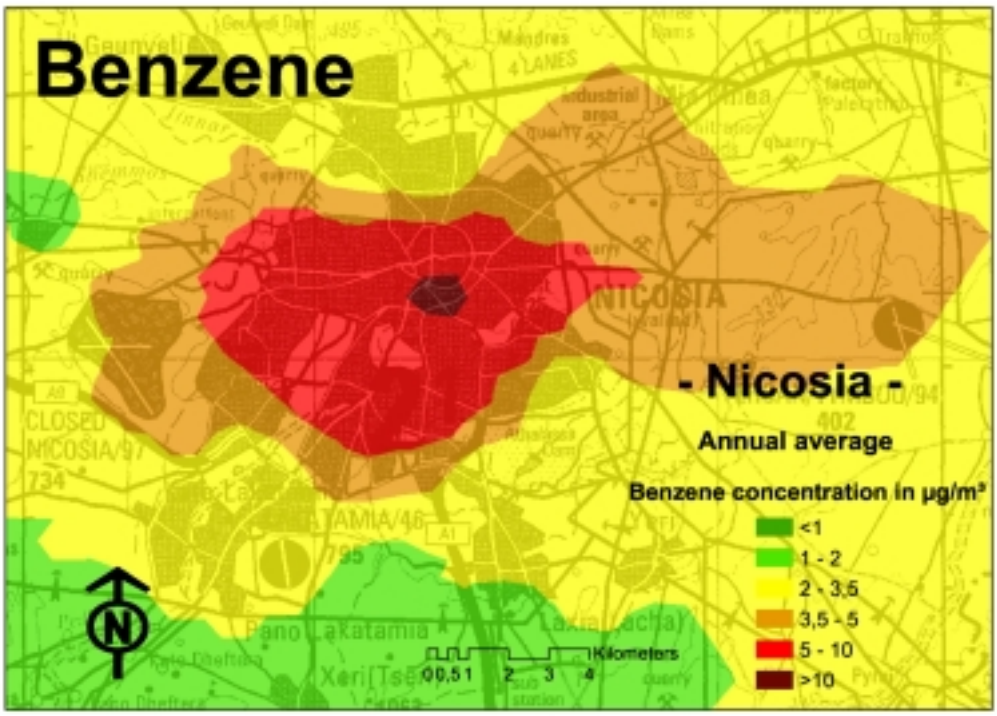

Figure 3.2. Mean annual interpolated Benzene distribution in Nicosia

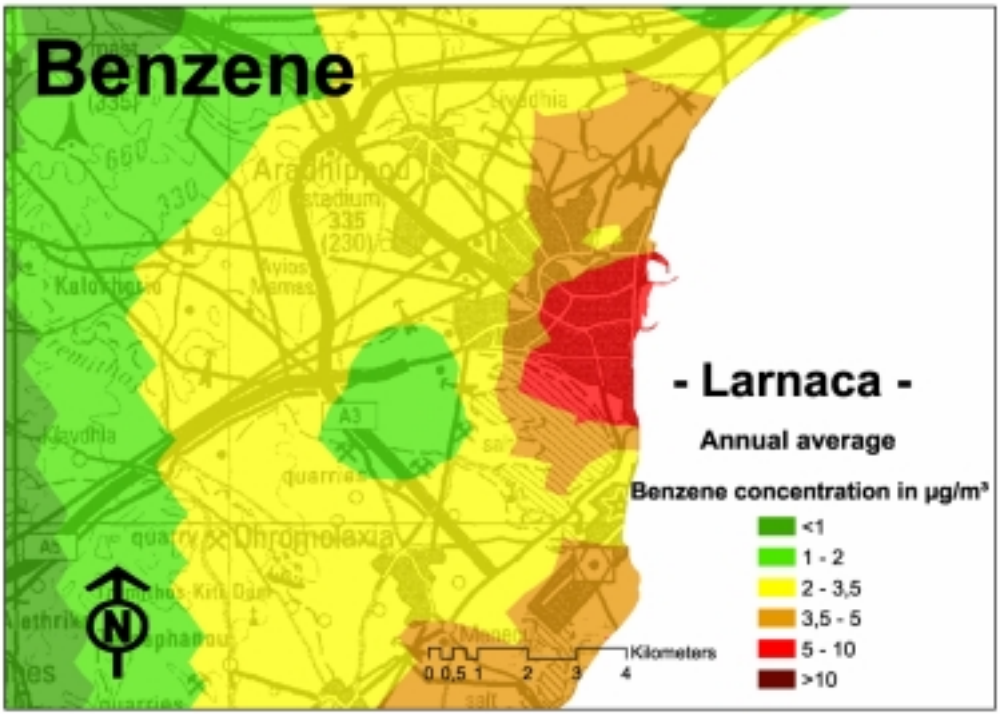

Figure 3.3. Mean annual interpolated Benzene distribution in Larnaca

The method of interpolation does not consider the concentration structure between the sampling sites. To improve the concentration maps a Neural Network Model was used which has been trained with the following parameters:

- Concentrations at the diffusive sampling sites
- Emissions Inventory with dispersion modeling
- Population density

The result of this kind of Neural Network modelling shows a much better fine structure than the interpolation. The Neural Network modeled air quality Cyprus map for the component NO_2 is depicted in Figure 3.4. The problematic zones of air pollution can clearly identified in the cities, along the highways and around the industrial zones (e.g. power plants).

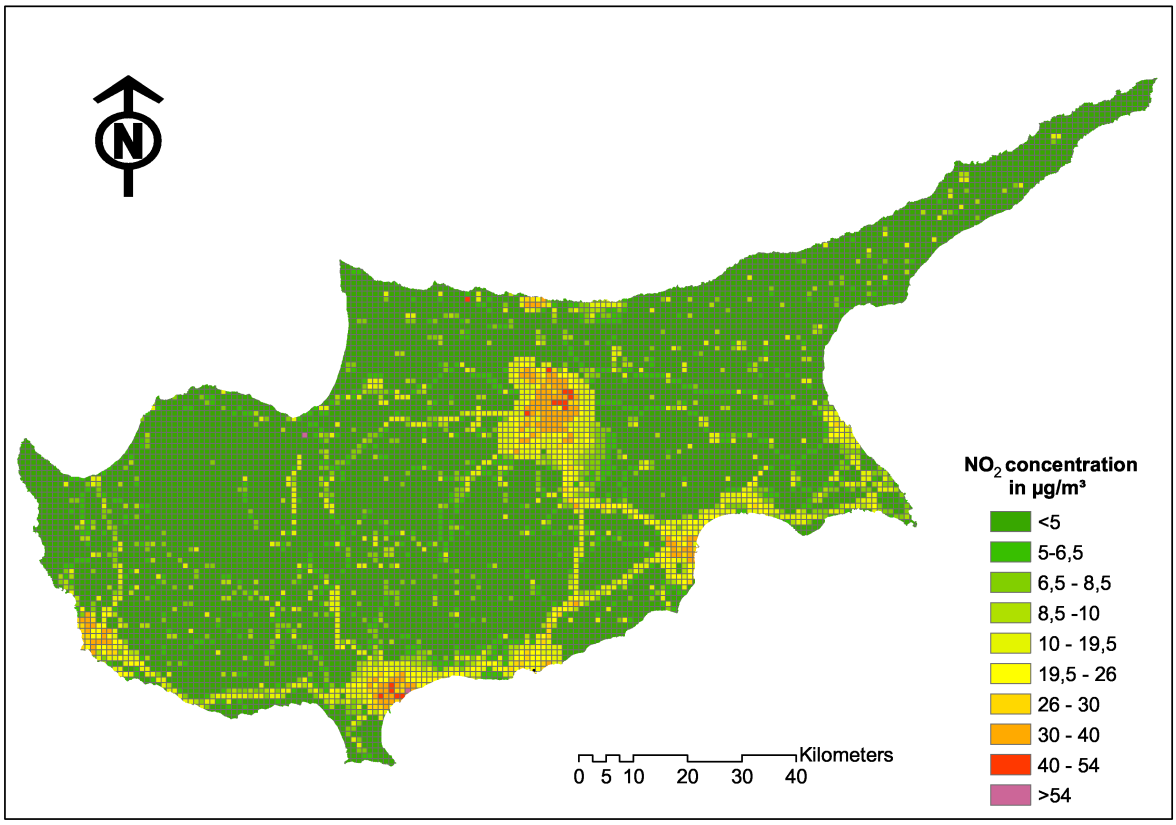

Figure 3.4. NO_2 distribution calculated with neural network model, based on diffusive sampling, emissions inventory with plume dispersion modelling and population density

Table 2.3. NO_2, Benzene, SO_2 and Ozone concentration levels at the different site categories – averages from one year diffusive sampling

Site Category	NO_2 average in µg/m³	Benzene average in µg/m³	SO_2 average in µg/m³	Ozone average in µg/m³
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