Air quality in the North of Portugal

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Abstract: Air pollution in urban areas is a major topic of concern in many large cities. In Portugal, a monitoring network measures relevant pollutants for zones and agglomerations. The measurements of two zones and four agglomerations located in the North of Portugal were used to diagnose the pollution level and the relative air quality. It was found that, despite the need for densification of the network of monitoring stations, ozone (O3) and particulate matter (PM10) reach significant levels in a number of days during the year. Some recommendations are made regarding the inclusion of planning and mitigation actions in the Regional and Municipal Master Plan.

Key-Words: Air pollution in Portugal; Air quality in Portugal

1 Introduction

With time air quality has started to deteriorate mainly due to diversification and intensification of human activities in urban areas affecting negatively the health of population and ecosystems.

Portugal maintains a network of stations monitoring air quality in order to assess the level of air pollution. Their measurements are concentrated in a database of national scope (QualAr).

Based on these measurements the Air Quality Index (IQAr) is calculated on a daily basis for a number of zones and agglomerations.

For this purpose zones are determined as areas with at least one evaluation station for background pollution and of pollution caused by natural events. In the "State of the Environment Report 2005" [1] information is available concerning the following areas: Algarve, Alentejo Interior, Alentejo Litoral, Tagus Valley and West, Centro Litoral, Centro Interior, ZI de Place, North Interior, North Coast.

For this purpose the agglomerations are defined as areas with highest population concentration, with at least two monitoring stations - urban traffic and other urban background. In the "State of the Environment Report 2005" information is presented regarding the following agglomerations: Funchal, Faro/Olhão, Albufeira/Loulé, Portimão/Lagoa, Setúbal, Área Metropolitana de Lisboa Sul, Área Metropolitana de Lisboa Norte, Coimbra, Aveiro/Ílhavo, Vale do Sousa, Vale do Ave, Porto Litoral, Braga.

For the North Region, which is in the administrative district of the CCDR-N (North Regional Coordination and Development Commission), two zones and four agglomerations have been determined [2]: the zones of Norte Litoral and Norte Interior and the agglomerations of Braga, Vale do Ave, Vale do Sousa and Porto Litoral (Figure 1).

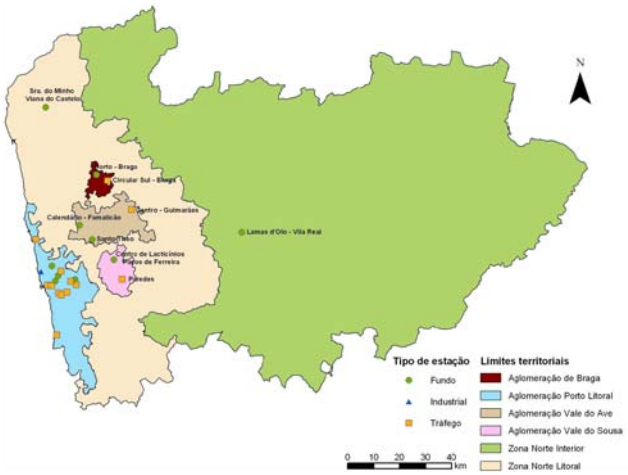

Fig. 1: Zones, Agglomerations and monitoring stations of the North Region [3]

The agglomeration Porto Litoral in turn has 15 monitoring stations as shown in Figure 2.

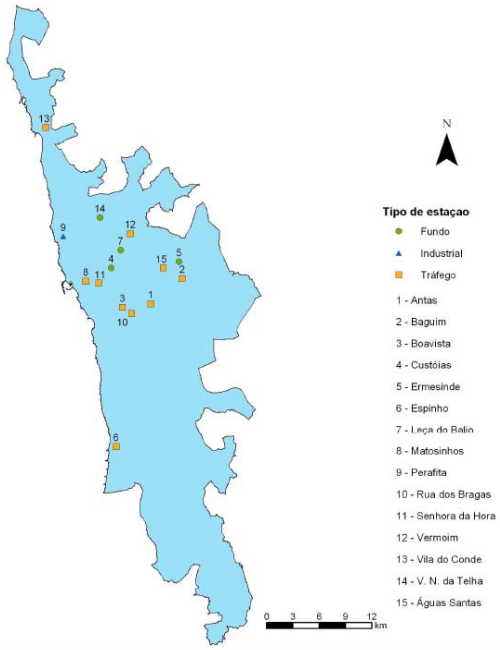

Fig. 2: Monitoring station of the agglomeration Porto Litoral [3]

2 Pollution Measurements and Air Quality Calculation

The APA (Agência Portuguesa do Ambiente - Portuguese Environmental Agency) of the Ministry of Environment of Portugal provides public information on pollution levels based on measurements taken through a pollution monitoring network. The information on pollutant levels is presented as an index called Air Quality Index (IQar) - "Índice de Qualidade do Ar" [4]. The IQar is based on 24–hour average concentrations, and therefore does not reflect short term peak levels.

The IQar is expressed as a single value taking into consideration the concentrations of five major air pollutants (CO, NO2, O3, SO2, PM10). The index is based on the pollutant with the highest concentration relative to the Portuguese annual limit values for the protection of human health. The values of the other four pollutants are then disregarded. The calculation of IQar takes into account the following averages:

- Nitrogen Dioxide (NO2) – hourly average;
- Sulphur Dioxide (SO2) – hourly average;
- Ozone (O3) – hourly average;
- Carbon Monoxide (CO) – 8-hour average;
- Suspended Particulates (PM10) – daily average.

The air quality assumes the classification from Poor to Good according to a classification system summarized in the Table 1.

The classification of the air quality is based on the pollutant with the highest concentration relative to the Portuguese annual limit values for the protection of human health (Decree-Law 111/2002; Portaria 623/1996), [i.e. for an atmosphere with pollutants levels SO2 - 35 µg/m3 (very good), NO2 - 180 µg/m3 (fair); CO - 6000 µg/m3 (good), PM10 - 15 µg/m3 (very good) and O3 - 365 µg/m3 (very poor): Air Quality was Very Poor due to ozone].

Figure 3 represents the Air Quality Index for 2005, expressed by the number of days within each of the quality classes (Very Good, Good, Fair, Poor, Very Poor).

The analysis of daily index numbers during 2005 shows that the predominating class of the IQAr was "Good", which is in accordance with the values of the previous years. However, in urban areas more densely populated or with some industrial importance, the number of days with an index "Fair", "Poor" or even "Very Poor" are remarkable, as it is the case in the zones of Vale do Ave, the catchment area of Estarreja, Setúbal, Porto Litoral and the Metropolitan Area of Lisbon.

Fig. 4 shows the variation of air quality from 2002 to 2005.

The assessment of these four consecutive years shows that the number of days where the index is presented as "Fair" or "Poor" was still high. There is even a tendency of decrease of "Fair" days and simultaneously a growth of "Poor" days. However the number of days classified as "Good" has grown.

A curious fact is the increase of "Good" days in Lisbon and Porto, while there is a "migration" of "Fair" days to "Poor" days usually due to high concentration of particles or ozone.

Table 2 shows the reality of the North Region in 2005, expressed through the number of days registered in each Air Quality Class. .

The situation is not a very serious one, taken into consideration that this is mainly due to urban areas with a typically higher road (traffic) and industrial density. However the percentage of "Poor" and "Very Poor" are not negligible, so there is definitely need to emphasis this situation and to consider strategies including preventive practices for the use and occupation of land.

In addition to this information resulting from the calculation of the Air Quality Index, there is a need to analyse in particular some pollutants in order to explain the more extreme values indicated in bold in Table 2.

It is the particular situation of Norte Interior, where 25 "Very Poor" days were registered, due to the higher concentration of ozone. And also in the case of Vales do Ave and do Sousa with values "Poor" in more than 25% of the day, mainly due to high concentration of Particulate Matter PM10.

Table 1: Classification of IQar for 2010 [4]

Pollutant	**CO (µg/m3)**		**NO2(µg/m3)**		**O3(µg/m3)**		**PM10(µg/m3)**		**SO2(µg/m3)**	
Classification	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Very Poor	10000	-----	400	-----	240	-----	120	-----	500	-----
Poor	8500	9999	200	399	180	239	50	119	350	499
Fair	7000	8499	140	199	120	179	35	49	210	349
Good	5000	6999	100	139	60	119	20	34	140	209
Very Good	0	4999	0	99	0	59	0	19	0	139

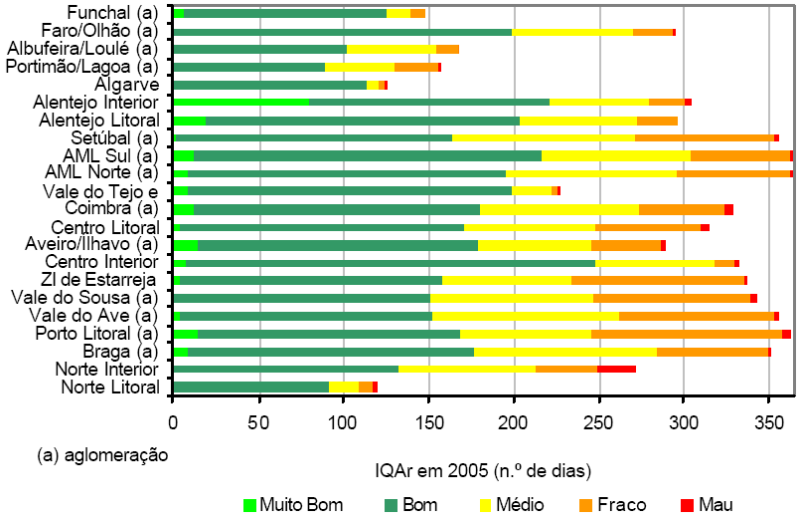

Fig.3: Air Quality Index, in 2005 (Very Good, Good, Fair, Poor, Very Poor) [4]

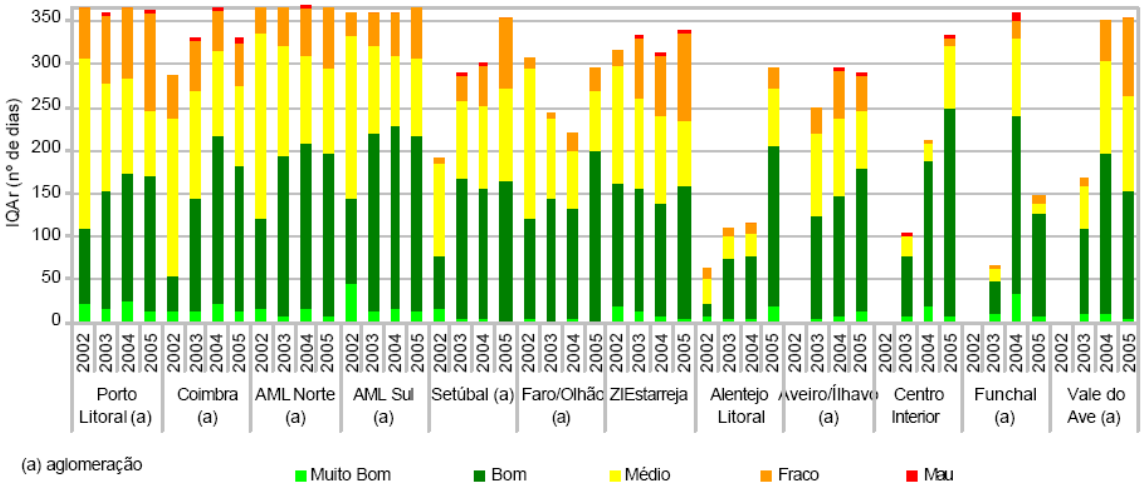

Fig. 4: Number of days included in each Air Quality class (Very Good, Good, Fair, Poor, Very Poor) [4]

Table 2: Air Quality Index in the North Region, in 2005 - Source: www.qualar.org.

Agglomerations (a) and Zones	Very Good		Good		Fair		Poor		Very Poor	
	Days	%	Days	%	Days	%	Days	%	Days	%
Porto Litoral (a)	12	4.5%	157	59.2%	79	29.8%	13	4.9%	4	1.5%
Braga (a)	9	2.5%	174	48.3%	110	30.6%	66	18.3%	1	0.3%
Vale do Ave (a)	3	0.8%	149	41.5%	113	31.5%	92	**25.6%**	2	0.6%
Vale do Sousa (a)	0	0.0%	155	42.7%	100	27.5%	105	**28.9%**	3	0.8%
Norte Litoral	0	0.0%	116	76.3%	25	16.4%	9	5.9%	2	1.3%
Norte Interior	0	0.0%	148	48.2%	95	30.9%	39	12.7%	25	**8.1%**

The Ozone and particulate matter are in fact the pollutants that the "Thematic Strategy on Air Pollution", adopted in September 2006 within the Sixth Environment Action Programme of the European Community, identifies as most worrying with regard to human health. An exposure to these pollutants may lead to impacts ranging from mild effects on the respiration system to premature mortality.

Ozone is a secondary pollutant as it is not directly emitted to the atmosphere, but results from a complex process involving a series of chemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOCs), which are considered to be the main precursors of ozone, in the presence of oxygen and sunlight. These gases, mainly of anthropogenic origin, are emissions from road transport and certain industrial activities which might even be produced in areas different to those where the ozone occurs.

Figure 5 shows the number of days of 2005 where the information threshold was exceeded (180 ug/m3, and the alert threshold of 240 ug/m3), in areas with monitoring stations.

The zone that in 2005 had most pollution events due to ozone has been in Norte Interior, with 62 days where the information threshold has been exceeded. This has already happened in 2004.

Concentrations of PM10 are influenced by anthropogenic emissions and emissions of natural origin, such as the transport of particles from the Sahara desert, forest fires or re-suspension of particles. The values of the daily average of the concentration of PM10 may not exceed on more than 35 days per year the daily limit of 50 ug/m3, which is regulated by law.

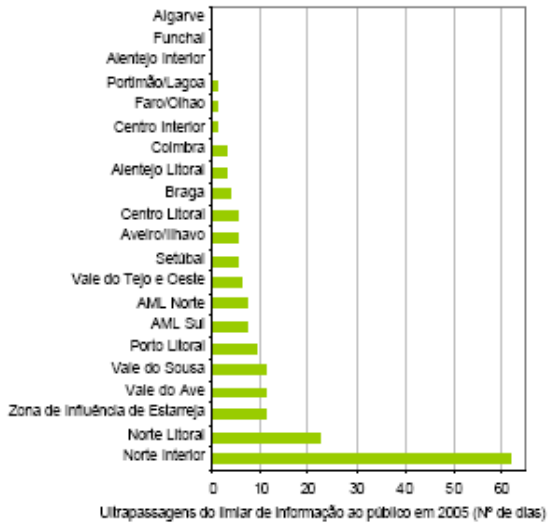

Fig. 5 – Excess of information threshold of ozone, in 2005

Figure 6 presents the number of days when the limit value of PM10 has been exceeded in 2005.

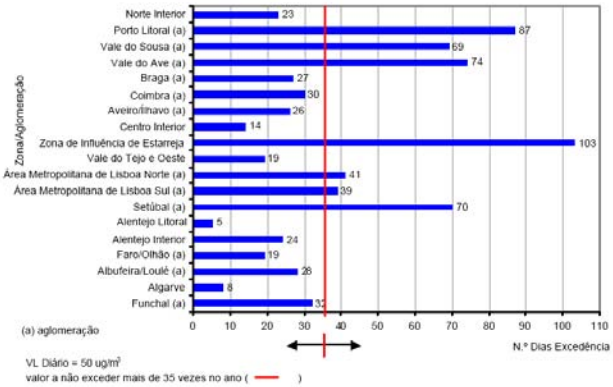

Fig. 6 – Excess of daily limit values of PM10 in zones and agglomerations with monitoring stations, in 2005

In 2005, three out of the five zones in the North Region exceeded the daily limits of particles: Porto Litoral, Vale do Ave and Vale do Sousa.

These registrations already caused some concerns, especially in the region of Porto Litoral. This fact has already been diagnosed in the study "Elaboração de planos e programas de acção para a melhoria da qualidade do ar na Região Norte – Relatório Final" [5] (Development of plans and action programmes to improve air quality in the North – Final report), where the pollutant PM10 together with ozone has been identified as the ones with exceeds of the limit values in the years 2001 and 2002.

3 Discussion

The analysis of the data presented confirms that the greatest source of concern with regard to air quality in the North region is PM10 particles. As a matter of fact the level of excess affects three of the densest areas of the Region – Porto Litoral, Vale do Ave and Vale do Sousa -, which means that the number of people potentially exposed to high concentrations may reach several hundred thousand.

The diagnosis has been undertaken to enable the development of strategies, plans and action programmes for the improvement of air quality, since it is necessary to understand what the source of the emission of particles is.

Atmospheric particles are emitted by a variety of natural and anthropogenic sources, whose nature affect both the physical and chemical composition of the particles [5].

Among the natural sources are:

- dust of geological origin, especially dust transported from North Africa (Sahara and Sahel desert);

- dust from forest fires, whose size and intensity has been significant due to occurrences in the last years;
- sea spray, that can contribute to increase the level of particles on the coastline.

Some of the anthropogenic sources of PM10 are the following:
- in urban environment as a result of combustion processes or from road traffic;
- as well in urban environment as a result of erosion of pavement due to traffic (road dust) and the abrasion of brakes and tires;
- construction activities, that generate significant emissions of particulate matter into the air including dust emitted by mechanical actions of machines, through movement of vehicles, material handlings, and even wind on the soil;
- industrial activities such as cement industry, ceramics and foundries;
- large agricultural areas and the combustion of fossil fuels and biomass are important sources of organic vapour, which are precursors of secondary aerosols of anthropogenic origin.

With regard to natural sources, there is not a lot that can be done except of reducing forest fires.

With regard to anthropogenic sources it is possible to design strategies, plans and action programmes in order to improve the air quality and thus act preventively on activities related to theses sources.

Another aspect where insufficiency was diagnosed is the lack of density of the basic network for data collection of air quality in the region, especially in urban areas. Their densification and the use of mobile devices for measurement is a priority.

4 Recommendations

The North Regional Coordination and Development Commission (CCDR-N) has launched the development of a Regional Master Plan, which is expected to be approved by the first quarter of 2009. In line with the diagnosis resulting from the previous sections, some recommendations were submitted to be included in the guidelines of the Plan, as follows.

With regard to reference norms of sectoral character - Guidelines for action for the Central and Local Government with regard to air quality:
- Promotion of the development of integrated procedures for actions on factors regarding air quality in urban areas, particularly concerning transport systems including traffic, industry, construction and others, and the establishment of monitoring systems and interventions in real time.
- Development of planning solutions in the Municipal Master Plans to avoid situations of potential conflict with regard to air quality and to ensure the relocation of pollution activities incompatible with their surroundings.

With regard to Means/Actions:
- Redefinition and densification of the basic network for data collection in the region, especially in urban areas.
- Promotion of regular monitoring campaigns of the concentration of PM10 particles, mainly through measurements by mobile devices in the centres of larger cities of the region and the production of respective pollution maps, including the evaluation of population's exposure.
- Promotion of interventions planned to improve the air quality in the zones of Porto Litoral, Vale do Ave and Vale do Sousa, as well as in other urban areas where limits might not be observed.
- Development of sustainable urban transport plans to enhance the use of public transport and non-motorized mobility, particularly in areas of high population density.

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