

# Establishment of Air Quality Zones in Italy

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**Abstract**—Member States shall establish zones and agglomerations throughout their territory to assess and manage air quality in order to comply with European directives.

In Italy decree 155/2010, transposing Directive 2008/50/EC on ambient air quality and cleaner air for Europe, merged into a single act the previous provisions on ambient air quality assessment and management, including those resulting from the implementation of Directive 2004/107/EC relating to arsenic, cadmium, nickel, mercury and polycyclic aromatic hydrocarbons in ambient air.

Decree 155/2010 introduced stricter rules for identifying zones on the basis of the characteristics of the territory in spite of considering pollution levels, as it was in the past. The implementation of such new criteria has reduced the great variability of the previous zoning, leading to a significant reduction of the total number of zones and to a complete and uniform ambient air quality assessment and management throughout the Country.

The present document is related to the new zones definition in Italy according to Decree 155/2010. In particular the paper contains the description and the analysis of the outcome of zoning and classification.

**Keywords**—Zones, agglomerations, air quality assessment, classification.

## I. LEGISLATIVE FRAMEWORK

**D**IRECTIVE 2008/50/EC of the European Parliament and of the Council of 21<sup>st</sup> May 2008 on ambient air quality and cleaner air for Europe [1] is the main legislative act regulating air quality assessment and management in Europe. It is integrated by directive 2004/107/EC of the European Parliament and of the Council of 15<sup>th</sup> December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air [2].

Among the main objectives of European legislation on air quality, “assessing the ambient air quality in Member States on the basis of common methods and criteria” is a central issue. Having results which are comparable all over the territory of European Union is necessary in order to evaluate the real state of the environment; starting from reliable data on concentrations of the main atmospheric pollutants, the proper strategies can be chosen to pursue a general improvement of the quality of air everywhere.

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Regarding air quality assessment, directive 2008/50/EC foresees the following steps:

- definition of zones and agglomerations;
- classification of zones and agglomerations;
- establishment of the monitoring network;
- annual air quality assessment;
- recognition of the specific areas where measures are necessary to improve air quality.

The present paper is related to the first actions to be undertaken to organize a proper air quality assessment, which are the definition of the zones and agglomerations and their classification.

According to article 4 of directive 2008/50/EC, air quality has to be assessed over the whole territory of each Country and this activity is carried out easily by dividing the territory in different air quality zones and agglomerations. The directive sets definitions for such territorial delimitations; in particular, a zone “shall mean part of the territory of a Member State, as delimited by that Member State for the purposes of air quality assessment and management” while an agglomeration “shall mean a zone that is a conurbation with a population in excess of 250 000 inhabitants or, where the population is 250 000 inhabitants or less, with a given population density per km<sup>2</sup> to be established by the Member States”.

The air quality zones have to be established taking into account the population density, that is the size of populations exposed to air pollution.

After defining zones and agglomerations, they have to be classified in relation to the assessment thresholds and long term objectives established by legislation for all pollutants.

Annex II of directive 2008/50/EC sets assessment thresholds for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>), lead, benzene and carbon monoxide while Annex VII establishes long term objectives for ozone; in addition, Annex II of directive 2004/107/EC sets assessment thresholds for arsenic, cadmium, nickel and benzo(a)pyrene.

Concentrations assessed during the previous five years are compared with the assessment thresholds or long term objectives in order to determine the concentration regime of the zone (or agglomeration). Results of such an evaluation are used to determine the minimum structure of the monitoring network and the kind of assessment to be carried out in each area.

This process has to be reviewed regularly, at least every five years or more frequently if significant changes in activities relevant to the ambient concentrations of pollutants occur.

For all pollutants other than ozone, concentrations registered in the last five years are compared with the

assessment thresholds; if they are over the upper assessment thresholds or between upper and lower assessment thresholds for at least three over the five years, fixed measurements are mandatory and can be supplemented or integrated by modeling techniques and/or indicative measurements, respectively. Only modeling techniques or objective estimations may be used in case that the concentrations are below the lower assessment thresholds.

Regarding ozone, fixed measurements are mandatory when the long term objective is exceeded during any of the last five years.

Above mentioned provisions on the definition and classification of zones have been established in the in force legislation since 1996, where the first framework directive on ambient air quality was adopted (Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management [3]).

Italian legislation has introduced in its regulatory framework provisions on zoning coherent to the European ones since 1999, with the legislative decree n. 351 of the 4<sup>th</sup> August 1999 [4], transposing directive 96/62/EC.

Such decree was substituted by the legislative decree n. 155 of the 13<sup>th</sup> August 2010 [5], covering all provisions of directive 2008/50/EC and also those of directive 2004/107/EC related to heavy metals and polycyclic aromatic hydrocarbons. All provisions included in European legislation have been transposed into the national decree; regarding criteria set for establishing zones and agglomerations, more stringent requirements are established in order to provide clear indications to local authorities for their definition over the national territory.

Competences on environmental issues in Italy are distributed among different authorities. The State has the right to establish general rules related to the protection of the environment. Therefore also legislation on air pollution and ambient air quality is produced for the whole Country at national level. Local Authorities, and mainly Regions and Autonomous Provinces, have specific competences related to air quality assessment and management; in particular, air quality zones are established with a legal act by each administration for its own territory. Such a distribution of competences leads in the past to different application of the legislative provisions in the different Regions and to an increase of the total number of zones.

Decree 155/2010 establishes also a national coordination on the regulated issues, composed by representatives of the Ministry for Environment Land and Sea, Ministry of Health, Regions and Autonomous Provinces, Union of Italian Provinces (UPI), National Association of Italian Municipalities (ANCI), Institute for Environmental Protection and Research (ISPRA), Italian National Agency for New Technologies Energy and Sustainable Economic Development (ENEA), National Research Council (CNR) and any competent authority designated by the previous ones. Through periodic meetings, representatives agree on common methods and criteria for implementing legislation and collecting and reporting data.

Specific criteria to designate agglomerations and zones are summarized as follows.

When zoning the territory, agglomerations have to be identified firstly. Agglomerations are selected according to urban structure, population and population density, following the indications given in the definition. According to national legislation, the agglomeration is a “zone constituted by a urban area or a group of more urban areas at no more than few kilometers or a main urban area and some minor urban areas connected to the main one for several reasons (demography, services, people and goods mobility), and having a population in excess of 250 000 inhabitants or a population of less than 250 000 inhabitants with a population density per km<sup>2</sup> higher than 3 000 inhabitants”.

Afterwards, the remaining part of the territory has to be divided in zones. Zones are chosen on the basis of the characteristics of the territory and not evaluating the air quality regime, as it was in the past.

Analyzing these characteristics, the aspects mainly affecting air quality are determined in the different areas and those which are similar for the dominant aspects are merged together in the same zone. In practice, the analysis has to be carried out in different ways depending on the nature of the pollutants. For primary pollutants (lead, carbon monoxide, sulphur oxides, benzene, benzo(a)pyrene and heavy metals) zoning is determined by the emission levels registered over the territory. For secondary pollutants such as particulate matter, nitrogen oxides and ozone, the analysis includes also orographic and meteo-climatic characteristics and the level of urbanization of the territory.

Zones can also be constituted by not neighboring areas if they are homogeneous in terms of the dominant characteristics. For instance, all coastal areas with high level of urbanization, where road transport is the main emission source, can be merged in the same zone, even if they are not all contiguous. Indications are also given for defining the same zones for nitrogen oxides and particulate matter, if feasible; as much as possible, zones are also to be selected respecting the administrative boarders in order to simplify air quality management. Finally, in order to facilitate any necessary action to reduce the atmospheric concentration of pollutants, whenever it is possible it is recommended to define zones in accordance to the local administrative borders.

In relation to the protection of vegetation it is possible to merge areas belonging to different Regions.

## II. AIR QUALITY ZONING, COMPARING PAST AND PRESENT

In accordance with Italian legislation, Regions and Autonomous Provinces must submit projects with a preliminary zoning and classification of their territory to the Ministry for the Environment, Land and Sea for an evaluation before final adoption. All Regions and Autonomous Provinces completed the process of designation of zones for the protection of human health, except one. The designation of zones for the protection of vegetation and ecosystems is being defined.

The information extracted from the mentioned regional

projects and made available by the Ministry has been analyzed and results are shown in the present paper. Table I gives an overview of the total number of zones defined for the protection of health according to the Decree 155/2010 compared to those defined according to previous legislation.

TABLE I  
NUMBER OF ZONES AND AGGLOMERATIONS FOR SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>10</sub>, LEAD, BENZENE, CO AND PM<sub>2.5</sub>

Region Autonomous Province	Previous legislation			Decree 155/2010		
	Total	N. zones	N. agg.	Total	N. zones	N. agg.
Piemonte	17	16	1	4	3	1
Valle d'Aosta	3	3		2	2	
Lombardia	5	4	1	7	4	3
Liguria	7	6	1	6	5	1
Trento	2	2		2	2	
Bolzano	18	14	4	2	2	
Veneto	5	4	1	9	4	5
Friuli Venezia Giulia	6	6		3	3	
Emilia Romagna	31	18	13	4	3	1
Toscana	5	2	3	6	5	1
Umbria	5	4	1	3	3	
Marche	2	2		3	3	
Lazio	3	2	1	4	3	1
Abruzzo	4	3	1	3	2	1
Molise	1	1		3	3	
Campania	6	1	5	3	2	1
Puglia	4	2	2	4	3	1
Calabria	4	4		4	3	1
Sicilia	9	9		5	2	3
Sardegna	6	5	1	4	3	1
Total	143	108	35	81	60	21

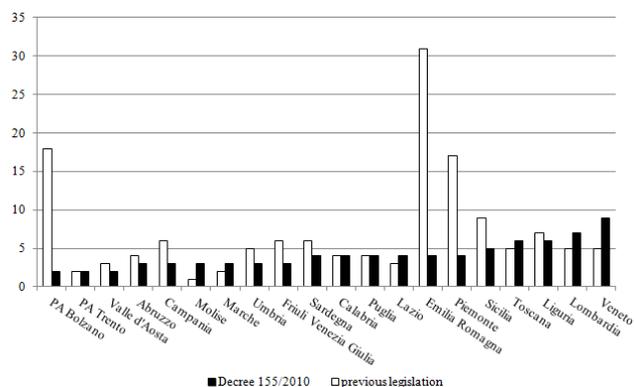


Fig. 1 Total numbers of zones designated in relation to health protection for SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>10</sub>, Lead, benzene, CO and PM<sub>2.5</sub>

Regions designated zones for all pollutants; zones cover the territory of the entire Country. With the implementation of new law, Italy reduced the total number of zones from 143 to 83 (Fig. 1). The number of agglomerations was reduced from 35 to 21 (Fig. 2).

Many Regions reduced the number of zones.

The largest decreases in number of zones are in Regions Emilia Romagna and Piemonte and the Autonomous Province of Bolzano. On the other hand, Molise, Marche, Lazio,

Toscana, Lombardia and Veneto increased the number of zones. For Calabria, Puglia and the Autonomous Province of Trento the number of designated zones is not changed.

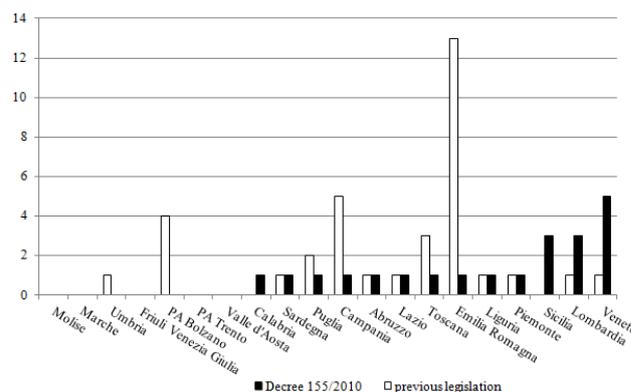


Fig. 2 Number of agglomerations for SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>10</sub>, lead, benzene, CO and PM<sub>2.5</sub>

TABLE II  
NUMBER OF ZONES AND AGGLOMERATIONS FOR OZONE, AS, CD, NI, B(A)P

Region Autonomous Province	Ozone		Pb, As, Ni, Cd		B(a)P	
	N. zones	N. agg.	N. zones	N. agg.	N. zones	N. agg.
Piemonte	1	1	3	1	3	1
Valle d'Aosta	1		2		2	
Lombardia	5	3	4	3	4	3
Liguria	1	1	2	1	1	1
Trento	1		2		2	
Bolzano	1		2		2	
Veneto	4	5	4	5	4	5
Friuli Venezia Giulia	3		3		3	
Emilia Romagna	3	1	3	1	3	1
Toscana	3	1	5	1	5	1
Umbria	1		3		3	
Marche	3		3		3	
Lazio	2	1	3	1	3	1
Abruzzo	2	1	2	1	2	1
Molise	2		3		3	
Campania	2	1	2	1	2	1
Puglia	3	1	3	1	3	1
Calabria	3		3		3	
Sicilia	2	3	2	3	2	3
Sardegna	1	1	3	1	3	1
Total	44	21	57	21	56	21

The zones designation for all pollutants is exactly the same in most of the Regions in order to simplify air quality assessment and management.

A specific zoning for benzo(a)pyrene and heavy metals (Pb, As, Ni, Cd) was made only in Liguria.

As regards the ozone zoning designation, the results are presented in Table II.

In some Regions zones defined for ozone are the same defined for all other pollutants (Veneto, Friuli, Emilia Romagna, Marche, Abruzzo, Campania, Puglia, Calabria and Sicilia); other Regions identified a number of zones lower than

that identified for other pollutants (Piemonte, Valle d'Aosta, Liguria, Trento, Bolzano, Toscana, Umbria, Lazio, Molise and Sardegna). In addition, some of these zones cover the whole territory (Bolzano, Valle D'Aosta, Trento, Umbria).

Lombardia is the only Region that defined a higher number of zones for ozone than for other pollutants.

Generally the identification of agglomerations is based primarily on population, population density and urban structure, while the topography of the area has been the priority factor which led to the identification of the other zones, which took into account specific situations of orographic complexity and variability of climatic zones and the presence of significant emission contributions as industrial areas.

### III. CLASSIFICATION OF ZONES AND AGGLOMERATIONS

As already mentioned, regional projects of designation of zones and agglomerations contain either the definition of zones and agglomerations, either the classification of each zone with reference to pollutant thresholds and the long term objective established in Decree 155/2010.

Thus for sulphur dioxide, nitrogen dioxide, particulate matter (PM<sub>10</sub>, PM<sub>2,5</sub>), lead, benzene, carbon monoxide, arsenic, cadmium, nickel and benzo(a)pyrene, each classified zone may fall in one of the following categories: zone classified above the upper-assessment-threshold (indicated as 'UAT' in the following text), zone classified below the lower-assessment-threshold (indicated as 'LAT'), or zone classified between the two previous thresholds (indicated as 'UAT-LAT').

In regional projects, exceedances of the mentioned thresholds are determined on the basis of concentration of each pollutant measured during five years, following the rule that an assessment threshold shall be deemed to have been exceeded, if it has been exceeded during at least three separate years out of those previous five years.

For ozone, each classified zone may fall in one of the two categories: zone classified above or below the long-term objective of ozone.

In regional projects, exceedances of long term objective are determined on the basis of concentration measured during five years; following the rule that long term objective shall be deemed to have been exceeded, if it has been exceeded during any of the five years considered.

Five years considered for classification are selected by regional administration between years 2004 and 2011.

When less than five years measured data are available, Regions estimated pollution level combining information about available measurement, with measurement campaigns of short duration, emission inventories and modeling results.

The results of the analysis of information related to the classification of zones/agglomerations contained in regional projects are summarized as follows.

For ozone, all defined zones and agglomerations are classified above long-term objective, showing a critical situation of such pollutant in Italy, because of the extent of the Italian coastline and for particular climatic conditions which is

known that favor the formation of ground level ozone.

Other pollutant levels that result critical in examined regional projects are particulate matter and nitrogen dioxide (Fig. 3). Generally projects show a higher number of zones with exceedance of upper-assessment-thresholds established for PM<sub>10</sub> (daily and yearly), for nitrogen dioxide (hourly and yearly) and for PM<sub>2,5</sub> (yearly).

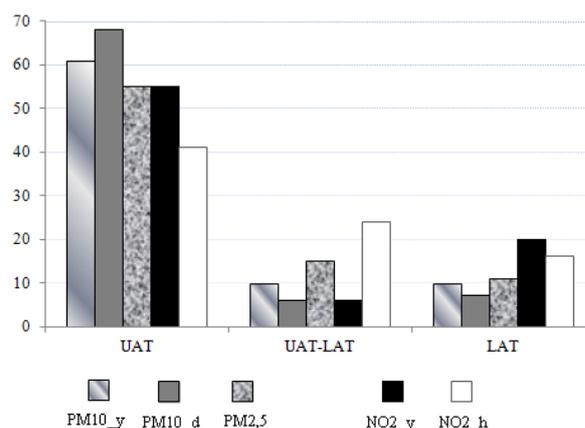


Fig. 3 Number of zones classified above UAT, below LAT or between UAT and LAT, with reference to PM<sub>10</sub> (yearly and daily), PM<sub>2,5</sub> and to NO<sub>2</sub> (yearly and hourly)

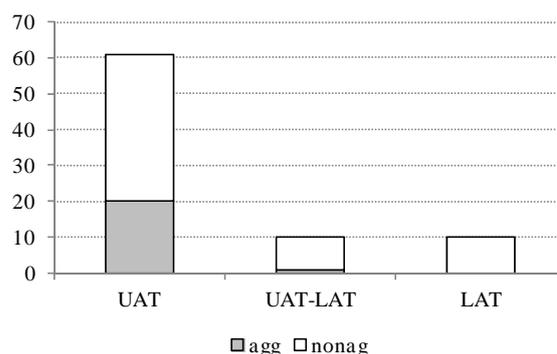


Fig. 4 Number of zones or agglomerations classified above UAT, below LAT or between UAT and LAT, with reference to PM<sub>10</sub> (yearly)

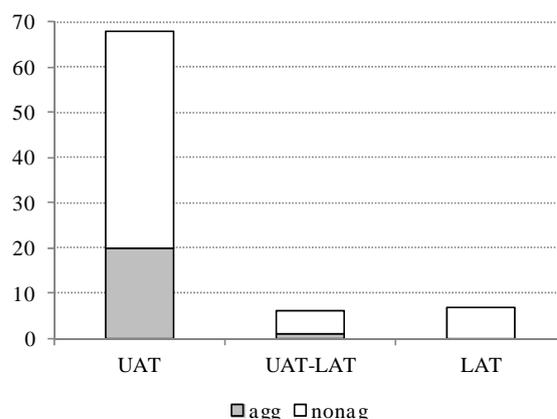


Fig. 5 Number of zones or agglomerations classified above UAT, below LAT or between UAT and LAT, with reference to PM<sub>10</sub> (daily)

For these pollutants, concentrations result critical in particular in agglomerations (indicated as 'ag' in the following text) rather than in other zones (indicated as 'nonag'), as shown in Figs. 4-8.

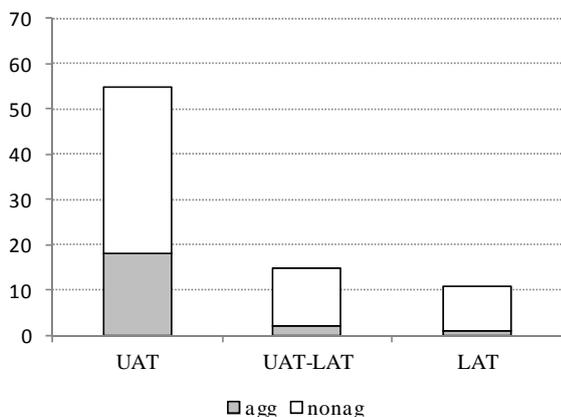


Fig. 6 Number of zones or agglomerations classified above UAT, below LAT or between UAT and LAT with reference to  $PM_{2.5}$  (yearly)

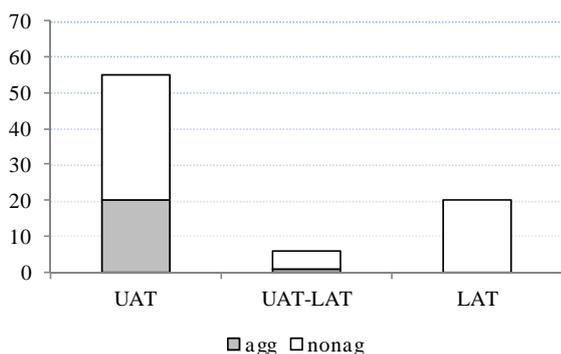


Fig. 7 Number of zones or agglomerations classified above UAT, below LAT or between UAT and LAT, with reference to  $NO_2$  (yearly)

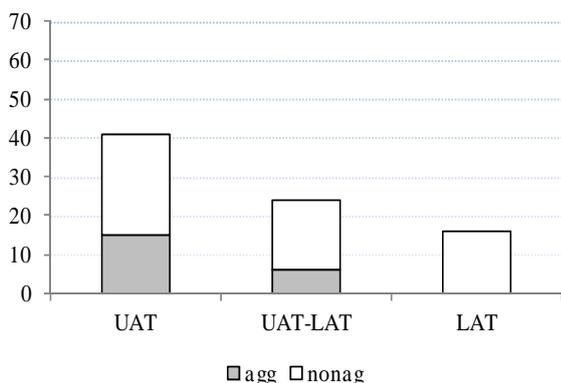


Fig. 8 Number of zones or agglomerations classified above UAT, below LAT or between UAT and LAT, with reference to  $NO_2$  (hourly)

For other pollutants, regional projects show a different situation, with a predominant number of zones or

agglomerations classified below LAT and secondly, classified between UAT and LAT.

For instance, with reference to benzene, zones are classified mainly under UAT and LAT, exception for a limited number of zones located in Umbria, Liguria, Piemonte, Friuli Venezia Giulia and Abruzzo Region and for most of the zones in Sicilia region, in which level results above UAT.

For benzo(a)pyrene, arsenic, cadmium and nickel there is a large number of zone classified upper UAT: all zones designated in Puglia, Campania, Abruzzo and Friuli Venezia Giulia Regions, some of zones designated in Piemonte, Lombardia, Umbria, Toscana, Sicilia and Sardegna Regions and in both the Autonomous Provinces of Trento and Bolzano.

In this regard, it is important to highlight that decision to classify pollution level above the upper-assessment-threshold is almost always due to a precautionary measure in zones where in the period considered for classification, few concentration data were available, also from monitoring and modeling.

For sulphur dioxide, lead and carbon monoxide, pollutant levels are classified in almost zones below relevant LAT. For sulphur dioxide exceptions are found for Piemonte Region, with some zones with  $SO_2$  level estimated between UAT and LAT, and for Sicilia Region, where there are zones with concentration of this pollutant estimated between UAT and LAT or above UAT. The latter are zones with large industrial plants.

As regards lead, almost all zones were classified below relevant LAT, with the exception of Puglia Region (this classification is driven by the caution principle described above) and some zones in Calabria and Sicilia Regions (due to the presence of industrial plants).

For carbon monoxide almost of the zones are classified below LAT, with the exception of some zones in Lombardia, Umbria, Lazio, Campania and Sicilia Regions estimated between UAT and LAT or above LAT, and one zone in Liguria Region. In general areas classified upper LAT are agglomerations, zones with large urban areas and zones characterized by the presence of main roads.

#### IV. CONCLUSIONS

In the past, zones were defined mainly on the basis of the assessment of air quality and there was a wide variability in the delimitation of zones in the different Regions; therefore it was quite difficult to make mutual comparison of regional data.

Decree 155/2010 introduced new rules for designation of zones. Thus the great variability of the previous zoning was solved and a more harmonized identification was obtained over the whole Country. In addition, a significant reduction of the total number of zones was reached and a complete ambient air quality assessment and management throughout the Country was assured.

Regarding classification, general improvements have been achieved in terms of covered surface and applied assessment methods.

REFERENCES

- [1] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe.
- [2] Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air.
- [3] Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management.
- [4] Legislative decree 4 agosto 1999, n. 351 "Attuazione della direttiva 96/62/CE in materia di valutazione e di gestione della qualità dell'aria ambiente"
- [5] Legislative decree 13 agosto 2010, n.155 "Attuazione della direttiva 2008/50/CE relativa alla qualità dell'aria ambiente e per un'aria più pulita in Europa".