CHAPTER 4

WATER QUALITY

Introduction

The objective of Directive 2000/60/EC, assimilated by Italian law under Legislative Decree 152/06, establishing a framework for Community water policy for the decades to come, is to modulate the wide variety of regulatory scenarios found in Member States giving them a common footing, in order to reach a consistent policy for safeguarding waters. Application of the directive entails noteworthy variations in the criteria for setting up the monitoring of the water bodies, with the classification system based on stipulated reference conditions that can vary, depending on the different types of water bodies involved, and on situations in which there are a greater number of biological and hydromorphological elements to be evaluated. The groundwork is also laid for a radical and sustainable change in the uses of water resources, under the principle that their use must be compatible with the environment and the needs of future generations.

Italy is closely involved in the common strategy, working through its Ministry of the Environment, Land and Sea while drawing on the technical support of ISPRA and the institutions responsible for water sector, in order to contribute to the intercalibration of the methodologies for designing networks to monitor and assess the ecological condition of surface water bodies, an exercise in which all the member states are required to participate.

The general commitment to developing a common strategy, as well as the new monitoring initiative, have seen increasing involvement on the part of regional governments, environmental agencies and water-basin authorities.

The state of inland water quality

The SECA defines the ecological status of waterways, combining the contributions of the IBE and LIM indexes.

Since the issue of Legislative Decree 152/06, the regional governments and the system of environmental agencies have undertaken intensive activities to bring the monitoring of water bodies in line with the new regulatory requirements, though the majority continue to follow the procedures of the obsolete Legislative Decree 152/99 in the case of both surfaced and underground waters. In large part waterways are classified under the IBE method – Extended Biotic Index – and through the use of chemical assessments that take into consideration the seven parameters that contribute to determining the LIM – Level of Pollution from Macro-Descriptors (dissolved O_2, BOD_5, COD,

NH_4, NO_3, total phosphorus, *Escherichia Coli*). The combination of the LIM and IBE indexes determines the SECA index, or Ecological Status of Waterways. In the case of lakes, the SEL index, or Ecological Status of Lakes, is determined, while underground waters are subject to the SCAS, or Chemical Status of Underground Waters, index. On the national level, the data for the Ecological Status of Waterways (SECA) show that, in 2008, 45% of the sites monitored fell under classes 1 and 2, meaning an ecological status of "high" (4%) or "good" (41%), while 33% were classified as being of "moderate" quality (Figure 4.1). A total of 999 stations were monitored throughout Italian territory, as compared to the 1,014 registered in 2007. The percentages of stations in quality classes 1 and 2 feel slightly, by respective figures of -1% e -2%, reflecting the increases in class 3 (from 32% to 33%) and in class 4 (from 15% to 17%). The figures for class 5 were the same as for last year (5%). In analysing the results, it should be kept in mind that six regions either failed to communicate their data or did so after the deadline: Basilicata, Calabria, Sicily, Sardinia, Campania and Umbria (Umbria, which began testing the new monitoring in June 2008, did not have sufficiently meaningful data).

In 2008, 78% of the sites monitored fell under SECA quality classes 1, 2 and 3, meaning an ecological status of "high" (4%), "good" (41%) and moderate (33%).

The regions whose data, for various reasons, were not included in the final analysis are: Basilicata, Calabria, Sicily, Sardinia, Campania and Umbria.

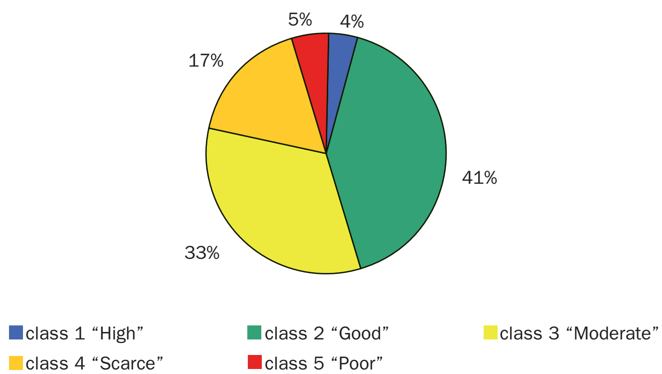


Figure 4.1: Percentage distribution of the classes of the SECA quality index (2008)[1]

In 2008, the SECA situation was not particularly critical in Italy, seeing that 45% of the 999 points monitored fell within the quality classes of "good" and "high", while 33% were classified as "moderate". On the whole, 78% reached the quality objectives set for December 2008.

An analysis of the data subdivided by macro-areas (Figure 4.2) shows that the best situation is found in Northern Italy, where the

In Northern Italy 80% of the points monitored fell in classes 1, 2 and 3.

[1] Source: ARPA/APPA data processed by ISPRA

In 2008, 80% of the 605 stations in Northern Italy fell within classes 1, 2 or 3, while 76% of the 226 stations in Central Italy were rated in the same classes, as were 73% of the 168 stations in Southern Italy and the Islands.

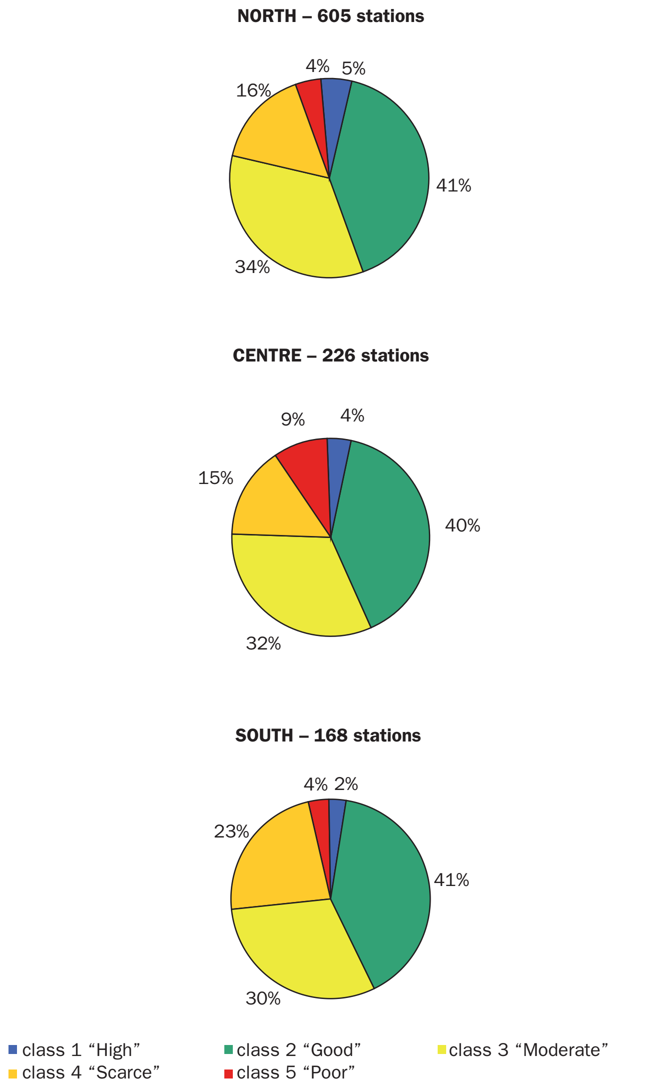


Figure 4.2: Percentage distribution of the SECA index quality classes by macro-region (2008)[2]

[2] Source: ARPA/APPA data processed by ISPRA

percentage of stations falling under classes 1, 2 and 3 is 80%, while the figure is 76% for the Central Italy and 73% for the South and the Islands. In evaluating these results, however, consideration should be given to the differences in the numbers of stations monitored in the various macro-areas: 60% of the total in the north, as compared to 23% in the central regions and 17% in the south. As is known, the SECA is established with the combined results of the chemical and biological analyses, meaning that, in terms of the incidence of the LIM and the IBE in determining the SECA (Figure 4.3), in the case of half the points sampled, the chemical and biological analyses both contribute to determining the ecological status, though, in the majority of the cases where the results show discrepancies, it is the biological analysis that determines the ecological status, given that the animal organisms analysed are sensitive not only to the water quality, but also to alterations and artificial modifications in the river and stream beds, as well as fluctuations in the flow.

In 2008, as in previous years, the macrobenthic community played a greater role in determining the SECA than did the chemical-physical macro-descriptors.

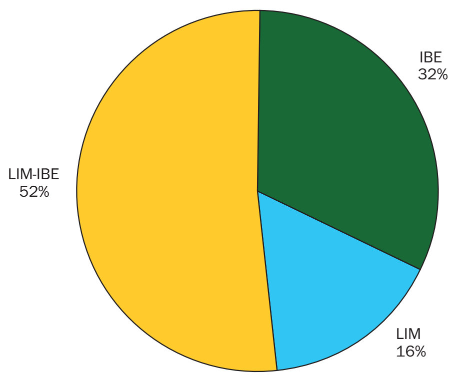


Figure 4.3: The percentage incidence of the LIM and IBE indexes on the SECA index (2008)[3]

Lake quality (Ecological Status of Lakes - SEL), taken from a total of 134 stations in 13 regions (on less region than in 2007), falls within the classes of "moderate" to "high" 65% of the time (Figure 4.4), an incidence that marks an 8% decrease compared to 2007.

The SEL is used to determine the ecological status of lakes by evaluating their different trophic states.

[3] Source: ARPA/APPA data processed by ISPRA

In 2008, 65% of the stations (134, representing 116 lakes) were ranked in the classes from "moderate" to "high".

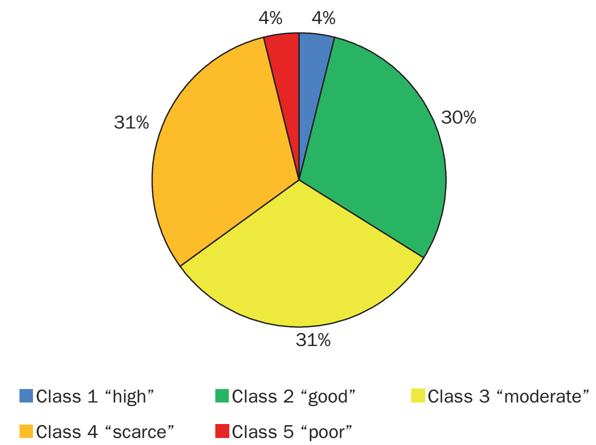


Figure 4.4: Percentage distribution of the SEL quality classes (2008)[4]

In the North, 42% of the stations fall under the SEL quality classes of "high" and "good", while 28% were classified as "sufficient".

In Northern Italy 42% of the stations fell under the quality classes of "high" and "good", while 28% were ranked as "moderate". In interpreting these results, consideration should be given to the geographic distribution of lake areas in Italy, which are more numerous in the north, as is further confirmed by the differences in the numbers of stations between the various macro-areas.
In light of the monitoring data for 2008, it can be assumed, in the case of surface water bodies (rivers and lakes), that the stations ranked in ecological quality classes 1 and 2 (SECA and SEL) belong to water bodies that should not present particular problems in arriving at the quality objective to be met by the end of 2015 under European regulations.

Monitoring of waters designated as suitable for molluscs to live in.

Another assessment of quality is that required to satisfy the objectives for the specific designated use of the waters, as per annex 2 of Legislative Decree 152/06. For 2008, data are available on 7 out of 15 coastal regions, where marine and brackish areas suitable for molluscs to live in were designated by the regions and monitored. These areas hold

[4] Source: ISPRA/Lombardy ARPA processing of data supplied by the ARPA/APPA of the autonomous provinces

bank sites and natural populations of bivalve and gastropod molluscs, but require protection and/or upgrading to safeguard the quality of the products of mollusc growing as food (Table 4.1).

Monitoring in 2008 of waters designated for molluscs to live in regarded 66 areas, 45 of them marine and 21 brackish. The suitable areas numbered 47, of which 36 were marine and 11 brackish.

Table 4.1: Waters designated as suitable for molluscs to live in (2008 monitoring)[5]

Region	Designated areas									
	TOTAL		Marine		Suitable	Not suitable	Brackish		Suitable	Not suitable
	no.	km²	no.	km²	no.		no.	km²	no.	
Veneto	8	684	1	46.5	1	0	7	637	5	2
Friuli Venezia Giulia	12	312	10	204	6	4	2	108	0	2
Liguria	2	3.92	2	3,92	2	0	0	0	0	0
Emilia Romagna	13	1,784	11	1,748	11	0	2	36.5	1	1
Tuscany	-	-	-	-	-	-	-	-	-	-
Marche	-	-	-	-	-	-	-	-	-	-
Lazio	3	-	3	-	3	0	0	0	0	0
Abruzzo	-	-	-	-	-	-	-	-	-	-
Molise	11	65.5	11	65.5	11	0	0	0	0	0
Campania	-	-	-	-	-	-	-	-	-	-
Basilicata	-	-	-	-	-	-	-	-	-	-
Apulia	-	-	-	-	-	-	-	-	-	-
Calabria	-	-	-	-	-	-	-	-	-	-
Sicily	-	-	-	-	-	-	-	-	-	-
Sardinia	17	-	7	-	2	5	10	-	5	5
TOTAL	**66**	**2,849**	**45**	**2,068**	**36**	**9**	**21**	**782**	**11**	**10**

The other designated uses regulated under Legislative Decree 152/06 regard waters suitable for fish to live in, for use as drinking water and for swimming.

The quality of underground waters, defined in accordance with Legislative Decree 152/99, is represented by the SCAS index (Chemical Status of Underground Waters), which highlights the zones containing critical environmental problems through a 5-class rating system (1-2-3-4-0). The first three classes stand for levels

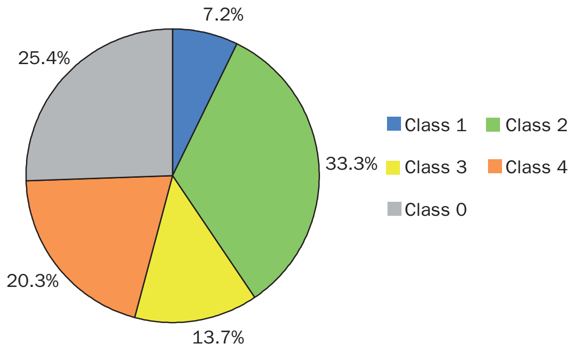
The Chemical Status of Underground Waters defines the quality of the water resource. It is obtained by analysing not only levels of pollutants generated by anthropogenic activities, but also chemical parameters of

[5] Source: Regions and autonomous provinces data processed by ISPRA

natural origin found in water tables, at times at elevated concentrations, and capable of compromising the use of the water.

of quality from good to sufficient, while the remaining two point to scarce quality, distinguishing between contaminants of anthropogenic origin (class 4) and those of organic origin (class 0).
In 2008 (Figura 4.5) 54.2% of the sampling points presented a chemical status falling within classes 1 to 3, meaning good to sufficient quality, while 20.3% were rated in class 4, poor quality due to anthropogenic causes, and the remaining 25.4% in class 0, or waters of poor quality due to natural causes tied to the specific hydrogeochemical conditions of the water tables.

In 2008, on a national level, out of 3,229 sampling points distributed in 11 regions and 2 autonomous provinces, 54.2% present a chemical status ranked between classes 1 and 3, while 20.3% are characterised by water of poor chemical quality due to causes of anthropogenic origin, and the remaining 25.4% are rated poor due to natural causes.



Note: Judgment of quality attributed to the classes:
Class 1 – *Anthropogenic impact non-existent or negligible, with excellent hydrochemical characteristics;*
Class 2 – *Anthropogenic impact limited and sustainable long-term, with good hydrochemical characteristics;*
Class 3 – *Anthropogenic impact noteworthy and hydrochemical characteristics generally good, but with certain signs of compromise;*
Class 4 – *Anthropogenic impact significant, with poor hydrochemical characteristics;*
Class 0 – *Anthropogenic impact non-existent or negligible, but with certain natural hydrochemical facies present in concentrations above the class-3 levels.*

Figure 4.5: Sampling points for SCAS quality classes (3,229 points – 11 regions and 2 autonomous provinces) (2008)[6]

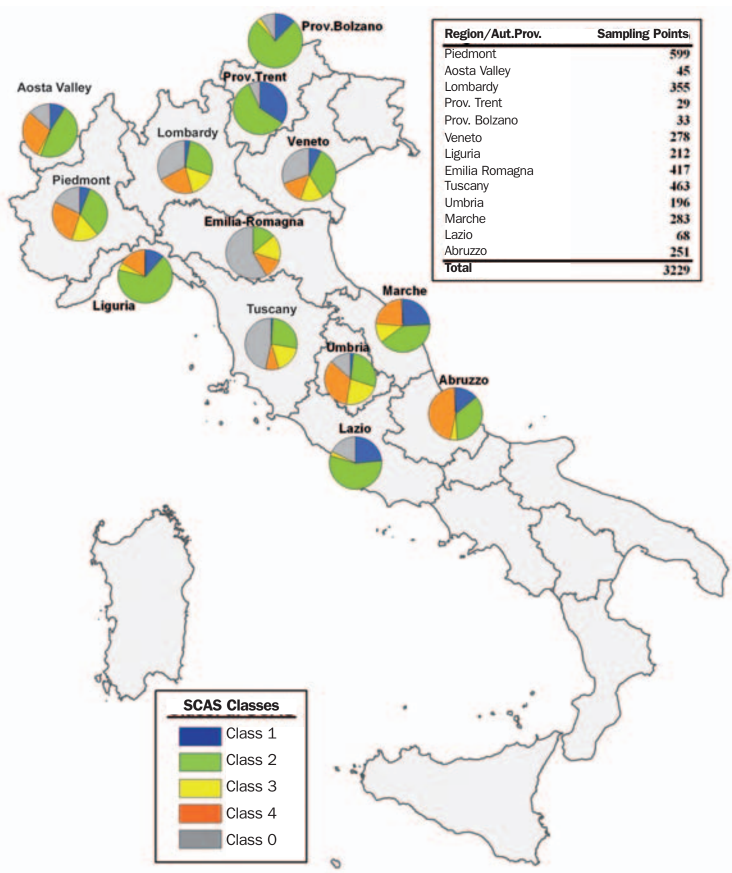
The contaminants of anthropogenic origin responsible for the demotion of many of the regions considered to class 4 include nitrates at concentrations above the limit of 50 mg/l (drinking water limit). Their presence is correlated to forms of pollution that are widespread, such as the use of nitrate-enriched fertilisers,

[6] Source: Regions and autonomous provinces data processed by ISPRA

the disposal of livestock waste, poor management of slime and dispersion from sewage systems, as well as specific sources of pollution, such as waste treatment plants etc.. Other substances responsible for deterioration in the quality of the resource include plant care products, aliphatic halogenate compounds and certain heavy metals (primarily chrome, lead, nickel and zinc), plus, though to a lesser degree, aromatic polycyclic hydrocarbons.
The presence of arsenic, iron, manganese, the ammonia ion, sulphates, chlorides and conductivity has been attributed by various regions to natural causes, in certain hydrogeological settings, producing a class 0 result.

The number of monitoring stations in the considered regions varies significantly, in absolute terms, running from a minimum of 29 to a maximum of 599. Figure 4.6 shows the percentages of the total (regional/provincial) sampling points ranked under the different quality classes. The autonomous provinces of Trent and Bolzano, and the regions of Liguria, Lazio, Marche, Aosta Valley, Veneto, Piedmont, Abruzzo and Umbria, in that order, presented percentages of sampling points falling in the classes of 1 to 3, meaning good to moderate quality, of between 93.1% to 52.6%. The highest percentages for class 4, poor on account of anthropogenic causes, were found in Abruzzo and Umbria, at respective figures of 45.8% and 34.2%. Finally, poor quality on account of natural causes, or class 0, was prevalent in Emilia Romagna and Tuscany, at respective figures of 58.3 e 46.7%.

The regions showed significantly different numbers of monitoring stations (from 29 to 599). The autonomous provinces of Trent and Bolzano, and the regions of Liguria, Lazio, Marche,Aosta Valley, Veneto, Piedmont, Abruzzo and Umbria, presented, in that order, percentages of sampling points falling under classes 1 to 3 of between 93.1% and 52.6%, while 45.8% of the points were ranked class 4 in Abruzzo and 58.3% were class 0 in Emilia Romagna.



Region/Aut.Prov.	Sampling Points
Piedmont	599
Aosta Valley	45
Lombardy	355
Prov. Trent	29
Prov. Bolzano	33
Veneto	278
Liguria	212
Emilia Romagna	417
Tuscany	463
Umbria	196
Marche	283
Lazio	68
Abruzzo	251
Total	3229

Figure 4.6: The chemical status of underground water bodies (3,229 points monitored – 11 regions and 2 autonomous provinces) (2008)[7]

Keeping in mind the differences in the numbers of both the points monitored and of the regions that have contributed to the formulation of the indicator over time, the changing quality of underground waters can be illustrated, as in Figure 4.7. During this

[7] Source: Regions and autonomous provinces data processed by ISPRA

period, the class 4 ranking, poor due to anthropogenic causes, was given to an average of 23.4% of the total stations monitored. The best situation, with the lowest percentage of 20.3%, was recorded in 2008, while the worst year, when the percentage reached a high of 28.3%, was 2006. On the average, 53% of the monitoring stations were given quality ratings of good to sufficient (classes 1, 2, 3), while class 0, poor due to natural causes, accounted for an average of 23.6% of the total.

Between 2000 and 2008 the quality classes 1, 2, 3 and 0 accounted for an average of 76.6% of all the stations monitored in all the years considered, while the remaining 23.4% of the waters were classified, on the average, as poor in quality due to anthropogenic causes.

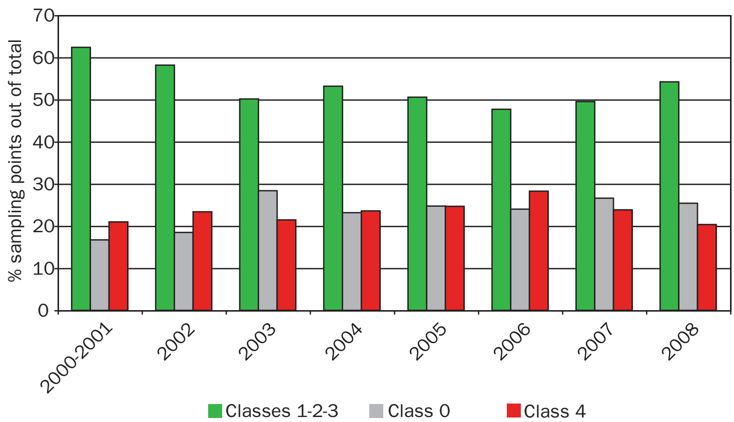


Figure 4.7: Classes of chemical status over the years[8]

Legislative Decree 152/2006, recently modified and supplemented by Legislative Decree 30/2009, in compliance with European Directives 2000/60/EC and 2006/118/EC, sets 2015 as the deadline for achieving the objective of a “good” chemical and quantitative status. Each underground water body, therefore, shall be classified by a chemical and a quantitative status, each classified as “good” or “poor”, with the overall status of the water body corresponding to the worst of the two rankings. It follows that the new classification of chemical status, to be utilised in the upcoming monitoring cycles, will be simplified to 2 classes, as compared to the current 5. In establishing an approximate equivalency between the current classification of chemical status

Under the new measures, approximately 76.6% of the monitoring stations receive a chemical status of good, while 53% of the water stations qualify for the more valued uses of the resource.

[8] Source: ISPRA/Emilia Romagna ARPA processing of data supplied by the ARPA/APPA of the regions and autonomous provinces

and the new system, the current class 4 can be considered "poor", while the current classes 1, 2, 3 and 0 would be rated "good", considering that class 0 is the result of natural conditions found in the water table as opposed to anthropogenic impact. Under the new classification of chemical status, therefore, an average of 76.6% of the stations monitored between 2000 and 2008 would be rated "good", while 53% of the total corresponds to a quality of water compatible with the more valued uses of the resource.

The main causes of alteration

Water pollution may have natural causes, though it more often results from human activity.

Water pollution is defined as the effect of the introduction into water's bodies of substances or energies able to compromise human health, damage living resources or, in more general terms, the water-based ecological system, or to pose an obstacle to any legitimate use of water, including its potential role as an environmental attraction (the European Union). Pollution may have natural causes, though it more often results from human activity. Natural pollution occurs when rainwater comes into contact with substances of the mineral or biological worlds, whereas pollution tied to human activity is the result of massive anthropogenic development and industrialisation.

Forms of manmade pollution include the non-purified discharges of residential sewers, the dumping in the water environment of residues of industrial raw materials, plus intermediate and final products, as well as the wash-off of waste and pollutants from roads, airports and lots connected with service activities (repair shops, gas stations etc.).

Industry causes chemical and thermal pollution.

In addition, large-scale industry causes thermal pollution, which alters the chemical and biochemical balances of bodies of water, leading to a decrease in dissolved oxygen and directly reducing solubility, or indirectly increasing the metabolic rate of aquatic flora, with all the attendant consequences.

The gases polluting the air lead to "acid rains", with direct and indirect consequences on aquatic organisms, as well as damage to human health.

The acid rains, the result of fallout from the atmosphere of particles, gases and acid precipitation, are a further problem. Acid rains are essentially caused by sulphur oxides and, to a lesser extent, by nitrogen oxides found in the air due to natural causes (volcanoes) or on account of human activities. The consequences on aquatic organisms can be direct, due to the toxicity of the water, or indirect, tied to the disappearance of vegetable matter or prey more sensitive to acidification and part of

the food chain. Acidity in rivers and lakes can modify populations of diatoms and brown algae, in addition to altering the distribution and variety of fish life. Furthermore, foodstuffs originating from acid waters can be harmful to human health, such as fish whose bodies have accumulated large quantities of toxic metals (aluminium, manganese, zinc, mercury, cadmium). The drawing of excessive supplies of water can also alter the quality of the resource. Areas highly settled by man constitute a critical component in the elevated water demand for civic, industrial, agricultural and recreational uses, as well as the equally voluminous flows of waste needing to be purified. In certain cases, the systems of collection and purification prove to be inadequate and not suitable (in terms of potential, levels of processing, absence of appropriate measures to control stormwater runoff) to reduce the pollution content of sewage's volumes and industrial waste water produced by vast areas of development. A further difficulty is monitoring industrial discharges precisely, as well as the lack of awareness of such problems on the part of some operators in the various production sectors. Finally, the drawing of excessive supplies from water tables in coastal zones can lead to the intrusion of sea water in the water table, with the onset of salinity that renders the water no longer fit for its designated uses.

Areas highly settled by man constitute a critical component in the elevated water demand and in the production of equally voluminous flows of waste needing to be purified.

Intensive livestock raising activities generate noteworthy pressures, on account of the liquid waste produced and the runoff of defecations, as well as the residue from slaughterhouse and milk and cheese producing activities. The intensive use in agriculture of fertilisers (mineral, organic, organo-mineral fertilisers and soil enhancers), as well as plant care products (herbicides, fungicides, insecticides, miticides and various others), used to defend crops against parasites and pathogens, to control the development of infesting plants and to ensure greater quantities and higher quality standards of agricultural products, can have an impact of water life, in addition to modifying the quality of both surface and underground drinking water. Apart from the runoff of fertilisers, an overabundance of nutritional substances, as well as nitrogen and phosphate compounds from residential and industrial outlets, can lead to the eutrophication of water, meaning excessive growth and unruly multiplication of aquatic vegetable matter, and especially algae.

Residues from livestock raising and the massive use of plant care products and fertilisers in agriculture can have an impact on aquatic life and modify the quality of drinking water.

The survey initiated in 2003 on the presence of plant-care product residues in bodies of water, as part of the "Plan for Controlling the Envi-

Plan for controlling the environment la effects of plant-care products.

ronmental Effects of Plant Care Products" (Legislative Decree 194/95), called for a rationalisation of the regional monitoring programs, focussing the research on the substances effectively used within the territory while identifying the priorities for potential environmental risks. The monitoring, which was performed in 2006, involved a total of 3,403 sampling points (1,123 for surface waters, 2,280 for underground waters), 11,703 samples and 331 substances researched. The most widespread contamination was found in surface waters, with residues of plant-care products observe at 644 monitoring points (57.3% of the total) and, in 36.6% of these cases, at concentrations greater than the limits set for drinking water under the law. Of the monitoring points for underground waters, 707 were contaminated (31.0% of the total), and in 10.2% of these cases the concentration was above the limit. A total of 131 substances were detected, with a greater number found in the surfaced waters (125), while the underground waters contained 52. In terms of the types of substances found in the waters, the most widespread were herbicides and the related metabolites (especially the triazinetriones). This is due both to the mode of use, which can take place directly in the soil, and to the period of the treatments, which generally coincides with the heaviest meteoric precipitations, so that streams an infiltration transport the substances into the surface and underground bodies of water more rapidly. A critical problem would appear to be contamination from Terbuthylazine, the lone triazine substance still on the market, used primarily for the growing of corn and sorghum. This contamination is widespread throughout the Po Valley and Veneto areas, and it can also be found in certain central-southern regions: it was reported for 51% of the surface-water sampling points and 15.8% of those for underground waters. Also worthy of note is the widespread presence, throughout the Po Valley and Venetia areas, of Atrazine, a substance that had not been sold for roughly two decades, making its residue a contamination from past. There are also note-worthy levels of Metolachor, Oxadiazon, Cloridazon, Procimidone and certain herbicides used in rice fields, such as Bentazone, Quinclorac, 2.6-Diclorobenzammide and Esazinone. Mention should also be made of the presence of Glyphodate, which, though one of the most widely used substances in Italy, is currently monitored only in Lombardy, where it was found in 31.8% of the surface water points surveyed. The national overview of the presence of plant-care products in waters is still incom-

In 2006, overall monitoring involved 3,403 sampling points, 11,703 samples and 331 substances.

Many priority substances and other pollutants are present in the waters, but the most widely found were herbicides and their metabolites.

The presence of Terbuthylazine and Atrazine was an especially critical problem in the Po Valley and Venetia areas and in certain central – southern regions.

plete (Figures 4.8 and 4.9). There remain significant differences between the regions, not only in terms of the extension of the monitoring networks and the frequency of the sampling, but also the number of substances surveyed. Overall the monitoring is more effective in the northern regions than in the central–southern zones, where it often fails to accurately reflect the actual situation, seeing that it regards a limited number of substances no longer used in agriculture.

Levels of contamination of Italian surface waters, especially noticeable in the Po Valley and Venetia areas, where the surveys performed were more effective.

Figure 4.8: National outlook for the presence of pesticides in surface waters (2006)[9]

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[9] Source: Regions and autonomous provinces data processed by ISPRA

Levels of contamination of Italian underground waters, especially noticeable in Piedmont, Lombardy, Veneto and Friuli Venezia Giulia, where the surveys performed were more effective.

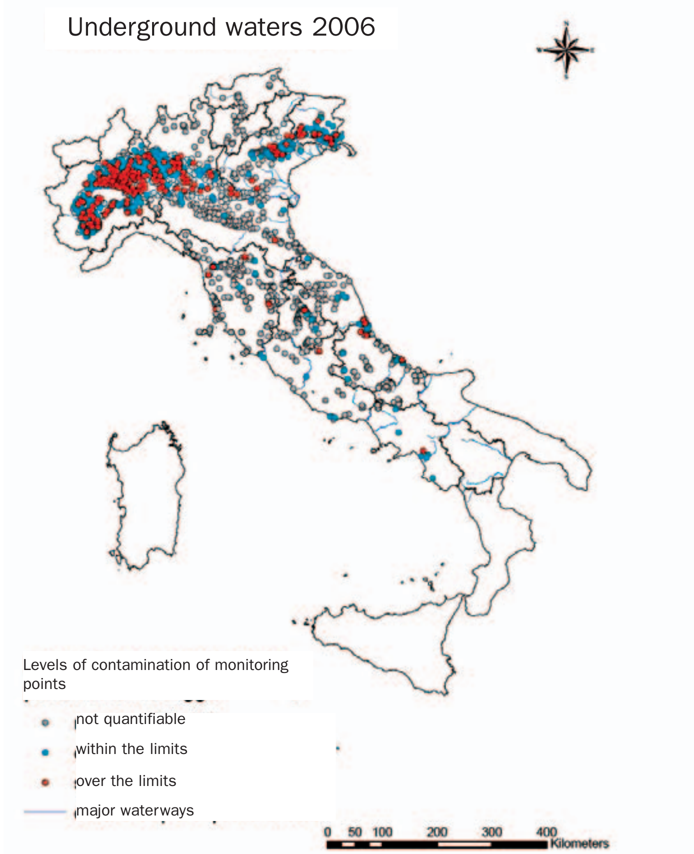

Figure 4.9: National outlook for the presence of plant care products in underground waters (2006)[10]

A survey carried out by the ISTAT statistics institute, together with the Environmental Observatory on Italian Cities, showed that per capita consumption of water for domestic use in Italy's 111 provincial seats was lower in 2008 than in 2007 (-2.2 %), falling to a level of 61.7 m^3 per inhabitant/year (Figure 4.10). When the figure for 2008 is compared to that for 2000, a decrease of 11% is observed, with this reduction

[10] Source: Regions and autonomous provinces data processed by ISPRA

due primarily to a more attentive use of the resource, as well as to the planning initiatives undertaken by municipal governments.

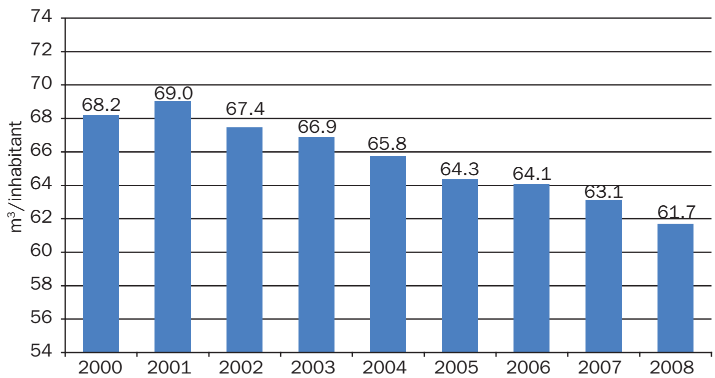

Figure 4.10: Per capita consumption of water for domestic use in 111 provincial seats[11]

In 2008, per capita consumption of water for domestic use in Italy's 111 provincial seats was lower than in 2007 (-2.2 %), reaching a level of 61.7 m^3 per inhabitant.

The distribution of drinking water in municipal systems is analysed using two quantitative variables recorded during the census[12]: water placed in the distribution networks and total water supplied for all the different uses. The regional differences between the water placed in the networks and the water supplied is due to a variety of factors, including: leaks in the conduits; overflows in holding tanks when available water exceeds capacity in given periods of the year or at certain points in the day; theft and the illicit drawing of supplies from the networks.
The difference between the water supplied and the water placed in the municipal distribution networks thus provides an indicator of the network dispersion. Within the national territory, this difference can reach 32.1%. The territorial distribution of network dispersion shows that the lowest level is found in northwest Italy (24.7%), while the highest was registered in the south (40.3%) (Figure 4.11).

The difference between the water supplied and that placed in the networks is equal to 32.1% for the entire national territory.

[11] Source: ISTAT data processed by ISPRA
[12] ISTAT, results of census on water services for 2008, carried out in 2009

The level of network dispersion in northern Italy (24.7%) is much lower than the maximum in the south (40,3%).

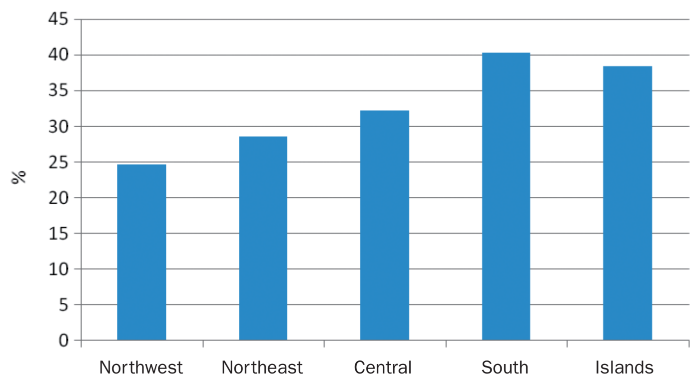

Figure 4.11: Geographic distribution of the difference between water placed in the networks and water suplied (2008)[13]

Actions designed to protect water quality

The regulatory instruments of planning, management and control make it possible, at different levels and in increasingly integrated fashion, to safeguard the status of water resources. The planning instrument called for under Directive 2000/60/EC is the District Basin Management Plan.

Watershed basins.

The districts can consist of one or more watershed basins.

The term "watershed basin" refers to the territory in which all the surface waters flow through a series of streams, rivers and lakes, emptying into the sea at a single mouth, estuary or delta.

Art. 64 of Legislative Decree 152/2006, which implemented the Directive, identified the watershed districts into which all of Italian territory were to be divided, while art. 117 governed the Management Plans, stipulating that a management plan was to be implemented for each district.

The Watershed District Management Plans must be implemented by 22 December 2009.

In order to meet the Community deadline for enactment of the Management Plans, meaning 22 December 2009, Legislative Decree no. 208 of 30 December 2008, converted following modification into Law no. 13 of 27 February 2009, further stated that

[13] Source: ISTAT

"the Management Plans are to be implemented ......in accordance with the available acts and opinions, no later than 22^{th} December 2009, by the Institutional Committees of the Basin Authorities of national importance, with the addition of members designated by the regions whose territories fall within the watershed district referred to in the Management Plan and which are not already represented on the Institutional Committees".

In accordance with these instructions, and though the District Basin Authorities are not yet operative, the Basin Authorities established under Law 183/89, and falling within the watershed districts, have initiated, in collaboration with the regional governments, the procedures for drafting Management Plans for the eight watershed districts (Eastern Alps, Po Valley, Northern Apennines, Serchio River, Central Apennines, Southern Apennines, Sardinia, Sicily) into which the national territory is divided (Figure 4.12).

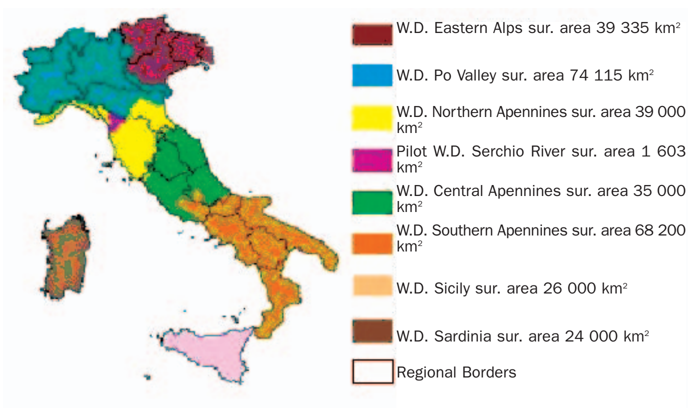

Figure 4.12: Italian watershed districts[14]

The Management Plans (art. 6 of Legislative Decree 152/2006, plus subsequent modifications and additions) fall under the category of plans for which Strategic Environmental Assessments must be drawn up (SEA). At present, in parallel with the phases of public

[14] Source: www.appenninomeridionale.it

consultation on the plans called for under Directive 2000/60/EC, the public consultations provided for under the SEA procedures are underway, regarding the environmental reports of the plans themselves. The plans must contain elements involving the planning and scheduling of initiatives and standards of use geared towards preserving, defending and upgrading the soil while making proper use of waters, all based on the physical and environmental characteristics of the territory of the basins involved.

The fundamental groundwork for the drafting of the Management Plans is provided by the Water Defence Plans of the regions with territorial jurisdiction, whose contents must be supplemented with regard to the district basin.

The PTA provides up-to-date knowledge on the status of waters while setting environmental objectives and determining the measures to be applied on the regional level.

The Water Defence Plan (PTA) is drawn up by the regions; in accordance with art. 121 of Legislative Decree 152/06, it is specific to the sector and must contain, in addition to initiatives geared towards achieving or maintaining quality objectives, the measures needed to defend the levels of quality and quantity of the water system.

This plan, already contemplated under art. 44 of Legislative Decree 152/99, together with the initial characterisation of the meaningful watershed basins and the classification of the status of surface and underground water bodies, has made it possible to obtain, to date, excellent knowledge of the status of the water resources.

To date, 7 PTAs have been implemented and 11 have been approved.

The current national situation, in terms of protection plans, consists of seven plans that have been implemented (Veneto, Liguria, Umbria, Marche, Basilicata and Campania) and eleven plans that have been approved (Piedmont, Aosta Valley, Lombardy, the Autonomous Provinces of Trent and Bolzano, Emilia Romagna, Tuscany, Lazio, Apulia, Sicily and Sardinia).

Initiatives for the protection of water include the construction and upgrading of collecting systems and urban waste water treatment plants.

Initiatives for the protection of water include the construction and upgrading of sewage networks and urban waste water treatment plants. Community Directive 91/271/EEC on the treatment of urban waste water set 31th December 2005 as the deadline for the technological upgrading of urban waste water purification plants and sewage networks servicing agglomerates with more than 2,000 equivalent inhabitants (e.i.). Starting from that date, the purification and sewage infrastructures must meet the standards called for under the legislation.

Assessment of compliance has also been extended to purification and sewage systems servicing agglomerates of smaller

size.Though it was not possible to complete the national reference outlook for 2006, the information obtained regarded 17 regions, together with the autonomous provinces of Trent and Bolzano (Figures 4.13 – 4.14).

In 2006, the level of compliance for sewage systems nationally was 93%.
The figures on Calabria, Sicily and Basilicata were not available.

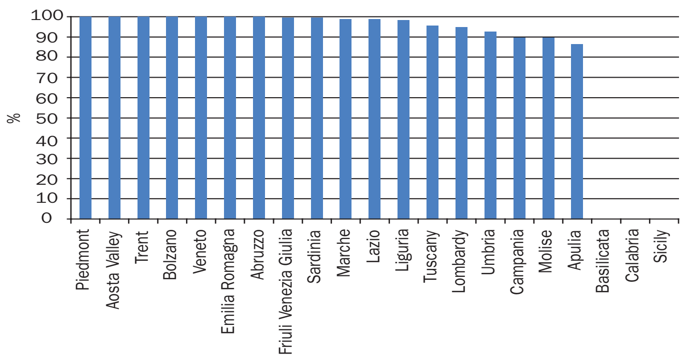

Figure 4.13: Level of compliance of the regions' sewage systems (2006)[15]

In 2006, the level of compliance for purification systems nationally was 77%.
The figures on Calabria and Sicily were not available.

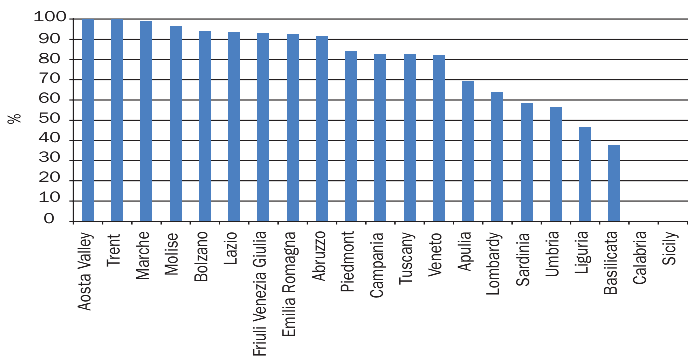

Figure 4.14: Level of compliance of the regions' purification systems (2006)[16]

In 2006, though all the information necessary for a complete overview has not been transmitted, the national level of compliance of purification systems was 77%, while the level for sewage systems was 93%.

The national level of compliance for sewage networks was 93%, while the level for purification systems was 77%.

[15] Source: Regions and autonomous provinces data processed by ISPRA
[16] Source: Regions and autonomous provinces data processed by ISPRA

There is scarce reuse of treated waste water.

Another critical problem affecting the overall system for rationalising the use of the resource on the national level is represented by the scarce reuse of treated waste water. In Italy initiatives involving the reuse of waste water are much more limited than in other countries, though there is a positive trend that has resulted in an increase in such efforts in recent years.

The Ministerial Decree of 185/2003 stipulates that treated waste water may be used for irrigation purposes, civic purposes and industrial purposes.

The reuse of treated waste water is governed by Ministerial Decree no. 185 of 2003. The decree regulates the designated uses and the related quality requirements, in order to protect the quality and quantity of water resources, and with the objective of limiting the procurement of supplies of surface and underground waters, reducing the impact of discharges on the receiving water bodies and favouring water savings through the multiple use of waste water.

Reuse constitutes one of the instruments for implementing a rational and sustainable management of water resources.

The measure referred to above stipulates that treated waste water may be used for *irrigation purposes*, *civic purposes* and *industrial purposes*, with such reuse being viewed as one of the instruments for implementing a rational and sustainable management of water resources.

The national legislation provides incentives for expanded reuse, providing for it to be included in Water Defence Plans.

For that matter, the national legislation provides incentives for expanded reuse, calling for it to be included in Water Defence Plans.

This means that the regions must implement regulations and measures that favour the recycling of water and the reuse of treated waste water.

In light of the above, the planning of the initiatives necessary for the modernisation of the existing purification plants and their upgrading to meet legal requirements must increasingly take into account the importance of the reuse of treated waste water and the recycling of slime.

The Nitrates Directive, transposed into Italian law first as Legislative Decree 152/99, and then under Legislative Decree 152/06, requires that the member

In terms of pollution caused by nitrates from agriculture, in '91 the Council of the European Communities implemented Directive 91/676/EEC (the Nitrates Directive), assimilated by Italian Law first under Legislative Decree 152/99 and then under Legislative Decree 152/06, for the purpose of reducing or preventing the pollution of waters caused either directly or indirectly by nitrates

from an agricultural source. Following implementation of this decree, the member states are required to carry out controls on the nitrate concentration of fresh waters, to designate "vulnerable zones" and to draw up action programmes for the same, in addition to formulating Codes of Good Practice and drawing up programs for training and informing farmers.

Among the crucial factors to enforce the Directive 2000/60/EC, mention should be made about the knowledge of availability and uses of the resources, the summary of pressures and significant impacts, the completion of monitoring network for all types of water bodies and a summary of the economic analysis on water utilise. In carrying out all these initiatives, every effort should be made to employ the economic, human and scientific resources available to our country in the best way possible.

states carry out controls on nitrate concentrations, designate vulnerable zones, formulate codes of good practice etc.

FOCUS

FIRST APPLICATION OF DIRECTIVE 2000/60/EC TO SURFACE WATERS

Introduction

The Community reference legislation regulating the ecological and chemical quality of waters is the Water Framework Directive (2000/60/EC) which came into force on 22 December 2000 and was implemented in Italy by means of Legislative Decree 152/2006. The said Directive creates a framework for greater cooperation between the European Union Member States with regard to the protection of aquatic environments and introduces the concept of environmental quality standards, establishing that they must achieve the best “ecological status” and “chemical status” possible or, nevertheless, achieve a “good surface water status” at the latest 15 years from the entry into force of the Directive, that is by 2015.
In Italy, the implementation of the Water Directive is coordinated at national level by the Ministry of the Environment, with the collaboration of the Institute for Environmental Protection and Research (ISPRA), and with the participation of the Basin Authority, the regions, ARPA/APPA and other research institutes.

Following approval by the Council of Environmental Agencies, ISPRA set up several inter-agency work groups, including: the coordination group, the rivers and lakes group, the groundwater group, the group relative to the European Information system. In order to meet the reporting obligations laid down by the Water Directive this system, WISE (*Water Information System for Europe*), develops instruments for the processing and transmission of data and information to the European Commission.
Under the mandate of the competent MATTM management, ISPRA is the coordinator of the *Geographical Intercalibration Group* for the Mediterranean Ecoregion (Med GIG) for marine coastal and transitional waters.

The application of the Directive involves four main stages which deal with the following:

1. Typology
   The Member States must identify distinct significant features for water bodies, on the basis of their hydromorphological and physic-chemical characteristics.
2. Reference conditions
   For each type, Member States must establish a group of reference conditions representing, as far as possible, undisturbed natural conditions or conditions where anthropogenic impact is absent or negligible with reference to Biological (BQE), hydromorphological, chemical and physic-chemical Quality Elements.
3. Monitoring networks
   Each Member State must establish monitoring networks designed to: classify water bodies into one of the 5 ecological status classes; identify eventual changes in the ecological status of water basins held to be “at risk”. The monitoring programmes must show the response of BQEs to impacts it may be exposed to distinguishing the spatial/temporal variability relative to the natural background values from variability linked to anthropogenic pressures to which the system is subject.
4. Classification system
   The conditions given for each BQE must be compared to the reference conditions. Depending upon the degree of deviation from the reference conditions (*Environmental Quality Ratio*, EQR) the water body will be allocated to one of 5 classes of ecological status: “high”, “good”, “moderate”, “poor”, “bad”.

The stages described are implemented at national level by the Ministerial Decrees linked to Legislative Decree 152/2006:

- Characterisation decree (DM 131/2008 – *Regulation containing the technical criteria for the characterisation of water bodies (characterisation and identification of water bodies, analysis of pressures*);
- Monitoring decree (DM “Ambiente” 14 April 2009, no. 56 – *Regulation containing “Technical criteria for the monitoring of water bodies and identification of the reference conditions for the amendment of the technical regulations of the legislative decree*

of 3 April 2006, n. 152, containing environmental regulations laid down under article 75, paragraph 3, of the legislative decree");
- the Classification decree (currently awaiting approval).

In order to facilitate a uniform and shared implementation of the Directive, the European Commission and the Union Member States launched *Common Implementation Strategies* that led to the creation of ad hoc work groups and drawing up of non-prescriptive guidelines publicly accessible via the website[1].

Italy has also taken over the European coordination of the second stage of measures for the intercalibration of classification criteria to the scale of the Mediterranean ecoregion (MED GIG: *Mediterranean Geographic Intercalibration Group* – Stage II). Coordination was entrusted to ISPRA which has the task of completing the Intercalibration activities by June 2011 and providing the European Commission with the different ecological classification methods that have been shared, tested and are therefore adoptable by all Member States in the Mediterranean Ecoregion.
An initial intercalibration exercise (MED GIG Stage I) was launched in 2004 and concluded in 2007 under the coordination of the former APAT. The results produced, although partial, were published in the Commission Decision 2008/915/EC.
The second phase of activities will address various problems and examine a number of issues in greater depth. These mainly relate to: a) the capacity of the classification systems proposed to adequately represent anthropogenic pressures and their effect upon ecosystems; b) a more precise assessment of the "Reference conditions", also in order to ensure the correct assessment of so-called "natural" variability; c) the right weight to attribute to the abiotic elements (hydromorphological, physico-chemical and chemical) that concur in determining the ecological status of water bodies.

[1] http://forum.europa.eu.int/Public/irc/env/wfd/library

NATIONAL CHARACTERISATION SYSTEM (ITALIAN MINISTERIAL DECREE 131/2008)

Rivers and lakes

The definition of river's type is based on the natural diversity of watercourses, taking into account the result of the integration of regional differences and upstream-downstream gradient.

The activity takes place on three levels:

a) definition of the hydro-ecoregion (HER), or geographic areas defined on the basis of factors such as orography, geology and climate, within which freshwater ecosystems should have a limited variability in terms of chemical, physical and biological characteristics (Figure 1);

b) definition of broad river types within HERs on the basis of a limited number of variables, not included among those used to define HERs – origin of the watercourse, distance from the source, etc;

c) definition of detailed types (optional).

The HERs defined by Cemagref [2] for Europe were adopted for Italy; the following obligatory descriptors were considered:

- perennial nature and persistence (temporary or perennial rivers);
- origin of watercourse (surface flow, from glaciers, etc.);
- distance from source (indicator of watercourse size);
- riverbed morphology (for temporary rivers);
- influence of upstream basin.

[2] Centre National du Machinisme Agricole, du Génie Rural, des Eaux et de Forêts (F) (The main research centre in the French water sector)

Hydro-ecoregion

1 Alpi Occidentali
2 Prealpi_Dolomiti
3 Alpi Centro-Orientali
4 Alpi Meridionali
5 Monferrato
6 Pianura Padana
7 Carso
8 Appennino Piemontese
9 Alpi Mediterranee
10 Appennino Settentrionale
11 Toscana
12 Costa Adriatica
13 Appennino Centrale
14 Roma_Viterbese
15 Basso Lazio
14 Vesuvio
16 Basilicata_Tavoliere
17 Puglia_Carsica
18 Appennino Meridionale
19 Calabria Nebrodi
20 Sicilia
21 Sardegna

Figure 1: Italian hydro-ecoregions[3]

Natural lakes and heavily modified natural and artificial lakes present in Italy are characterised on the basis of morphometric descriptors (quota, depth, surface area), the prevalent composition of the geological substrate (limestone, siliceous or volcanic) and physic-chemical descriptors (conductivity and thermal stratification), distinguishing between the Alpine and Mediterranean eco-regions.
DM 131/08 defines the methods to be used for the characterisation of different types of surface waters, the analysis of pressures and identification of water bodies, following characterisation, in 5 stages.
The first stage involves identifying the limits of surface water categories. A water body may only belong to a single category of water (rivers, lakes/reservoirs, transitional waters and coastal waters) and to one single type.
The second stage involves identifying size criteria only, at least during the preliminary stage, neglecting a great number of minor elements to avoid encountering important logistical difficulties.
The third involves identifying the limits by means of physical features that are significant with reference to the aims to be pursued for rivers (confluences, variations in gradient, morphology, hydrology, interac-

[3] Source: Italian Ministerial Decree 131/08

tions with the aquifer), for lakes (morphological components), for transitional waters (variations in salinity, morphological structures, barrier islands) and for marine waters (presence of a major source of freshwater and river mouths).
The fourth involves the assessment of the status of waters, the relative pressures and the boundaries of protected areas.
The fifth stage concerns the identification of minor elements[4] of surface waters as separate water bodies, grouping them into a larger adjoining water bodies as well as identification of heavily modified or artificial water bodies.
In order to analyse pressures and impacts, the regions will require accurate detailed knowledge of the anthropogenic activities (wastewater discharges, morphological changes, water withdrawals, use of plant protection products, surplus fertilisers) and of the environmental effects brought about by these pressures for each body of water.
In the Po basin, the Basin Authority, the regions and the System of Environmental Agencies belonging to them (Aosta Valley, Piedmont, Lombardy, Emilia Romagna, Veneto, Liguria and the Autonomous Province of Trent) acted in a coordinated manner to obtain a preliminary list of the types of water bodies (rivers, lakes, transitional and coastal waters) present in the basin, in compliance with the regulations drawn up by the Ministry of the Environment.

Table 1: Water bodies in the Po district[5]

Rivers	Lakes	Transitional	Marine	Groundwater
1,890	107	18	1	145

Characterisation was also carried out in the regions of Tuscany, Umbria, Marche and Abruzzo and in the Autonomous Province of Bolzano. Characterisation is currently underway in Friuli Venezia Giulia, Lazio, in Calabria (partly) and in Campania (to a very limited extent). Characterisation is currently not taking place in Basilicata, Molise, Sicily or Sardinia.

[4] Elements not included among those to be identified in the second phase because of their dimensions but that may be identified as individual water bodies provided they meet at least one of the criteria established in section B.3.5.1 of the decree; for example, surface water important for human consumption, for the life of fish, for swimming, elements that are important for biodiversity, identified as reference sites/environments, etc.
[5] Source: Region Lombardy

Marine coastal and transitional waters

The main geomorphological and hydrological factors distinguishing marine coastal environments were taken into consideration in order to carry out a full, accurate characterisation of Italian marine coastal waters: the morphology of the coastal area, whether exposed (including the adjacent land) or submerged; the nature of the substrate; the depth of the submerged intertidal zones; the vertical stability of the water column.

At national level, a coastal geomorphological study[6] had already lead to a distinction of the Italian coasts in 6 main types: mountain coast (A), terrace coast (B), littoral plain (C), torrent plain (D), river plain (E), dune plain (F) (Figure 2).

Figure 2: Characterisation of the Italian marine coastal zones on the basis of coastal geomorphology[7]

[6] Brondi *et al.*, 2003
[7] Source: Bondi et al., 2003

On the other hand, it is unlikely that all possible types of coast could be represented on the basis of a characterisation that only takes into account the geomorphological characteristics of intertidal zones.
For this reason it was decided to include factors further qualifying coastal zones relative to continental freshwater inputs which are lighter and therefore tend to stratify on the lower layers. The presence of fluvial inputs may bring about high density stratification like that taking place in the Adriatic coastal strip subjected to Po Valley inputs.

The hydrological parameter best suited to describing this type of approach is represented by the stability of the water column which provides a direct measurement of density stratification. This extends the concept of type to numerous factors, or anthropogenic pressure indicators, influencing the quality of the coastal zone (nutrients, pollutants, etc, potentially contained in freshwater leading to stratification).

The examination of data from the national monitoring programme (*ex lege* 979/82 “Defence of the Sea”) carried out by 15 coastal regions with the Ministry of the Environment led to the identification of three different types of hydrological system based on the mean annual values relative to the vertical stability of the water column: high (1), moderate (2), low (3).

The characterisation of Italian transitional waters took into account various hydromorphological and physic-chemical descriptors set out for System B, Annex II in section 1.2.3. of Directive 2000/60/EC: geo-morphology, tidal regime, surface area and salinity.
This led to the identification of 21 possible transitional water types, one of which relative to delta-river mouths and twenty relative to lagoons.
The division of water bodies into types is necessary for the definition of type-specific reference conditions. Given that it is not currently possible to determine 21 different reference conditions and that 70% of Italian transitional environments are euha-

line or polyhaline, 3 macrotypes were established by grouping together the types defined by DM 131/2008 on the basis of tidal excursion and salinity (distinguishing between water bodies with salinity greater or less than 30 PSU).
At regional level lagoons, represented as lagoon complexes on account of the considerable structural differences revealed when examining their geomorphological and hydrodynamic characteristics, can be further "sub-characterised" by applying physic-chemical, geomorphological and hydrodynamic descriptors in compliance with the provisions of Directive 2000/60/EC.

MONITORING AND CLASSIFICATION (ITALIAN MINISTERIAL DECREE 56/2009)

The aim of national monitoring programmes is to establish a coherent and exhaustive overview of the ecological and chemical status of the waters in each hydrographic basin, including marine coastal waters allocated to the hydrographic district in which the relative hydrographic basin lies, and to enable the classification of all surface waters "identified" for the purposes provided for by the Directive.
The competent authorities will define monitoring programmes for each period in which a district management plan is applied, ensuring that the following activities are carried out for each hydrographic basin:

- choice of water bodies to undergo surveillance and/or operational monitoring relative to the different aims of the two types of control;
- the identification of sufficient monitoring sites in appropriate locations for assessment of chemical and ecological status, taking into account the aims of the ecological status of the minimum indications set out in the sampling protocols.

Our knowledge of anthropogenic activities, their pressure and past monitoring data allows us to assess the vulnerability of water body status and forecast their capacity to meet the quality objectives established within the times laid down by the Directive. As far as

probable attainment of the above objectives is concerned, water bodies are classified as “not at risk”, “probably at risk” and “at risk”.
The directive provides for 3 types of monitoring: surveillance, operational and investigative.
Surveillance monitoring is undertaken for “water bodies likely to be at risk” (that is, where available data does not allow us to assign the risk category and further information is required) and for “water bodies not at risk”.
Surveillance monitoring may also be undertaken at points in water bodies at risk that are important for the assessment of long-term variations resulting from widespread anthropogenic activities, or that are particularly significant at basin level, or where held necessary by the regions on the basis of the characteristics of the area involved.
The priority target for surveillance monitoring is “water bodies likely to be at risk” so that the effective risk condition can be established.
Operational monitoring is to be undertaken for the category of “water bodies at risk” in order to establish the status of the water body identified as being at risk of not meeting environmental objectives as well as assessing any changes in the status of such water bodies due to programmes of measures for the purpose of classifying such water bodies.
Investigative monitoring will be carried for specific cases: where the reasons for any exceedance is unknown or where surveillance monitoring indicates that there is the risk to fail the objective. It may also be undertaken to assess the magnitude and impacts of accidental pollution.
The directive also establishes the frequency of sampling during the monitoring period, according to the different biological quality elements, chosen on the basis of the type of monitoring to be used.
The surveillance monitoring cycle must be six yearly while operational monitoring shall be undertaken on a three-yearly basis.

Classification involves determining the ecological and chemical status of each water body. The former is based on a comparison with the specific reference conditions for each type of water body (EQR)[8], while the latter is based on compliance with environmental quality standards laid down by the above decree for the substances in the priority list.

Until the official classification methods are established the various ARPA/APPA have partly complied with the new monitoring system, adopting it alongside the old system (under D.Lgs. 152/99) as well as replacing it.

The new regulatory situation requires in-depth studies to be carried out on the various biological compartments of the river, lake and marine systems for classification of ecological status.
Biological quality elements (BQE) play a key role in the classification of water bodies while hydro-morphological and physico-chemical quality elements provide "support" for the ascertainment of ecological quality status.

Listed below are various BQEs to be used for rivers, lakes, marine coastal and transitional waters for the classification awaiting definition, in the order given in Annex I of DM 56/09 (Table A.1.1), and the classification systems in use.

River systems are examined by taking into account **phytobenthos** formed by various types of algal *taxa* but the most tested and most suitable *taxon* for monitoring of flowing waters is the **diatom**. Diatomae are very well known from both a systematic and ecological point of view; moreover their cosmopolitan distribution in all flowing waters and high sensitivity to eutrophication and pollution make them excellent bioindicators.
Aquatic **macrophytes** include plants macroscopically visible in aquatic and brackish habitats and river beds. The group comprises herbaceous angiosperms, pteridophytes, bryophytes and filamentous algae. In addition to their important ecological

[8] *Environmental Quality Ratio* (EQR) = (Actual value of EQ/ Reference value of EQ)

role, the use of macrophytes as quality indicators for flowing waters is based on the fact that some species and groups of species are sensitive to changes in water bodies and are affected in different ways by anthropogenic impact.

The **benthic communities** of soft bottom have the capacity to respond significantly to environmental changes, whether natural or anthropogenic in origin. Their persistence allows us to develop a highly integrated interpretation of the spatial and temporal changes taking place in the physical world. In fact, they could be said to represent the "biological memory" of the ecosystem. The structure of the macrobenthic communities is strongly correlated to abiotic factors such as hydrodynamism, texture of substrate, concentration of organic matter and, last but not least, the presence of pollutants. As a result it is liable to considerable spatial and temporal variations. The analysis of these communities makes it possible to reveal eventual environmental changes taking place in relation to possible variations in the aforementioned factors for all types of surface waters.
The relative ease of collecting samples and identifying these organisms together with their widespread diffusion in water courses make benthic macroinvertebrates particularly suited to the use of bio-monitoring and assessment of the quality of fordable rivers[9]. The method being tested is based on a multi-habitat approach involving a collection of macroinvertebrates proportional to the relative extension of the various habitats estimated prior to start of sampling. In lake environments they live in sediment (endobenthos) or on it (epibenthos). Sediments play an important role in the chemical and biological processes of lake ecosystems because the substances dissolved in the water above accumulate in them by means of adsorption.

Classification methods used for coastal marine and transitional environments, at Mediterranean Ecoregion level, are merely indices concerning benthic communities on soft bottom. The various indices formulated generally respond extremely well to the

[9] Buffagni *et al.*, 2008

organic enrichment of the sediment, reflected in the composition of the species and the structure of the macro-zoo-benthic communities. M-AMBI (Multivariate AZTI *Marine Biotic Index*), an index consolidated by an extensive bibliography, will soon be used in Italy. It is based on the analysis of the structure of the community present which involves the division of the species present into 5 ecological groups, in relation to the degree of specialisation/ opportunism and their sensitivity to environmental stress gradients[10].

In addition to M-AMBI, the classification systems proposed for transitional waters included BITS (*Benthic Index based on Taxonomic Sufficiency*). BITS only requires taxonomic recognition of benthic macrofauna at family level. The analysis of the structure of the community then divides the families into 3 ecological groups: sensitive, tolerant and opportunistic[11].

Fish populations (rivers, lakes, transitional waters) play an important role in environmental assessments because they respond to various types of environmental stress, integrating the effects of environmental factors change on other components of the aquatic ecosystem, because of their dependence on them for survival, growth or reproduction. Moreover, given that many species have a relatively long life, analyses at population level (e.g. structures based on size or age classes) and population (e.g. list of species, relations between them) can provide long-term documentation of environmental stress as well as representing a way of assessing the efficiency of the environmental upgrading measures designed to bring about the quality objectives[12].

Phytoplankton monitoring (composition, abundance and biomass) is requested for lake, transitional and marine coastal waters with blooms of potentially toxic or harmful species being identified, where present, for the latter.

Due to its position at the base of the trophic level phytoplankton

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[10] Muxika *et al.*, 2007 - Borja *et al.,* 2008
[11] Mistri and Munari, 2008
[12] Tancioni *et al.,* 2005; Scardi *et al.*, 2005

plays an important ecological role. Phytoplankton primary production is an important link in the food chain in fresh and marine waters, guaranteeing the necessary flow of matter and energy for the maintenance of heterotrophic organisms. Phytoplankton is equally important as an indicator because it comprises a high number of species with different ecological role, many of which sensitive to both organic and inorganic pollution, as well as to variations in the salinity, temperature and trophic level of the waters. It consists of small photosynthetic organisms (unicellular microalgae) that live in suspension in the waters of lakes, rivers and seas.
These organisms have a short life cycle and rapid growth and reproduction rates, making them ideal as short-time impact indicators. However, their excess proliferation leads to a rapid reduction in the quality of the waters (eutrophication).
Microalgal studies make it possible to evaluate the influence of eutrophic factors (nitrogen and phosphorus loads) and pollutants upon biological communities. In the marine context chlorophyll *a* is a useful trophic indicator because it is directly correlated to the quantity of phytoplankton biomass present in the water column.
The current classification system for the phytoplankton BQE in coastal waters is based on the values of the chlorophyll *a* parameter measured on the surface, chosen as a biomass indicator.

The infralittoral communities on rocky substrate dominated by **macroalgae** respond to changes in environmental conditions in relatively brief times, which is why they are particularly suited to monitoring of the ecological status of coastal waters.
The prevalent methods used to classify coastal waters according to this Biological Quality Element at Mediterranean Ecoregion level, are based on the principle that a high ecological status of the water body corresponds to the presence of macroalgal communities dominated by well structured brown algae (*Cystoseira* sp.), while a poor status was characterised by the dominance of opportunistic species with low morphological complexity like *Ulvales* (green algae), *Bangiophycidae* (red algae) and Cyanobacteria.
In Italy, positive results seem to have been obtained using the

CARLIT (Littoral Cartography)[13] method which implies "visual census" followed by the mapping of algal associations present along the infralittoral belt, highlighting the different types of anthropogenic pressures present and revealing good correlation with other water quality parameters[14].
Transitional waters are notoriously eutrophic environments by their own nature. Methods based on the observation of communities comprising macroalgal and phanerogam species seem to be particularly suitable for the assessment of the ecological status of these water bodies. The different species present can be divided into three ecological groups: opportunist, indifferent and sensitive to environmental stress gradients. The reliability of these methods is linked to the number of species present in the monitoring stations. The adopted approach for the formulation of classification indexes include presence/absence of opportunist, indifferent and sensitive species, the percentage of dominance in the area under examination, the R/C (*Rodophyceae/Chlorophyceae*) ratio and marine spermatophyta coverage, if present[15].

Posidonia oceanica prairies play an important role in the characterisation process of marine coastal environments. . Thanks to its wide distribution and sensitivity to anthropogenic disturbances *Posidonia oceanica* is one of the angiosperms listed by Italian Ministerial Decree DM 56/2009 "Monitoraggio" as a Biological Quality Element used in classifying ecological status.
Various classification indexes were proposed by the Member States belonging to the Mediterranean Ecoregion. One index that has already been tested in Italy (POSWARE - ISPRA, 2009) is formulated on the base of the following set of descriptors: density of prairies (no. of bundles per sq m), primary production (assessed in terms of annual weight increase of rhizome), annual rhizome elongation and leaf production (no. of leaves produced per year). Another factor that must be considered is the natural variability of these descriptors along the depth gradient, from the shore

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[13] Ballesteros *et al.*, 2007
[14] Mangialajo *et al.*, 2007
[15] Sfriso *et al.*, 2007, 2009

outwards, which has made it necessary to "discrete" the survey areas in bathymetric intervals and to take these effects into account when calculating the index.

As far as chemical quality is concerned, Directive 2000/60/EC establishes that water pollution prevention and control must be pursued through a combined approach involving both control of pollution at source (emission limits) as well as the application of Environmental Quality Standards (EQSs). Environmental Quality Standards are defined as "the concentration of a particular pollutant or group of pollutants in water, sediments or biota which should not be exceeded in order to protect human health and the environment".
The Directive classifies pollutants as: priority substances (including priority hazardous substances); hazardous substances; major pollutants.
As far as the classification of chemical status is concerned, water should be classified as achieving good chemical status or failing to achieve good chemical status, on the basis of emission limits and Environmental Quality Standards laid down by the previous European Directives on hazardous substances (76/464/EEC and following legislation), as well as in relation to the Environmental Quality Standards established for pollutant compounds not included in these Directives.
Italian Ministerial Decree 56/2009 lays down the technical guidelines for the monitoring programmes for surface water status assessment, in compliance with Directive 2000/60/EC and Annex II to the same Directive. In particular, the substances defining chemical status are contained in a priority list with 33 "priority" substances and 8 substances from the secondary legislation resulting from 76/464/EEC.

The definition of chemical status and safeguarding of water bodies requires compliance with the EQSs listed in Directive /105/EC of 16th December 2008.
As mentioned in the Directive, in addition to accepting the EQSs, Member States may also independently define quality standards (also for sediments and biota) provided that these standards guar-

antee the same “safety” in guaranteeing water bodies as those laid down for waters. Referring to biota, the Directive identifies three quality standards relative to mercury (and its compounds), hexachlorobenzene and hexachlorobutadiene.

In both surveillance monitoring as well as operational monitoring the chemical substances to be monitored are identified by analysing pressures and impacts on the area under examination. The substances in the priority list are monitored whenever there are discharges, emissions or losses in the water bodies under examination. The other chemicals, listed in Annex 8 of Italian Legislative Decree 152/06 are monitored whenever the level of discharges, emissions or losses are such that they are considered a risk for the attainment or maintenance of the quality objectives (art. 77 and following of Italian Legislative Decree 152/06).

Two case studies are described below: “Experimental monitoring of surface waters in the region of Umbria (2008/2009); “Characterisation of the Venice lagoon and identification of water bodies”.

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CASE STUDY

Experimental monitoring of surface waters in the region of Umbria (2008/2009)

2008 was a year that brought major changes in the monitoring of the environmental quality of surface waters in the region of Umbria. During the year, in compliance with the new legislation regulating this sector, the region of Umbria has defined the preliminary phases of monitoring programme and launched the monitoring activity in compliance with Italian Legislative Decree 152/06, and subsequent amendments and additions, both for the category of watercourses and the category of lakes.

The first phase involved the characterisation of the surface hydrographic network (watercourses and lakes) and the identification of water bodies, in compliance with Italian Ministerial Decree 131/2008 and in agreement with the technical indications laid down by both community and national guidelines. 133 rivers belonging to 18 types were identified for the watercourse category within the 3 Hydro-ecoregions[1] making up the region as shown in Table 1.

10 water bodies belonging to 3 different types were identified for the lakes category (Table 2).

During the second phase, the water bodies were subjected to the analysis of significant pressures affecting the relative sub-basins. The main pressure factors considered were as follows:

- diffuse sources (urban areas, agriculture, fertilised-irrigated areas);
- point sources (pollutant loads from municipal waste water treatment plants, point loads from sewage overflows, industrial pollution, potential presence of priority substances).

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[1] Uniform macro-areas with aquatic ecosystems distinguished by highly comparable general features due to the limited variability of the chemical, physical and biological characteristics of the surface waters

Table 1: Types identified in the Region of Umbria in compliance with DM 131/08 and distribution of water bodies by type (watercourses)[2]

	TYPE	Water bodies belonging to the type
		no.
1	13SR1T	1
2	13SR2T	12
3	13SR3T	2
4	13SR4T	1
5	13SR5T	3
6	13SS2T	1
7	11SR2T	5
8	11SR2D	2
9	11SR3D	2
10	11SR4T	1
11	11SR5F	2
12	11SS2T	24
13	11SS3T	16
14	11SS4T	2
15	11SS5T	6
16	14SR2T	2
17	13IN7T	12
18	11IN7T	39
TOTAL		133

Table 2: Types identified in the Region of Umbria in compliance with DM 131/08 and distribution of water bodies by type (lakes)[3]

	Type	Description of type	Water bodies belonging to the type
			no.
1	ME-1	polymictic Mediterranean lakes	5
2	ME-2	Shallow limestone Mediterranean lakes	3
3	ME-4	Deep limestone Mediterranean lakes	2
TOTAL			**10**

The analysis of pressures were carried out by means of cluster analysis which grouped water bodies in nine pressure levels. This analysis was accompanied by a preliminary assessment of the potential risk of failure to attain the environmental quality

[2] Source: ARPA Umbria
[3] Source: Ibidem

objectives laid down by Directive 2000/60/EC, based on existing monitoring data for the entire regional network. On the basis of this analysis 27 water bodies in the watercourses category were identified as being at risk (R), 13 not at risk (NR) and 93 potentially at risk (PR); 6 water bodies in the lakes category were identified as being at risk (R) while 4 were considered potentially at risk (PR).

On the bases of pressures' results and risk analyses, it was decided to test the possibility of grouping water bodies as suggested by Italian Ministerial Decree DM 56/2009, limited to water bodies belonging to the watercourses category because it was held necessary to monitor directly all water bodies identified in the lakes category.

This led to the identification of 55 "basic monitoring units", compounded by one or more water bodies belonging to the river type, to the same pressure cluster and with the same risk status, and in sites not too distant from each other. Representative water bodies were identified for each unit so that they could undergo monitoring, giving preference to those which already had active monitoring stations in compliance with existing laws and for which time-series data was already available.

The initial identification of water bodies undergoing monitoring and their distinctive features was followed by complex checks and fine-tuning of the network by means of on-site inspections designed to observe environmental parameters confirming the representative nature and adequacy of features proposed. Specific programmes of measures were proposed for each surveillance and operational monitoring station. As far as monitoring of biological quality elements is concerned, the monitoring programme was defined on the bases of criteria dictated by the applicable laws and on the bases of the spatial and temporal variability of the bio-indicators monitored.

As far as physic-chemical parameters are concerned, it was decided to divide both the main parameters and substances in the priority list into analytical sets. In the purposes of monitoring, rivers were divided into four groups: the first comprises water

bodies at the outlet points of the main basins; the second comprises water bodies defined as significant by the Italian Legislative Decree 152/99; the third comprises other water bodies belonging to the main network and the last group composed by the water bodies belonging to a minor or temporary network.
A general monitoring programme (parameter sets and frequencies) was developed for each of these groups together with specific monitoring programmes for the single stations within each group on the basis of the pressure analysis results.
In general, it was decided to subject stations at the outlet point of the main sub-basins to “complete” surveillance monitoring including all analytical sets.
As far as lakes were concerned, the detailed monitoring programmes were defined on the basis of pressures acting upon the single water bodies.

Table 3: Set of analytical parameters monitored[4]

Analytical set	Analytical sub-set	Type of parameter
B		Main physico-chemical parameters
E		*Escherichia coli* + chemical parameters
A	A1	Metals (Table 1/A + Table 1/B)
	A2	Phenols (Table 1/A + Table 1/B)
	A3	VOC+BTEX (Table 1/A + Table 1/C)
	A4	Pesticides+IPA (Table 1/A + Table 1/B)
C		Phenoxyacids

Table 4: General monitoring programme of rivers – division of micropollutant sets within groups of stations identified for monitoring[5]

River groups	Analytical sets			
	B	E	A	C
Water bodies at the outlet points of the main basins	three-monthly	monthly	monthly	three-monthly
Water bodies defined as significant under Italian Legislative Decree 152/99	three-monthly		monthly	three-monthly
Other water bodies in the main network	three-monthly		monthly	three-monthly
Minor and temporary rivers	three-monthly		three-monthly	

[4] Source: Ibidem
[5] Source: Ibidem

The results of these activities enabled the definitive identification of the regional monitoring network for the purposes of the assessment of the environmental quality of surface waters in the region of Umbria under Italian Legislative Decree 152/06 and amendments and additions.

For the water courses category, the monitoring network proposed comprises 44 surveillance monitoring stations relative to water bodies defined as “probably at risk” and 24 operational monitoring stations for water bodies “at risk”. The network comprises 24 stations active for the environmental quality monitoring of water bodies defined as significant under Italian legislative decree 152/99 and amendments and additions; the remaining newly activated stations are distributed both among other main water bodies not monitored so far as well as among minor and temporary water bodies.

The proposed network for lakes comprises 7 surveillance monitoring stations and 8 operational monitoring stations. Each station represents the environmental quality of a water body with the exception of Lake Trasimeno whose size and morphological characteristics are such that two monitoring stations will be activated, also with the aim of checking the homogeneity of the water body. Only 3 stations in the network are newly activated; the others are all stations activated for monitoring in compliance with Italian Legislative Decree 152/06 and amendments and additions.

Trials involving the new monitoring network began in 2008 and are due to conclude in 2009. In 2008 a sampling activity was begun in the monitoring stations concerning water bodies belonging to the main watercourses (for a total of 28 stations) for the watercourse category while trials were extended to the minor water bodies in 2009.

As far as lakes are concerned, trials concerned 8 stations representing 7 lakes; the trials are due to conclude in 2009.

During the current phase, ARPA Umbria is involved in the process

of identification of river reference sites. The first step of the activity, carried out in accordance with technical guidelines contained in Italian Ministerial Decree DM 56/2009, involved the selection of potential reference sites, carried out using the spatial method, that is, on the basis of the assessment and quantification of the existing anthropogenic pressures and collection of information on a wide scale (cartographic information and experimental data). In the coming months, the selected sites will undergo checks, in the form of on-site biological validation designed to confirm their suitability as reference sites. The results of the application of the spatial method have already proved inadequate given that it was only possible to identify potential reference sites for some of the river types present in the region.

As a result, in order to complete this phase of the process it will be necessary to adopt other methods put forward by Ministerial Decree 56/2009 (theoretical method, temporal method, combined approach, etc.). The absence of time-series data or paleo-reconstructions for Umbrian rivers excludes the possibility of using temporal methods; therefore the only possibilities are use of statistical or forecast methods or, alternatively, a search for reference sites representative of Umbrian water bodies in other Italian regions. This last possibility may only be examined once the process of adjustment to Italian Legislative Decree 152/2006 has been carried out throughout Italy.
The identification of reference sites for lakes within the region is even more complex. In fact, the initial analysis of pressure distribution and past monitoring data showed that none of the water bodies identified possessed the characteristics necessary to be defined a reference site.

After identifying the reference conditions for each type of water body, the next step involves identifying and designating Heavily Modified Water Bodies (HMWBs) and Artificial Water Bodies (AWBs). Only then will all the elements necessary for the complete definition of the monitoring network, including the reference site network, be available.

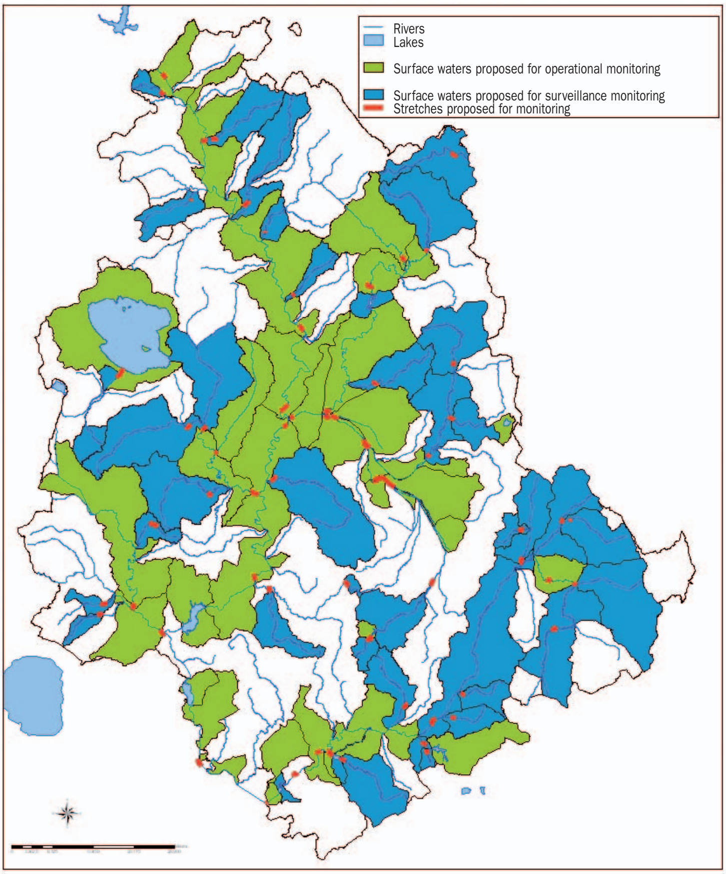

Figure 1: Surface waters to undergo monitoring and stretches proposed for operational and surveillance monitoring[6]

All the activities described are merely the first part of the process outlined by Italian Legislative Decree 152/2006. The assessment of the environmental quality of surface waters in compliance with the new laws will only be concluded once all the technical-legisla-

[6] Source: Ibidem

tive instruments are available at national level and once a wider scale comparison has been carried out with all actors involved by competent area:

- Integration of the monitoring network at district scale (Central Apennine District);
- Definition and fine-tuning, at national level, of the biological indicator assessment metrics, together with the intercalibration system launched at community level by intercalibration groups for ecoregions (GIG – Geographical Intercalibration Group).

In conclusion, although the absence of definitive methods for the assessment of biological elements and the continued uncertainties with regard to the definition of reference sites have made it impossible to assess the quality of regional water bodies, steps have been taken to launch various procedures and define criteria adapting monitoring plans for the classification of water bodies in compliance with the provisions of the laws implementing the directive in Italy.

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CASE STUDY

Characterisation of the Venice lagoon and identification of water bodies

This section presents a case study adopting the criteria for the characterisation and identification of water bodies, applying the procedures laid down by the Italian Ministerial Decree DM 131/2008 to the Venice lagoon. An initial example of zonation of the Venice lagoon under Directive 2000/60/CE was proposed in the document *"Guida alla tipizzazione dei corpi idrici di Transizione e alla definizione delle condizioni di riferimento ai Sensi della direttiva 2000/60/CE - EI-Pr-TW-Tipizzazione_Condizioni di Riferimento-01.01" – Guide to to the characterisation of transitional waters and to the definition of reference conditions in compliance with directive 2000/60/EC – EI-Pr-TW-Characterisation_Reference Conditions-01-01* (ICRAM, 2007). The proposal was subsequently implemented, with various amendments agreed upon with ICRAM, by ARPA Veneto and published in *"Proposta di prima tipizzazione delle acque marine coastal e di transizione della Regione del Veneto, ai sensi del Decreto del Ministero dell'Ambiente e della Tutela del Territorio e del Mare n. 131 del 16 giugno 2008 recante modifiche al Decreto Legislativo 3 aprile 2006, n. 152 (allegati 1 e 3 della parte terza), di attuazione della Direttiva 2000/60/CE" (Proposal for a preliminary characterisation of the marine coastal and transitional waters of the Veneto Region under the Decree of the Ministry of the Environment no. 131 of 16 June 2008 amending the Italian Legislative Decree of 3 April 2006, no. 152 (Annexes 1 and 3 of the third part), implementing Directive 2000/60/EC)* . Finally, to date, the official document containing the characterisation and identification of the water bodies of the Venice lagoon is the "Piano di Gestione dei bacini delle Alpi Orientali - sub-unità idrografica bacino scolante, laguna di Venezia e mare antistante" ("Management Plan for the basins of the Eastern Alps – hydrographic sub-unit drainage basin, Venice lagoon and adjoining sea") published in July 2008.

Limits of the hydrographic basin and of the transitional waters

The area comprising the Venice lagoon, its drainage basin and adjoining sea is identified as the "Hydrographic sub-unit of the Venice lagoon, its drainage basin and adjoining sea" belonging to the Eastern Alpine District.

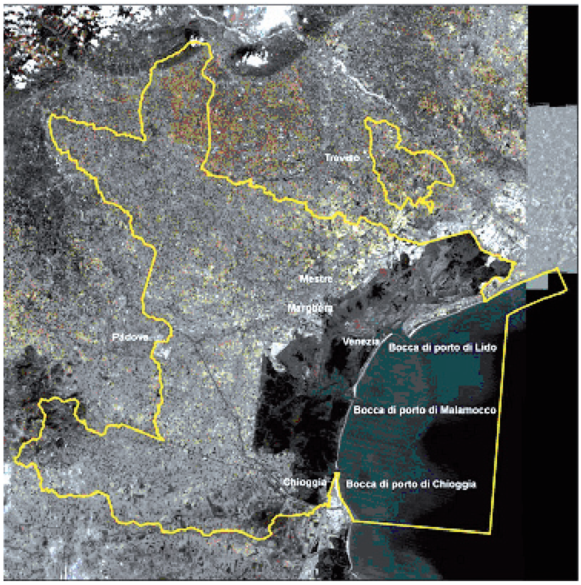

Figure 1: Hydrographic sub-unit of the Venice lagoon, its drainage basin and adjoining sea[1]

The first step in the zonation of water bodies involves identifying the limits of the category to which the environment concerned belongs. For transitional waters these limits are the river category, upstream, and the coastal water category, downstream.
Under the definition of "transitional waters" contained in the Italian Ministerial Decree 131/2008, the limits of the Venice lagoon can be identified:
upstream, as the permanently exposed lagoon boundaries;
downstream, as the barrier islands (Cavallino, Lido, Pellestrina and Sottomarina) and by the outer edge of the breakwaters at the three inlets (Lido, Malamocco and Chioggia).

[1]Source: PG_laguna_venezia_rev01, www.alpiorientali.it

Once the limits of the transitional waters have been defined, we need to identify heavily modified water bodies, which form a separate category and are therefore initially excluded from the characterisation procedure (they will be subsequently included in the category that most closely resembles their characteristics). The water bodies in the Venice lagoon provisionally allocated to this category are the industrial canals of Porto Marghera, the canals in the historic centre of Venice and the fish farms.

Characterisation of the lagoon

The Venice lagoon is a large microtidal coastal lagoon (surface area of approximately 550 km^2 and tidal excursion of over 50 cm throughout). Given the vast area covered and the heterogenous nature of the environment it is impossible to consider the whole lagoon in terms of a single type given that its ecological status cannot be referred to a single reference condition.

On the basis of the three-yearly mean annual salinity data contained in past studies (Progetto MELa3 – Magistrato alle Acque di Venezia – Consorzio Venezia Nuova) two different types were identified: polyhaline, with reference to the lagoon boundary areas which are permeated by freshwater; and euhaline, in the areas subjected to exchanges with the sea.

Adopting this procedure, in compliance with the national system, the Venice lagoon can be divided into 2 types:

- coastal lagoon, microtidal, large, polyhaline;
- coastal lagoon, microtidal, large, euhaline;

However, adopting this division, the internal homogeneity within each type does not permit the identification of type-specific conditions representing the biological quality of the various environments. The two types contain zones characterised by extremely different depths, residence times and intertidal structures. The hydromorphological analysis of the lagoon reveals a clear distinction between areas that are more or less sheltered by saltmarshes in both the northern and central-southern lagoon areas. It should also be pointed out that the southern lagoon is crossed by the Romea state road which creates a physical barrier reducing the speed of the exchange of water between the Val di Brenta and the rest of the lagoon.

Considering the degree of exposure/shelter as a sub-characterisation criteria, the Venice lagoon can be divided into 4 types of surface water body (Figure 2):

- coastal lagoon, microtidal, large, polyhaline – sheltered (mt.g.pol.c);
- coastal lagoon, microtidal, large, euhaline –sheltered (mt.g.eu.c);
- coastal lagoon, microtidal, large, polyhaline – exposed (mt.g.pol.nc);
- coastal lagoon, microtidal, large, euhaline – exposed (mt.g.eu.nc);

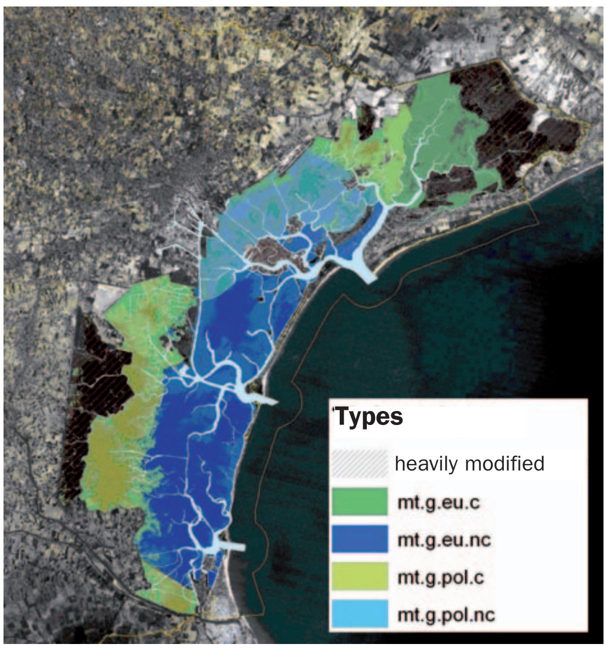

Figure 2: Characterisation of the Venice lagoon[2]

[2] Source: Ibidem

Identification of the water bodies

The final phase of zonation of the Venice lagoon involves identifying the water bodies, the physical reference unit for the classification of the environmental status and for the planning of monitoring activities.
Subdividing the area into water bodies makes it possible to obtain geographical units that are as uniform as possible in terms of pressure and status for the purpose of attaining a representative classification without excessive fragmentation.

The Venice lagoon is currently divided into 12 water bodies (Figure 3), 8 of which natural and 4 heavily modified, as shown in the "Management Plan for the basins of the Eastern Alps – hydrographic sub-unit drainage basin, Venice lagoon and adjoining sea".

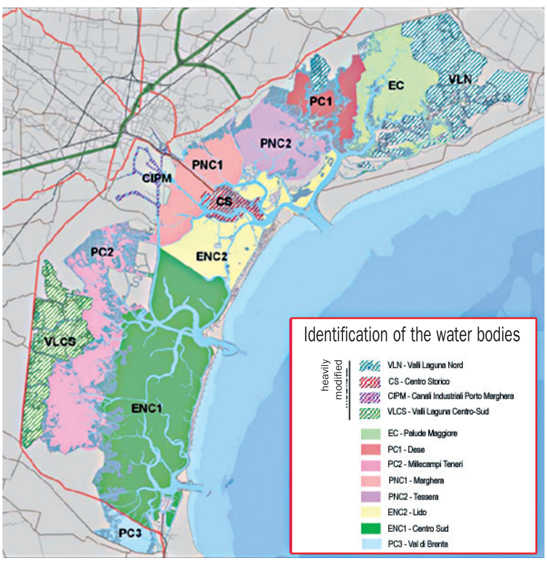

Figure 3: Identification of the water bodies of the Venice lagoon[3]

[3] Source: Ibidem