Ann Ist Super Sanità 2002;38(2):149-153

Needs of ecotoxicological methods in Italian and European Union legislations in the field of water policy

Claudio FABIANI and Gianna CASAZZA

Dipartimento Stato dell'Ambiente, Controlli e Sistemi Informativi, Settore Monitoraggio e Controllo Integrati, Agenzia Nazionale per la Protezione Ambientale, Rome, Italy

Summary. - Recent water policy at national and international level have been addressed toward environmental objectives aimed to protect water resources and develop their sustainable management. Water framework Directives, considering all surface waters and their specific ecosystems and interrelationships among the different components, were just approved in Italy in 1999 and in the European Union in 2000. A brief analysis on the chemical, physical and biological monitoring and ecotoxicological methods required is shown in this paper. The need of developing a series of adequate biological and ecotoxicological tests is underlined.

Key words: water policy, biological monitoring, water quality.

Riassunto *(Metodi ecotossicologici nelle legislazioni europea ed italiana di politica delle acque)*. - Le recenti politiche sulle acque, sia a livello nazionale che internazionale, sono state indirizzate verso obiettivi ambientali miranti a proteggere le risorse idriche e a sviluppare la loro gestione sostenibile. La direttiva quadro sulle acque, tenendo conto di tutte le acque superficiali e dei loro specifici ecosistemi e correlazioni fra le diverse componenti, è stata approvata in Italia nel 1999 e nell'Unione Europea nel 2000. In questo lavoro è riportata una breve analisi sul monitoraggio biologico, chimico, fisico e sui metodi ecotossicologici richiesti. Viene evidenziata la necessità di sviluppare una serie di test biologici ed ecotossicologici adeguati agli obiettivi.

Parole chiave: politica sulle acque, monitoraggio biologico, qualità delle acque.

Introduction

The general opinion that the results obtained in the European Union (EU) countries by the last ten-twenty years environmental policy for water resources protection and their sustainable management are unsatisfactory, has promoted a reexamination of the conceptual basis and objectives of European community action plans concerned with water policy both at community and national levels.

The main conclusions of this analysis can be summarized in two statements:

- scarse knowledge of the environmental phenomena and hence not efficient planning of actions to undertake to improve water quality and uses at national level, not effective monitoring and control (single pollution parameter control, lack of integrated effect measurements);

- negative cost benefit results due to exceedingly large investments in financial and human resources focused on point sources pollution control with poor attention paid to effective impact on recipient water bodies [1].

At Italian national level, where great efforts has been made to improve water treatment works, polluted site remediation and network monitoring, still a lot of critical issues in water resources remains and needs careful attention:

- scarce water availability and critical quality status;

- unwise use of water resources (70% of fresh water total abstraction for crops irrigation, large exploitation of groundwaters, poor recycling, large losses in water catchment and distribution works);

- not efficient control of point and diffuse pollution sources (lack of emission inventories and poor information level on quantity and quality of emissions);

- absence or poor level of integrated monitoring and control procedures.

Two combined legal and structural responses have been recently developed to support a new water policy:

- a new national framework law [2, 3] enforced on May, 11, 1999, which integrates and repeals the different laws in act (about 20 laws and regulations) for water policy. A very similar one (same conceptual basis and principles) was approved by the EU (Water Framework Directive) in October 2000 [4];

- development of an integrated Environmental Protection Agency (EPA) network [5] (the national

Indirizzo per la corrispondenza (Address for correspondence): Gianna Casazza, Dipartimento Stato dell'Ambiente, Controlli e Sistemi Informativi, Agenzia Nazionale per la Protezione Ambientale (ANPA), via Vitaliano Brancati, 48 - 00144 Roma. E-mail: casazza@anpa.it.

ANPA and 20 regional EPA) and implementation of a national environmental information system (ruled by ANPA and part of the National Statistic System).

Quality objectives in the planning of water resources protection and management

The overall purpose of the quoted new Italian law (and the EU Directive) is to establish a general discipline for surface fresh water, transitional waters (estuaries, brackish coastal lagoons), coastal waters and groundwaters with the aim at:

- preventing further deterioration, protect and enhance the status of aquatic ecosystems and connected terrestrial ecosystems;

- promoting sustainable water use based on a long-term protection of available water resources.

All significant water bodies mentioned above are defined according to specific dimensions of catchment basin or other quantitative parameters. They are considered as ecosystems directly connected to a territorial district which is recognized to be the basin district as the most significant territorial unit.

Water bodies are ecosystem and monitoring and control must be performed on water, sediments and biota.

For each different type of water body environmental quality classes are defined and the quality objective of a good environmental status is fixed to be reached by the year 2016, for all significant water bodies.

The good environmental status (in the EU directive "good ecological status") is defined as that condition in which the water body, although influenced by human activity, nevertheless maintains its capability of recovering the natural conditions needed to support rich and balanced animal and vegetal communities.

Normative definitions for the ecological status classification (Table 1) are described, and the quality elements (biological, hydromorphological and chemical) to be considered for assessment of the quality status are fixed (Table 2) according to the different water types.

The monitoring and control networks and their operative procedures are thus intended as tools to verify and design the basin district action plan, to reach the quality objectives.

Table 1. - Normative definitions for high, good and fair ecological status in general

EU water framework directive	Italy (law 152/99) [3]
High quality	**High quality**
No evidence, or very minor evidence, of anthropogenic impacts on biological communities, physicochemical and physical environment	No evidence, or very minor evidence, of anthropogenic impacts on biological communities, physicochemical and physical environment
The composition and abundance of the biota reflect that normally associated with the ecotype under undisturbed conditions	The composition and abundance of the biota reflect that normally associated with the ecotype under undisturbed conditions
	The micropollutant (synthetic and not synthetic) concentration reflects the background level concentration in undisturbed water bodies
Good quality	**Good quality**
Detectable but low level impacts on biological communities, physicochemical and physical environment	Detectable but low level impacts on biological communities, physicochemical and physical environment
The biota shows sign of disturbance but deviates in terms of survival, reproduction and development only slightly from that normally associated with the ecotype under undisturbed conditions	The micropollutant (synthetic and not synthetic) concentrationsare at levels with no short or long term effects on biological communities
Fair quality	**Sufficient quality**
Significant impacts on biological communities and their physico-chemical and physical environment	The biota deviates moderately from that normally associate with the ecotype under undisturbed conditions
The biota deviates moderately from that normally associated with the ecotype under undisturbed conditions	The micropollutant (synthetic and not synthetic) concentrations are at levels with no short or long term effects on biological communities

Table 2. - Elements to be considered for the assessment of the quality status

EU water framework directive	Italy (law 152/99) [3]
Rivers	
Hydromorphological elements Hydrological regime River continuity Morphological conditions	**Hydromorphological elements** Hydrological regime River continuity
Biological elements Phytoplankton Macrophytes and phytobenthos Benthic invertebrate fauna Fish fauna	**Biological elements** **Compulsory**: Benthic invertebrate fauna: EBI (Extended Biotic Index) **Additional**: Toxicity test
Chemical elements General conditions (physico-chemical parameters) Specific synthetic pollutants Specific non synthetic pollutants Concentrations not in excess of the standard set or not in excess of the NOEC for algae, *Daphnia* and fish in the case of good state	**Chemical elements** **Compulsory**: Physico-chemical parameters **Additional:** Presence of micropollutants (Table 3) Limit values for these parameters and definition of others shall be established on the base of LC50 and EC50 results from toxicological tests on the three throphic levels Toxicity test in sediments Suggested specie: *Oncorhincus mykiss, Daphnia magna, Ceriodaphnia dubia, Chironomus tentans* and *C. riparius, Selenastrum capricornutum* and bioluminescent bacteria
Coastal waters	
Hydromorphological elements Tidal regime Morphological conditions	**Hydromorphological elements** Different typology of depth
Biological elements Phytoplankton Macroalgae and angiosperms Benthic invertebrate fauna	**Biological elements** No biological indicator A water quality index “TRIX” (trophic index) The index is based on a few parameters, most commonly measured in monitoring activities of marine waters (chlorophyll, oxygen, nitrogen and phosphorous) Biocoenotic map of coastal area (1:25.000)
Chemical elements General conditions (physico-chemical parameters) Specific synthetic pollutants Specific non synthetic pollutants Concentrations not in excess of the standard set or not in excess of the NOEC for algae and/or macrophytes representative organisms for saline waters and fish in the case of good state	**Chemical elements** No water analysis for micropollutants detection **Compulsory**: Physico-chemical parameters **Additional**: **Biota** - bioaccumulation in mollusks bivalve (Mytilidae or Ostreoidea families) of: • heavy metals • polycyclic aromatic hydrocarbons (PAH) • organohalogen compounds (PCB and pesticides) **Sediment** - parameters to be detected: • heavy metals • polycyclic aromatic hydrocarbons (PAH) • organohalogen compounds (PCB and pesticides) • organic carbon • organotin compounds (TBT) Where necessary toxicological tests (short and long term) will be accomplished

NOEC: no observed effect concentration.

Chemical, physical, biological monitoring and ecotoxicological methods

The reported conceptual framework stresses the picture of the water body as an integrated and complex ecosystems to be monitored in each of its components: chemical and physical status of water and sediments, impact on biota, presence and accumulation of micropollutants.

For each of the different types of water bodies, a specific monitoring and classification procedure is defined to classify the water body according to a scoring method.

Indexes of chemical quality (based on a reduced number of parameters), biological quality (in the case of rivers, for the Italian law, the EBI index [6], based on the macro invertebrates community is compulsory), ecological quality (combined chemical and biological index) and of environmental quality (ecological index and presence/absence in water, sediment and biota of dangerous micropollutants) are established to assign the defined quality to the examined water body.

As shown in Table 2 the European Water Framework Directive stresses the biomonitoring approach and essentially limits the need of toxicological tests to assess the environmental quality standard of micropollutants and dangerous substances [7].

These substances are defined into a specific annex (Annex VIII) as families of substances: organohalogen compounds, organophosphorus compounds, organotin compounds, substances proven to have carcinogenic or mutagenic or effects on reproduction in or via aquatic environment, persistent hydrocarbon or bioaccumulable organic toxic substances, cyanides, metals and their compounds, arsenic and their compounds, biocides and plant protection products, material in suspension, subtances which contribute to eutrophication/nitrates and phosphates), substances with negative influence in the oxygen balance.

For these substances, when necessary, member states will define environmental quality standard (eqs) which should not be exceeded in the case of a good quality status.

Where possible, both acute and chronic data for a base set of taxa should be used:

- algae and/or macrophytes;
- *Daphnia* or representative organisms for saline waters;
- fish.

These data are used to establish a maximum annual average concentration (MAC) according to the procedure showed in Table 3.

The procedure must also include, where available, data on persistence and bioaccumulation; standards so obtained should be compared with any evidence from field studies and shall be subject to peer review and public consultation within member states.

Table 3. - Procedure for setting the environmental quality standards

Data available	Safety factor
At least one acute L(E)C50 from each of three trophic levels of the base set	1000
One chronic NOEC (either fish or *Daphnia* or a representative organism for saline waters)	100
Two chronic NOEC from species representing two trophic levels (fish and/or *Daphnia* or a representative organism for saline waters and/or algae)	50
Chronic NOEC from at least three species (normally fish, *Daphnia* or a representative organism for saline waters and algae) representing three trophic levels	10
Other cases (field data or model ecosystems)	Case by case assessment

NOEC: no observed effect concentration.

In the Italian law the approach to fix eqs for micropollutant is not defined as a standard procedure.

For the assessment of the chemical status the presence of micropollutants in water, sediments and biota has to be established by regional authorities, where necessary.

A suggested list of main micropollutants to be checked in fresh waters is reported in Table 4: metals should be detected as dissolved species while organics must be detected in the whole sample (no filtration).

Limit values for these parameters and definition of others (not included in the table) shall be established on the base of LC50 and EC50 results from toxicological tests on the three throphic levels (according to EU suggestions).

Moreover for micropollutants possessing a higher affinity for sediments than waters, and for the great micropollutant dilution in water bodies like the sea, methods for the pollutants detection, for the assessment of the sediment quality and the evaluation of toxic effects on the biotic components of the ecosystems has to be established by ANPA.

Chemical analysis and toxicity tests

Surface fresh waters

In the case of fresh waters a suggested list of main micropollutants to be checked is reported in Table 4.

In the case of biota suggested toxicity tests are:

- *Daphnia magna*;
- teratogenic and mutagenic essay on concentrated samples;

Table 4. - Main micropollutants to be checked in surface fresh waters

Inorganic (dissolved)	Organic (whole sample)
Cadmium	Aldrin
Chromium	Dieldrin
Mercury	Endrin
Nickel	Isodrin
Lead	DDT
Copper	Hexachlorobenzene
Zinc	Hexachlorobutadiene
	1,2 dichlorohetane
	Trichloroethylene
	Trichlorobenzene
	Chloroform
	Tetrachlobenzene
	Chloroform
	Tetrachloride of carbon
	Perchloroethylene

- algae;
- bioluminescent bacteria;
- in the case of a possible presence of PCB, DDT and Cd bioaccumulation essay on fish muscle tissues or macrobenthos species.

In the case of sediments suggested tests refer to sediment extracts, sediment as a whole and intersticial water.

Suggested aquatic species for acute and (sub)chronic essay are: *Oncorhincus mykiss, Daphnia magna, Ceriodaphnia dubia, Chironomus tentans* and *C. riparius, Selenastrum capricornutum* and bioluminescent bacteria.

Marine coastal waters

In the case of marine waters (Table 2), as already mentioned, no water analysis for micropollutants detection are defined.

In the case of biota principal analysis are established for the bioaccumulation of:

- heavy metals;
- polycyclic aromatic hydrocarbons (PAH);
- organohalogen compounds (PCB and pesticides);
- in mollusks bivalve of the *Mytilidae* or *Ostreoidea* families.

In addition, biological *ad hoc* tests (both short and long term) on selected species, possibly autochthonous, using standard methods, are encouraged.

In the case of sediments the parameters to be detected are:

- heavy metals;
- polycyclic aromatic hydrocarbons (PAH);
- organohalogen compounds (PCB and pesticides);
- organic carbon;
- organotin compounds (TBT).

Where necessary (established by the regional competent authority) toxicological tests (short and long term) will be accomplished.

Thus, the Italian legislation suggests the development of specific toxicological tests and methodologies, for the different types of water bodies, encouraging the use of autochthonous species.

Moreover established ecotoxicological tests (acute tests) are already compulsory in the case of discharges (urban and industrial, water treatment plans and waste management) in surface waters.

Conclusions

All the different and complex procedure discussed, in the Italian water framework directive, indicate the need of developing a series of biological and ecotoxicological tests.

Not all the already required tests are in use by the public territorial organization (the regional agencies) which have the monitoring and control mission.

This is the present real challenge for the Italian scientific and technical organization, to succeed in the enforcement and implementation of the new law.

A similar and even more difficult task should be faced by European countries when applying the new Water Framework Directive, just approved. In fact in the EU WFD the need for biological monitoring and ecotoxicological methods is even more extended.

Submitted on invitation.
Accepted on 13 February 2002.

REFERENCES

1. European Environment Agency. *Europe's environment: the second assessment*. Copenhagen: EEA; 1998.

2. Italia. Decreto Legislativo 11 maggio 1999, n. 152. Disposizioni sulla tutela delle acque dall'inquinamento e recepimento della direttiva 91/271/CEE concernente il trattamento delle acque reflue urbane e della direttiva 91/676/CEE relativa alla protezione delle acque dall'inquinamento provocato dai nitrati provenienti da fonti agricole. *Suppl GU* n. 124, 29 maggio 1999.

3. Italia. Decreto Legislativo 18 agosto 2000, n. 258. Disposizioni correttive e integrative del DL.vo 11 maggio 1999, n.152, "Disposizioni sulla tutela delle acque dall'inquinamento e recepimento della direttiva 91/271/CEE concernente il trattamento delle acque reflue urbane e della direttiva 91/676/CEE relativa alla protezione delle acque dall'inquinamento provocato dai nitrati provenienti da fonti agricole". *Suppl GU* n. 218, 18 settembre 2000.

4. European Parliament and Council of the European Union. EU Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000, establishing a framework for Community action in the field of water policy. *Official Journal of the European Community* 22 December 2000, L 327(1-72).

5. Italia. Legge 21 gennaio 1994, n. 61. Disposizioni urgenti sulla riorganizzazione dei controlli ambientali e istituzione dell'Agenzia nazionale per la protezione dell'ambiente. *GU Serie generale* n. 21, 27 gennaio 1994.

6. *Indice Biotico Esteso (IBE). Manuale di applicazione*. Ghetti PF (Ed.). Provincia Autonoma di Trento; 1997.

7. *Study on the prioritisation of substances dangerous to the acquatic environment*. Luxemburg: Office for Official Publications of the European Communities; 1999.