

# **Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management**

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## **Chapter 7. IMPLEMENTATION OF MANAGEMENT PLANS**

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Control of hazards to human health from cyanobacteria is part of a wider picture of water quality and quantity management, environmental protection, policy formulation and general development concerns. Implementation of programmes to address cyanobacteria-related health hazards therefore takes place within the larger framework of other local, national, and international plans and activities relating to water. That framework is the subject of this chapter, which examines the principal elements required to respond effectively to cyanobacteria-related health risks. First the organisations, agencies and groups that may become involved where there is a cyanobacterial bloom are identified, then the tools governments can use to implement policy are examined, together with legislation as an implementation tool. The remainder of the chapter outlines how professionals and the public may be educated, informed and mobilised.

### **7.1 Organisations, agencies and groups**

#### **7.1.1 Vested interests**

Every water body has associated with it a set of persons and organisations with a vested interest and an involvement. Vested interests can be associated with the level of water (flooding, hydroelectricity, transportation, recreation); with the contents of the water (fishing, recreation); with the quality of the water (drinking water/domestic use, recreation); with the quantity of water (irrigation, industry, transportation); with its motility (wastewater, transport); with the preservation of the water body itself (ecosystem maintenance, wildlife conservation); or with some combination of these.

Few rivers, lakes, estuaries and seas can support all vested interests equally and so compromises amongst conflicting activities are inevitable. Diverting too much water for irrigation lowers water levels for transportation and may increase the salinity and mineral content of the water, reducing the numbers of fish and causing stagnation. It may also increase the likelihood of algal and cyanobacterial bloom formation in river reaches downstream of irrigation reaches, because many cyanobacteria species prefer slow-flowing river conditions for bloom development. Allowing unrestricted transportation of dangerous cargoes may damage the ecosystem and wildlife of the surrounding area.

Limiting the construction of dams to preserve a riverine environment may mean insufficient energy production and water inputs for industry, domestic needs and mining. Activities particularly likely to increase cyanobacterial hazards in water resources include:

- Land-use, land-use changes and abstraction practices, which may have an impact through diffuse and point sources of nutrients (such as agriculture) and through changing run-off regimes (e.g. caused by urbanisation and forest cutting).
- Pollutant discharges and especially nutrient-rich municipal wastewaters and sewage discharges, which are likely to increase eutrophication.
- Flow control and river flow reduction through, for example, damming, which may increase opportunities for cyanobacterial proliferation by increasing hydraulic retention times and the propensity for water column stratification.
- Abstraction, whether constant (such as for drinking water supply), seasonal (such as for irrigation) or intermediate (such as for power generation), which may tend to decrease flow rates and also increase opportunities for cyanobacterial proliferation by increasing retention times.

As with any other activity in relation to water resources, taking action in response to a cyanobacteria risk requires the recognition and balancing of vested interests. For example, increasing stream flows to decrease hydraulic residence time will have beneficial effects on drinking water and animal health, but may have detrimental effects on recreational use and agricultural (irrigation) interests.

Responding to an environmentally-related health issue, such as a toxic cyanobacterial blooms, implicates and involves many with vested interests who can be defined broadly as representing the public, the media, the government (or its agents) and the private or corporate sector. The largest and most vociferous vested interest group will often be the general public, who may demand that the quality of their drinking or recreational water be returned to a level that they deem acceptable, as soon as possible. Sometimes the water quality standard that the public expects may seem unrealistic (e.g. "*The water used to be crystal clear when I was a child, so why isn't it now?*"). Farmers may also represent a vociferous lobby who may insist that the water necessary for farms and livestock be again made safe so that productive activity may resume. However, they may also be a strong lobby against reduction of diffuse pollution input by arguing that changes in agricultural practices, e.g. fertiliser application, would inevitably reduce crop yields. Water suppliers often have a strong vested interest in a better resource quality because that increases the safety of their product and reduces treatment costs, but agencies may tend to avoid publicity on this issue in order to avoid a negative image and adverse public comment. Thus, the greatest driving force for action will nearly always come from the user sector.

The media can play a key role in acting as vehicles for public awareness, thereby triggering public outcry. They can also be vital for advising the public of potential health risks (or their absence), for informing the public whether appropriate actions have been taken and of the efficacy of these actions.

Notwithstanding governments' primary public safety role, where they exist, private companies involved in water supply and wastewater treatment processes will also have a key role in any response. Collaboration with such companies will be necessary whether planning is of an emergency or long-term strategic nature. However, private companies may view the monitoring data they generate as proprietary or commercial and their active participation needs to be encouraged, whereas governments may view information they hold as being in the public domain.

Other important sectors with a vested interest in many countries are tourism and recreation. Hotels, holiday resorts, water skiing and fishing-based tourism operations, for example, can be affected profoundly by adverse publicity and recreational restrictions brought about by toxic cyanobacterial blooms. Involvement of these sectors will be extremely important if local acceptance of management plans (short- and long-term) is to be obtained. The fact that private companies operate on a profit motive does not necessarily place them at odds with governments' public safety goals, because safe water is also a prerequisite for most, if not all, kinds of tourism and recreation activities, and is seen increasingly as a priority amongst tourists and other recreational water users.

Where a cyanobacterial bloom occurs, private companies, governments, the media, the public and others with a vested interest will express and seek support for their particular interests, some of which may conflict with one another. As a result, multi-sectoral co-operation is essential.

### **7.1.2 Multi-sectoral involvement, agencies and their roles**

Governments have ultimate responsibility for safeguarding public health and their role will be to minimise the damage and to assess the circumstances that led to the cyanobacterial problem (s) in the first place. They can also assist with public awareness activities, as outlined in section 7.4. Although governments usually take the leading role in co-ordinating policy amongst vested interests, they may later turn over leadership to a multi-sectoral committee or group to continue developing longer-term plans or strategies (see Box 7.1).

Human health issues affect many different aspects of environmental policy and management and therefore programme co-ordination is both desirable and necessary for effective action in environment and health. Yet in many countries, environmental health programmes are assigned to different specialised agencies, making co-ordination difficult to achieve. Chapter 18 of Agenda 21, the plan of action arising from the United Nations Conference on Environment and Development outlines the problem as follows: *"The fragmentation of responsibilities for water resources development among sectoral agencies is proving, however, to be an even greater impediment [to effective action]... than has been anticipated. Effective implementation and co-ordination mechanisms are required"* (Anon, 1992).

### **Box 7.1 Development of the New South Wales Blue-Green Algal Task Force and New South Wales Algal Coordinating Committee**

In 1991, an extensive toxic cyanobacterial bloom along the Barwon/Darling River system in Australia triggered the implementation of policy for reactive and planned management. The Barwon arises in the Great Dividing Range of Eastern Australia and flows southwest for 2,735 km until it joins the Murray River. The Barwon/Darling River runs through an arid and seasonally very hot environment where temperatures of 40-45 °C occur during the summer; flow is regulated for irrigation and the supply of drinking water.

Flow in the Barwon/Darling River is controlled by the release of water from large reservoirs in the mountain catchment area, by numerous weirs along the length of the river, and by an extensive off-river storage towards the downstream end of the system. The release is determined largely by irrigation requirements. The river is subject to floods at irregular intervals, usually through subtropical storms. Rainfall in the catchment was low during 1991, leading to a high demand for water for irrigation and very low river flows. In late spring (October/November 1991), a massive bloom of *Anabaena circinalis* occurred in over 1,000 km of the river. As an example, 245,000 cells per ml were recorded in the weir pool from which drinking water is supplied to the town of Bourke, New South Wales (NSW). The drinking water in this town was, at the time, chlorinated river water with no additional treatment. Such supplies are common world-wide. Widespread scums occurred along the riverbanks where livestock drank.

The bloom came to public attention when the local newspaper printed a picture of several dead cows in a weir pool, with comments on the water quality. Water samples were collected and sent to the laboratory for toxicity testing. Intraperitoneal injection of lysed extracts of the *Anabaena* cells showed considerable neurotoxicity, with evidence of some neurotoxicity in drinking water samples. The toxins concerned have subsequently been identified as saxitoxin-type neurotoxins.

The NSW State Government declared a State of Emergency, which enabled rapid action including the deployment by the Army of portable water treatment plants capable of using highly contaminated water to produce a safe supply. These units provided dissolved air flotation with flocculation for cyanobacterial cell removal, followed by filtration and granular activated carbon adsorption of any toxic organic materials. The water supplied to the affected towns from these plants had no detectable toxin content. A major public information campaign was rapidly put in place with local meetings, radio and press coverage. Health officers recommended that swimming and water sports were discontinued, with variable success. Farms drawing their own water supply directly from the river were particularly at risk. Livestock deaths along the river were difficult to quantify, but about 2,000 sheep and cattle deaths were reported. The State of Emergency ended when heavy rain in the catchment flushed the river and increased turbidity greatly. No further blooms occurred in the river that summer.

As a consequence of the Barwon/Darling River bloom the State Government established the NSW Blue-Green Algal Task Force (BGATF). The task force was chaired by the State Water Resources Department and made up of representatives from key state government departments (environment protection authority, departments of agriculture, conservation and land management, health and public works, state emergency services board and state "total catchment management committee" (itself a co-ordinated multi-sector public group)), local water boards and corporations, research scientists and the Murray Darling Basin Commission, a multi-state water management agency. Later, when the state of Emergency passed, the BGATF became the NSW State Algal Coordinating Committee (SACC). Members were added to the committee from the adjoining states of Queensland, Victoria and South Australia (these states had, in the interim, set up their own algal task forces). Their membership "helped speed

*information transfer, and reflected the principle that management measures must be implemented as part of an integrated resource management approach which cuts across established agency and geographical boundaries" (NSWBGATF, 1993).*

During the emergency phase of the bloom, the BGATF co-ordinated cyano-bacterial monitoring throughout the river, the provision of alternative water supplies, the drilling of new boreholes (for groundwater), the installation of water boom curtains to minimise cyanobacterial access to pump inlet valves, the installation of emergency water treatment systems that could remove (or were believed to remove) cyanobacterial toxins from contaminated drinking water supplies and, most importantly, the transfer of information on a regular basis to the media. After the emergency phase, the BGATF went on to develop the State's comprehensive integrated "Algal Management Strategy" which aimed to minimise the future occurrence and impact of algal (mostly cyanobacterial) blooms. The strategy included contingency planning, improving water system management, reducing nutrient levels in waterways, education and awareness raising (including media interactions) and research. Specific activities of SACC under the Algal Management Strategy were: development of a nutrient control strategy (which included establishment of nutrient management plans with actions such as plans for the upgrade of sewage treatment and disposal systems); reduction in the phosphorus content of washing powders and detergents; upgrades to septic tank systems in "high risk" catchments; reduction of soil erosion; fertiliser and stormwater control strategies; and a public and local government "Phosphorus Awareness and Reduction Campaign". The Committee also subsequently co-ordinated or implemented water allocation and water system management plans, some of which were governed by multi-state agreements (Box 7.3).

To improve the transfer of information to and from the State's many regions (some of which are over 1,000 km from its headquarters in Sydney), regional algal co-ordinating committees (RACCs) were also established. The RACCs were charged with the responsibility for developing local contingency and management plans (based largely on guidelines put forward by SACC), co-ordinating local media and public education, co-ordinating local monitoring and training in cyanobacterial and algal sampling and identification, and identifying when cyanobacterial alerts should be issued for regional waterways.

Table 7.1 outlines some of the functions necessary for cyanobacterial bloom management and indicates the different government departments or other organisations that may have responsibility for each function.

In addition to single-issue government or quasi-governmental agencies in a particular country, there may be national or regional co-ordinating groups which have as their mandate to bring together, or to attempt to bring together, the various sectors, user groups and agencies involved in water management. There may also be water users associations or co-operative societies with interests in water. Any one or several of these agencies and co-ordinating groups may be involved when a cyanobacteria problem arises.

The co-ordination necessary for effective action on environment and health issues is difficult to achieve, not only because it takes place amongst those with vested interests, agencies and groups representing (at times) divergent agendas, but also because the co-ordination itself is complex. That is, it does not simply consist of linking different institutions towards a common goal. It also requires combining inputs from different areas of expertise (inter-disciplinarity); facilitating collaboration between policy-orientated institutions and regulatory institutions; and fostering co-operation among sectors that

positively and negatively influence environmental health quality, including industry, agriculture, local government and transport. Experience in the UK and Australia has shown that an effective strategy to achieve this complex co-ordination is the formation of interdepartmental task forces, with representatives from all relevant government agencies and other key groups with a vested interest (Box 7.1). Such task forces have been crucial to the success of emergency and long-term management of toxic cyanobacterial blooms.

## 7.2 Policy tools

A number of tools may be deployed by governments in the pursuit of water management and health protection policy. Although sometimes discussed in isolation, these tools are generally inter-related, and policy implementation is most effective when a range of tools is employed (see Box 7.2).

The principal interventions and tools relevant to the control of cyanobacterial hazards include:

- *Consensus through conflict resolution.* Conflict resolution involves negotiation, through formal and informal processes, guided or unguided by an expert, which may be binding or non-binding, depending on the agreement of the parties before entering into the negotiation. Each party's interests are aired, then jointly evaluated, ranked and then balanced. Ideally, this process precludes, or at least places in abeyance, any subsequent conflict, because it is through consensus that a plan of action (balancing all relevant interests) is developed and agreed upon.
- *Guidelines and recommendations.* An enhanced role for experts informs the development of guidelines and recommendations. Such guidelines and recommendations suggest methods of complying with desired policies. They are generally not binding, but rather serve an educational and advisory purpose, in that those studying them learn what actions to take. To be effective (because adherence is voluntary), each guideline or recommendation should be explained and justified.
- *Non-binding agreements, including industry codes.* Non-binding agreements, such as industry codes, are similar to guidelines and recommendations, except that they may be more formal. Although not binding, such codes have a high success rate, especially where industry members are involved in their formulation. Such involvement is desirable because industry members know their capacities and, furthermore, once they have signed up to a code there is "peer pressure" by other members to adhere to it. In addition, there might have been reluctance to follow codes developed by third parties, such as environmental and advocacy groups. Such concerns are assuaged where the codes have been developed following wide consultation. As with consensus building through negotiation, non-binding agreements involve all parties in creating acceptable compromises, thus ensuring greater success.
- *Economic measures.* A set of measures, both supportive and penalising, can be implemented to encourage the reduction of water pollution. Generally, such economic incentives and disincentives are contained in legislation, although they may also appear in non-binding agreements such as industry codes. Supportive measures can be direct

subsidies for water protection technologies or practices (such as setting aside agricultural areas), or various forms of tax reductions (such as for introduction of treatment steps). Penalties involve fees for discharge, which can be calculated according to the load of individual hazardous substances, with each substance tagged with a sum per unit of loading.

- *National legislation.* Because of its formality and inflexibility, law may not necessarily be the best avenue for implementing policy. Nevertheless, it should be recalled that in situations where there are competing interests, legislation offers certain benefits. It provides stability in a complex and changing environment and those with vested interests know where to go to seek the rules that apply to them. In addition, at least at the national level, legislation provides a coercive effect (the force of the State) upon those that have neglected to take action despite having agreed to do so (this has been known to occur particularly where there are financial interests at stake).

**Table 7.1** Involvement of government agencies and other organisations in short-term (including emergency) and long-term management of cyanobacteria-related health hazards

Function	Agency
Water pollution control, water resources monitoring, enforcing water quality standards	Ministry of Environment, Ministry of Water Resources, Environmental Protection Agency
Protection of habitats and fisheries	Ministry of Environment, Environmental Protection Agency, Ministry of Wildlife, Ministry of Fisheries
Independent surveillance of drinking water supplies and recreational water quality, enforcement of corresponding standards	Ministry of Health, Ministry of Public Health, local government
Drinking water supply	Local government, private companies
Provision of recreational facilities, promotion of recreational water use	Ministry of Tourism, local and state government, private companies
Allocation of water rights	Government agencies, parastatals, water users' associations, courts adjudicating disputes
Water storage and river management, monitoring, water allocation policy	Ministry of Water Resources, Ministry of Environment, Ministry of Water, Ministry of Public Works, Environmental Protection Agency
Catchment (watershed) management, agricultural policy	Ministry of Natural Resources, Ministry of Agriculture
Upgrades to public infrastructure, e.g. drinking water and sewage treatment plants	Ministry of Public Works, private and semiprivate sector utilities and service organisations
Shipment of emergency water supplies	Local government, private companies
Public education, research into causes and control of toxic blooms	Ministry of Education, Ministry of Health, local government, universities and research institutions, recreational or other users' groups
Implementation of emergency response plans	Local defence organisations, local government, emergency preparedness agencies, Environmental Protection Agency, health ministries/departments

### **Box 7.2 A combination of tools successfully reduced pollutant loads in Germany**

To reduce hazardous substances and nutrients in wastewater, the federal government of the former Federal Republic of Germany ("West Germany") introduced pollution fees per unit loading in the 1970s. The combination of continuously rising fees with options of exemption from their payment if new investments were made in wastewater treatment, resulted in great improvements in treatment technology and water quality. At the time, many critics expected the fees to have little effect because the fine per unit of loading appeared to be substantially lower than the costs for improving treatment. However, the imposition of fees was only one of several tools used by the government and society to achieve the goal of reducing loads. At the same time a strong "green movement" produced public pressure against industrial pollution, industry developed new production procedures which either avoided producing wastewater or included treatment, an international treaty in 1987 targeted the reduction of pollution loads to the North Sea by 50 per cent, and new legislation was discussed and implemented (such as European Union and national legislation to introduce nutrient stripping in all treatment plants handling more than 10,000 population equivalents). In conjunction, these measures caused a very clear downward trend for many pollutants, largely because industrial effluents have become substantially "cleaner", and many sewage treatment facilities have introduced steps for nutrient removal. The major source of nutrient loading into surface waters now is agriculture, and measures to reduce this source of input require implementation.

All legislation must be underpinned with a firm policy background so as to ensure that it will be effective once enacted. As one expert explains:

*"Simply to promulgate laws and designate responsible officers will not suffice. It is first necessary to build an effective political base of opinion and power and then to design adequate systems, assign authority, provide resources and translate plans into action; finally the development of the systems must be monitored, so that they can be adapted as required. In most countries sectoral bureaucracies have to be brought under a considerable degree of control and given clear, consistent and persistent policy direction, if co-ordination schemes are not to flounder."* (Schaefer, 1981, pp 42-43)

In most countries, before new legislation is introduced by a sector ministry, policy approval must be sought and obtained from the Cabinet or Council of Ministers. This ensures that the process of formulation of legislation is not an academic exercise, undertaken with no thought for the realistic chances for enactment and implementation. The existence of laws which are either unachievable or unenforceable means that financial or human resources have been diverted from other, perhaps more important (e.g. health), priorities. Moreover, the existence of such legislation reflects negatively on the entire legal system.

- *International and interstate plans and agreements.* As noted in section 7.1.1, actions taken to further one interest may have effects on other vested interests. Where a body of water crosses international or state lines, such actions have international and, at times, diplomatic implications. Few rivers and lakes remain within national or state boundaries, adding a diplomatic or more complex legislative dimension to many water resources management issues. There is a clear trend towards development of international plans and agreements which organise water management around particular water bodies. Box 7.3 gives one example of an inter-state response to cyanobacterial bloom management in Australia.

### **Box 7.3 The Murray-Darling Basin Algal Management Strategy**

The Murray-Darling Basin (MDB) is the largest riverine catchment in Australia, crossing four states, Queensland, New South Wales, Victoria and South Australia, and the Australian Capital Territory. The MDB covers an area similar in size to Western Europe. The Murray-Darling River system is actually a network of more than a dozen major rivers that ultimately join with the Murray River and discharge to the sea at Lake Alexandrina in South Australia (the site of the world's first scientifically documented toxic cyanobacterial bloom in 1878, see Chapter 3). The catchment is the agricultural "bread basket" of Australia, with a heavy reliance on water abstraction from the major rivers and headwater storages for irrigation.

Australia is a Commonwealth of states and legislative responsibility for the control and management of water resources (indeed, all natural resources) is vested in the individual states. In 1990, it was recognised that the four states covering the MDB needed to co-ordinate their actions in controlling cyanobacterial blooms because actions, or lack of action, by one state could have a deleterious effect on downstream states. Thus the MDB Commission (a non-government, multi-state organisation that manages the water resources of the MDB) set up an Algal Management Working Group. The working group was made up of members from the four states, the commonwealth government and CSIRO (the national scientific research organisation). Its charter was to *"reduce the frequency and intensity of algal (actually cyanobacterial) blooms and other water quality problems associated with nutrient pollution in the MDB through a framework of coordinated planning and management actions"*. Later the cyanobacterial management strategy was also to focus on the impact of the altered river flow regime on the occurrence of cyanobacterial blooms, as well as on problems associated directly with nutrient inputs.

The first project commissioned by the working group was the production of a major report identifying and quantifying (by modelling estimates only) all sources of nitrogen and phosphorus inputs in the MDB. Soon after that report was released in 1992, the MDB Commission convened 14 Technical Advisory Groups (TAGs) to provide expert advice on issues ranging from nutrient input control to cyanobacterial physiology and toxicology to water treatment. The 14 TAG reports were released in one major report (MDBC, 1993). Following the release of the TAG Report, the working group released a draft algal management strategy that was circulated widely among government departments, community organisations and interested members of the public. Public meetings and workshops were held to discuss key issues. The importance of gaining broad community support and "ownership" of the draft report were seen to be crucial to the success of the project. Comments obtained during this consultation phase were summarised and incorporated in the final report (Murray Darling Basin Ministerial Council, 1994).

Unlike the state task forces that were set up during a "crisis" period (see Box 7.1), there was little focus on short-term or emergency management. Rather, the MDB algal management strategy focused on longer-term, strategic initiatives to reduce the frequency and severity of cyanobacterial blooms. Its key elements were nutrient reduction, river flow management, education and awareness, research and monitoring, and funding. The published strategy also contains algal management case studies (on nutrient and flow management), techniques for determining nutrient targets for individual catchments (including the use of catchment-nutrient export models), and modelling studies on the impact of river regulation on natural flows in the MDB.

In addition to plans and strategies, many water bodies are governed by bi- or multilateral agreements which embody the customary rules and policy priorities of all the countries with an interest in the river, lake or sea. Such agreements may address issues such as reducing pollution, exchanging information on the level and volume of water, carrying out flood management, early warning systems, monitoring changes in the path of watercourses, sharing costs and managing dispute resolution mechanisms (Nanni,

1996). Few of these are of direct relevance to the control of cyanobacterial hazards beyond policies relevant to the control of eutrophication in general. Nevertheless, some international agreements specifically include provisions for notification of downstream countries of pollution events in order to enable them to take corrective action (Box 7.4). Including bloom formation as an issue requiring notification of downstream countries might assist in control of cyanobacterial hazards.

**Box 7.4 The UN ECE Convention on the Protection and Use of Transboundary Waters and International Lakes**

The Convention was drawn up under the auspices of the United Nations Economic Commission for Europe (UN ECE) and adopted at Helsinki on 17 March 1992 (UN ECE, 1992). It entered into force on 6 October 1996. The convention is intended to strengthen local, national and regional measures to protect and use transboundary surface waters and groundwaters in an ecologically sound way. The parties will prevent, control and reduce the pollution of transboundary waters by hazardous substances, nutrients, bacteria and viruses. The precautionary principle and the polluter-pays principle have been recognised as guiding principles in the implementation of such measures, together with the requirement that water management should meet the needs of the present generation without compromising the ability of future generations to meet their own needs. This will protect and conserve not only water resources but also soil, flora, fauna, air, climate, landscape and cultural heritage.

In order to comply with the Convention, emission limits for discharges from point sources shall be based on the best available technology. The Parties will also issue authorisations for wastewater discharges and monitor compliance therewith, adopt water quality objectives, apply at least biological or equivalent processes to treat municipal wastewater, and develop and implement best environmental practices to reduce the input of nutrients and hazardous substances from agriculture and other diffuse sources. Parties bordering the same transboundary waters will conclude specific bilateral or multilateral agreements which will provide for the establishment of joint bodies (e.g. river or lake commissions). They will consult each other on any measures to be carried out under the Convention, jointly elaborate water quality objectives, develop concerted action programmes, jointly monitor and assess transboundary waters, set up joint warning and alarm systems, and provide mutual assistance in critical situations.

Governments will also undertake any additional action that may be required to protect human health and safety. One of these measures is the preparation, under the auspices of UN ECE and the European Regional Office of WHO, of a protocol on water and health expected to be adopted at the 1999 London Ministerial Conference on Environment and Health. Its objective is to promote the protection of human health and well being and sustainable development through improving water management and preventing, controlling and reducing water-related disease.

At the international level there is no "supranational" enforcement mechanism for nations that decline to follow even the agreements they have signed. Nonetheless, international agreements do offer certain benefits, namely that they are formal, written, and embody two or more countries' policy compromises (Box 7.5). They are also usually vetted and approved by a majority of the national legislature before being signed.

### **Box 7.5 The Baltic Sea**

The Baltic Sea, the largest body of brackish water on Earth, has notorious phenomena of blooms of cyanobacteria. The understanding of the biology of the species of cyanobacteria involved and their production of cyanotoxins is necessary for an effective water management of the Baltic Sea. The problems related to such mass development of cyanobacteria illustrate the need to combine efforts at the local level with national and international policies in order to improve the environmental situation in this geographical area.

The Baltic Sea has a surface area of 374,000 km<sup>2</sup> and a mean depth of approximately 60 m and is subdivided into a number of areas: the Gulf of Bothnia in the northernmost part; the Finnish Gulf, bordered by Finland, Russia and Estonia; the Gulf of Riga; the Baltic proper; the Gotland Sea and the Bornholm Sea. The Baltic Sea is connected by narrow channels to the Kattegat and Skagerrak that lead to the North Sea. The salinity gradient varies from 1-4 ‰ in the most eastern and northern parts, to 7-8 ‰ in the south.

The Helsinki Commission has estimated the pollution loads entering the Baltic Sea (Helcom, 1993, 1997). Nutrient input from the atmosphere (through rainfall and particulate deposition) and from the surrounding land by rivers and run-off is high. Elevated levels of nutrients in the water, especially of phosphate and nitrogen compounds, stimulate the growth of cyanobacteria and algae. In the Baltic Sea several cyanobacteria, such as the genera *Nodularia* and *Aphanizomemon*, are capable of biological nitrogen fixation.

The cyanobacteria blooms that are typical of the Baltic Sea may cause a number of serious problems: they discolour the water and may produce bad smells; the decomposition of their organic matter may result in depletion of oxygen, which leads to the death of fish and other animals; and cyanotoxins are produced with consequences to other living organisms, including people.

Co-operation between the countries in the Baltic Sea region occupies a central position in the field of environmental protection. A priority action plan that also addresses problems of blooms has been made and is being operated by the governments in order to determine the major problems and the main measures to reduce them (Ministry of the Environment of Finland, 1991).

## **7.3 Legislation, regulations, and standards**

Making generalised observations about legislative frameworks is difficult, not least because of the diverse forms they may take (common law, civil law, Islamic law) but also because of the varied environments in which they operate. Nonetheless, it is possible to identify certain principal characteristics of the (national) legislative framework within which actions related to the control of cyanobacterial health risks may be effected.

### **7.3.1 Forms of legislation**

The term "legislation" or "laws" refers broadly to all legal texts which are promulgated by the legislative arm of the state exercising its legislative powers under the Constitution, or by the executive arm of the state exercising either its own executive powers under the Constitution or powers delegated to it from the legislative branch. A basic law is usually

introduced by a sector ministry and enacted by Parliament or other equivalent national lawmaking body.

The term "subordinate legislation" (most commonly known as regulations but in some jurisdictions denominated orders, notices, rules, schedules, bye-laws, ordinances, instruments, directives, or proclamations) refers to all legal instruments promulgated by the executive branch exercising delegated legislative power. Subsidiary regulations to a particular law enacted by the national legislature are elaborated and issued by the Minister with responsibility for the subject matter (with or without the approval of all other Ministers, depending upon the country). There may also be schedules or annexes to the regulations, consisting of even more detailed subject matter.

Under the principle of supremacy, laws adopted by the national legislature nearly always take precedence over subsidiary regulations as well as over legal instruments adopted by the legislative branches of the country's political subdivisions. In some countries, however, a variant of this provides that legislation promulgated by the national legislature has primacy for certain subject matters, whereas legislation by the local legislatures takes precedence for others. In other constitutional systems, such as the USA or Australia, any powers not expressly granted to the federal government (or Commonwealth) in the Constitution are the responsibility of the states.

In addition to laws and regulations, there may be other administrative legal texts such as rulings, circulars, guidelines, standards, administrative notes and decisions. Such legal instruments, although non-binding, assist the governments in achieving the aims of the umbrella legislation while at the same time providing guidance for private groups as to how government authorities will go about enforcing and implementing the law (Chiaradia-Bousquet, 1995).

### **7.3.2 Water laws and standards**

Enactment of a basic water law is important in countries where there are laws covering different subject matters and enacted at different times containing conflicting provisions relating to water. This might occur, for example, amongst a country's environment protection law, electricity law and public health regulations. However, during the process of updating or replacing legislation on water, it should be kept in mind that the trend in many countries is towards considering water issues in conjunction with other issues, such as the conservation and use of land, rather than viewing them in isolation (Burchi, 1991).

In order to be effective in addressing cyanobacterial hazards, the law should refer to the jurisdictions, responsibilities, and authority of specified competent agencies in relation to water and to their relationships to one another. Thus it becomes the instrument which brings together the diverse parts of the water medium from which problems arise, as well as the diverse groups associated with their control. These groups include water users, those constructing and administering water supply systems, those regulating different aspects of water and having responsibilities in related domains, and agencies involved in data and information management and sector planning (Table 7.1).

It is important for the water law to reflect the policy priorities and political realities of the particular country. For example, in the case of drinking water supply, legislation in the

established market economies is orientated principally towards the regulation of established water supplies administered by recognisable entities where extensive water supply infrastructure is in place. This may have little relevance to countries where the goal is principally to support the best use of available resources in the provision of incrementally improved service standards to the population as a whole. Such differences argue strongly for developing the policy for the particular country in light of its particular legislative and policy framework, rather than relying on some sort of "model" legislation which would not reflect the realities at hand.

Water laws generally follow the basic principle of national legislation, i.e., that a basic law is indeed basic, whereas any details, which may have to be changed in response to scientific advancements or other exigencies, are contained in the regulations or other subsidiary legislation. The rationale is that regulations are more easily changed because they are elaborated by the responsible Ministry and can be easily revoked, amended or replaced, rather than having to go through the Parliamentary process.

Among the details which will normally form part of the subsidiary legislation of a water law are standards of various kinds. For example, there may be standards on minimum treatment requirements linked to source type and quality. Chapter 5 describes the levels of safety provided by treatment regimes in relation to the nature and degree of cyanobacteria-related hazards in the source water. However, standard setting should not be restricted to water quality, but should also extend to water resource protection and water supply service quality more generally. It should also extend beyond the simple assessment of quality and include the adequacy of structures and systems, such as the definition of safe facilities and practices, minimum standard specifications, and minimum standard operating systems.

In some countries, service quality standards are contained in a "sanitary code" or "code of good practice". As mentioned above in the discussion of industry codes, such standards are most likely to receive support in their implementation if consultation with the affected entities (e.g. supply agencies and professional bodies) has occurred. Other standards consist of quality targets, or what are known as water quality standards. Comprehensive guidance on the setting of drinking water quality standards is available in the *Guidelines for Drinking-water Quality* (WHO, 1993). The *Guidelines for the Safe Use of Wastewater and Excreta in Agriculture and Aquaculture* (Mara and Cairncross, 1989) are also available and further guidelines for safe recreational-water environments are in preparation.

Table 7.2 outlines some of the many issues that may be addressed through water laws, regulations and standards. Not all of these should be seen as essential components of water legislation for all countries, because the contents of a particular country's laws, regulations and standards depend on the policy priorities of that country. This table does not attempt to indicate which matters "belong" in the basic law and which should be contained in subsidiary legislation. Although the general principle (that the more detailed material and the matters that may need to be changed should not be contained in the basic law) applies, the precise dividing line depends to a large extent on the particular legislative scheme. Other water management issues, which are not directly tied to a particular water use, but which might also be addressed through legislation, are given in Table 7.3.

The above discussion should make clear that legislation may play a positive, supportive role in target setting, particularly by virtue of the inclusion of details (such as standards) in subsidiary regulations. Nevertheless, penalties and other sanctions to assist in enforcement are also included in most laws and will occasionally be used. In order to moderate their use, it is appropriate that explicit schemes are provided for enforcement implementation and that they are pursued (Jensen, 1967). The imposition of other more innovative solutions, such as mandatory participation in working groups or monitoring programmes, may obviate the need for some of the harsher penalties. Alternatively, any of these may be used in combination (Box 7.6).

## 7.4 Awareness raising, communication and public participation

The understanding that cyanobacterial blooms and toxins present hazards to human and animal health is a prerequisite for anticipating, avoiding or reducing their adverse effects. Raising awareness on the causes and effects of cyanobacterial blooms serves two goals: protection from the health hazards presented by the toxins, and long-term reduction of toxic bloom development through public participation. Early recognition of blooms and scums facilitates better management of the blooms and associated problems and helps to reduce their impact on the community as a whole (NRA, 1990; NSWBGATF, 1992).

**Table 7.2** Types of water use and features of laws, regulations and standards

Water use type	Area of regulation	Main features of laws, regulations and standards
Drinking water supply	Drinking water quality	Place obligation to supply continuously safe water upon the supply agency Require supply agency to exercise due care Define what is "safe" in terms of acute or long-term exposure (for cyanobacteria this would normally relate to concentrations of some specific toxins (see Chapter 4) as well as toxins not recognised at the time of standard formulation)
	Monitoring requirements	Divide monitoring obligations amongst a number of agencies or sectors (public sector oversight of water resource management, public health authorities, drinking water suppliers, and recreational facility providers including local government) Require information sharing amongst these agencies Define the extent of monitoring required of each agency and define the conditions under which monitoring should be undertaken Define the technical requirements against which monitoring results would be compared
	Treatment requirements	Require supply agency to treat water to achieve the required standards (may be implicit in the requirement of the basic law to supply safe water) Require newly constructed or rehabilitated supply systems to reach minimum treatment capabilities (these may be formulated in terms of performance criteria or processes required, generally in relation to the characteristics of both the source water and the supplied population) Require the upgrading of existing systems to reach the standards required of newly constructed or rehabilitated systems

		Define technical details of construction or operating practice
	Contingency plans	Oblige government agencies to establish contingency plans Define the conditions under which contingency planning is required, and the type of contingency to be planned for (for Alert Levels Framework, see Chapter 6) Describe the basic components of an "adequate" plan (this may include, for example, the need to have alternative supply capacity in very high risk areas)
Recreational waters	Recreational water quality	Impose a "duty of care" (the standard of reasonableness) on those promoting or offering the use of facilities for recreational water use (both private facility owners or operators and local governments may be bound by these duties) Relate use types and water types or qualities to alert levels, and associate alert levels with actions Define a methodology for defining alert levels with consideration for local conditions

**Table 7.3** Water resources management: features of laws, regulations and standards

Management types	Main features of laws, regulations and standards
Pollution control	Require companies to control pollution (this could be interpreted as imposing a duty to control eutrophication and, by implication, cyanobacteria)
	Impose duty on industry to address nutrient discharge (especially sewage) and run-off
	Require agencies to manage river flows to prevent cyanobacterial blooms
Integrated management	Define alert levels and associate specific actions with each level (see Chapter 6)
	Include methodology for defining alert levels according to local conditions
Information and the public	Oblige government agencies to disclose information relating to public health risks
	Define the levels of information to be disseminated according to the alert level
	Impose a duty on public health authorities to inform the public and other government agencies of relevant risks
	Require public education and define its contents (this is different from disclosure)
Intersectoral co-ordination	Define roles of agencies and place responsibilities upon them
	Require minimum frequency of co-ordination at national/local level and wider consultation
	Establish local procedures for co-ordination and consultation

Case histories (e.g. Bell and Codd, 1994; Ransom *et al.*, 1994; Falconer, 1996; Codd *et al.*, 1997) and risk assessments (Chapter 4) point to the need for greater awareness of cyanobacterial bloom and toxin hazards amongst not only water users (such as the

general public, water recreational groups and water resource managers), but also professional groups. Awareness raising can serve several functions:

- To alert professionals and water users to the presence of hazardous accumulations of cyanobacteria and toxins and to the risks involved in drinking and using water containing blooms and toxins.
- To inform health-care professionals of the circumstances and exposure routes that lead to intoxications.
- To inform water users of the causes of cyanobacterial bloom development and of ways in which they can assist in reducing bloom formation.
- To inform environmental regulators, water user and water supply organisations about cyanobacterial toxin hazards, and to help identify and implement appropriate policies on water access, use, consumption and treatment.

#### **Box 7.6 Imposition of a monitoring programme after prosecution of a local council for serious environmental harm**

In May 1996, the waste management officers responsible for the safe operation of sewage treatment works in Tasmania, Australia, noted that a discharge was occurring from an almost empty sewage treatment pond into a nearby dry watercourse. This was not allowed under the terms of the operating licence. There was a dense bloom of *Microcystis aeruginosa* in the next pond, and the officers observed pools containing *Microcystis* in the watercourse and scums of blue-green slime along the banks and down into a recreational lake called Wrinklers Lagoon.

Water samples contained 511,000 cells per ml of *Microcystis* in the sewage pond and 144,000 cells per ml in a pool in the watercourse. Microcystin content in the pond was measured at 27 µg ml<sup>-1</sup>, and the scum in the lake at 120 µg g<sup>-1</sup> dry weight. Total nitrogen in the pond was 25.9 mg l<sup>-1</sup>, and total phosphorus was 7.3 mg l<sup>-1</sup>. About 14 × 10<sup>6</sup> litres had been discharged from the sewage pond into the lake, which had a volume of about 200 × 10<sup>6</sup> litres. The reason for the discharge was a subsidence in the sewage pond retaining wall, which caused the operators to employ repeated discharges from the pond to avoid collapse of the wall. Because the lake is a well-used swimming and fishing location, the discharge caused an immediate health hazard and a long-term risk of repeated blooms of toxic *Microcystis*. On receipt of the officers' report, the local Council excavated the retaining sand bank of the lake and established a channel to the sea, partly draining the lake and allowing sea water flushing.

Environment Tasmania, the state environmental protection agency, prosecuted the Council for serious environmental harm on eight counts of discharge of sewage pond contents containing toxic *Microcystis* into a recreational lake.

In discussions between the parties and an expert advisor, the Council proposed a monitoring programme for the lake and a reduction of the severity of the charges. The magistrate hearing the case found the Council guilty on a lesser charge of "material environmental harm", imposed a fine of A\$ 30,000 (approximately US\$ 20,000) and directed that a monitoring programme be carried out. The proposed monitoring programme was intended to make the lagoon safer with respect to blooms of *Microcystis* (or *Nodularia* which can be handled in a similar way to blooms of *Microcystis*); to improve the amenity value of the lagoon; and to minimise any risks to people, pets, livestock, or fishermen eating fish from the lagoon. The monitoring programme was to be

reviewed after three years.

Source: FCR Cattell v. Break O'Day Council; Court of Petty Sessions, Launceston, Tasmania, Australia. Complaint No. 9745521.

#### **7.4.1 Professional group awareness**

Professional groups are often no more cognisant of the circumstances leading to cyanobacteria-associated health problems than are the general public (Skulberg *et al.*, 1984). The kinds of professional groups that require up-to-date information on cyanobacterial blooms and toxins in order to manage effectively the associated problems include water treatment and supply authorities and companies, medical and veterinary practitioners, public and environmental health authorities, and national/state environmental agencies. Initiatives to increase the awareness of these groups and organisations have centred around conferences, workshops, correspondence in widely-read professional journals, review-type papers, and the large-scale publication of handbooks and reports. Such educational materials have been developed for the water supply, treatment and environmental sectors (NRA, 1990; Lawton and Codd, 1991; Carmichael, 1992; NSWBGATF, 1992; Yoo *et al.*, 1995); the human health-care sector (Codd and Roberts, 1991; Elder *et al.*, 1993; Ressom *et al.*, 1994), and the veterinary sector (Codd, 1983; Beasley *et al.*, 1989). In countries intending to address cyanobacterial risks, these communication routes should be established and developed further.

#### **7.4.2 Public awareness**

In some parts of the world, such as Australia, the UK and Scandinavia, cyanobacterial awareness programmes have operated for several years. However, in other countries with water resources and supplies containing toxic cyanobacterial blooms, awareness and the availability of information are more limited. These deficiencies can be combated in several ways. When cyanobacterial populations in water bodies exceed threshold levels, media warnings should generally be issued to the public. Such warnings and notifications may be issued through the newspapers, radio and television, and may require media targeting and press conferences. The content of any announcement varies according to individual bloom situations and the purposes for which the affected water body is used. For example, if a cyanobacterial bloom occurs in a municipal water supply source, media releases may be appropriate at lower cell populations than if the waters are used only for recreational purposes.

The information supplied in the warnings should be prompt, concise and should include details of expected changes in the quality of supply, such as tastes, odours, discolouration and the actions being taken to alleviate the problems. Where recreational activities, livestock watering, and further water uses other than human supply, are involved, media warnings may also contain a brief description of the bloom and how it can be recognised (such as a noticeable discolouration of the water or the presence of scums). Other information which may be supplied in the warnings and notices, if appropriate to the bloom situation, includes:

- Possible health problems including gastrointestinal upsets, skin rashes, and eye irritations.

- Warnings not to use the water for swimming, bathing, or showering.
- Advice on finding alternate sources of water for animals and preventing pets from swimming (and subsequently grooming scum material out of their fur) in affected areas.
- Notification that boiling the water will not destroy the toxins.

The community often has several concerns when a cyanobacterial bloom occurs in its drinking water supply or recreational amenity. Commonly-asked questions concern the use of water in evaporative air coolers; its use for drinking, laundry, dish washing, washing fruits and vegetables and cooking; whether fish, shellfish and crustaceans harvested from cyanobacterial bloom-containing water are suitable for human consumption; and where to obtain alternative water supplies. Information or fact sheets prepared in advance can be circulated upon request (see below).

It may be appropriate to display warning signs and notices at major points of public access to affected water bodies. For eutrophic waters with occasional bloom problems, provision of basic information to visitors is particularly likely to contribute to protecting them from health hazards, because the rapid appearance and disappearance of scums cannot always be detected in time for the responsible authorities to implement specific measures (such as temporarily restricting use). In such situations, health protection must, to some extent, rely on the users' own informed judgement.

Warning signs should be prominent and simple, with symbols or minimum text to indicate no swimming, paddling, drinking, livestock watering, pets in the water, or other activities deemed by the responsible agencies to present unacceptable exposure risks. The signs may be removed when the blooms decrease to acceptable levels, or they may be kept in place throughout the year in areas with year-round problems. If the latter option is taken, the gradual decrease in visual impact of warning signs and notices needs to be borne in mind.

Brochures and fact sheets are other tools which are increasingly used to convey to the general public and specialist water user groups information on the appearance and hazards presented by cyanobacterial blooms and scums. Examples are available from several countries which have experienced bloom-related problems, such as the UK, Australia, Denmark, Finland, South Africa, and the USA (NRA, 1990; NSWBGATF, 1992; Yoo *et al.*, 1995).

Brochures and fact sheets intended for the public should be simple and free of scientific jargon, and should include brief descriptions with the following kinds of information:

- The nature and occurrence of cyanobacteria.
  - The health hazards presented by cyanobacteria and their toxins.
  - The recognition of cyanobacterial blooms and scums.
  - The propensity of cyanobacteria to produce toxins.
  - Precautions and steps to be taken to avoid potential health problems.
  - Whom to contact if the presence of a cyanobacterial bloom or scum is suspected.
- Special fact sheets for farmers, regarding protection of farm water supplies for animals, and also for water sports organisations, have also been used. Professional associations

and user-group networks, such as national water sports bodies, provide a useful means of spreading information. Posters and displays in public places and association premises are additional tools for conveying information to the public on cyanobacteria and for increasing community awareness. Videos are another useful method of educating the public about cyanobacterial problems. They can be used to present the causes and consequences of cyanobacterial blooms, as well as to provide good visual examples of waters containing blooms and scums. They may also outline the strategies proposed and used by authorities to manage the problems, and to inform the public about what, as individuals, they can do to help. For example, to inform the public and to enable them to initiate action at a community level, Australia's Murray-Darling Basin Commission (Box 7.3) initiated and supported the development of a "study circle" kit for adults entitled "Blooming Blue-Green Algae". The kit contains a video, an audiotape, posters and printed information on cyanobacteria which enables people to discuss and find out more about cyanobacteria.

Education on the causes of blooms can begin through programmes run in schools. Students may be encouraged to participate in simple water quality investigations, such as in the Australian "Streamwatch" programme. Easy-to-use kits are employed to enable the early detection of impending cyanobacterial blooms.

The effectiveness of the tools discussed above is only as good as the efforts made to publicise and to distribute them. The need for contact points may be especially important in remote locations where monitoring waters by government agencies or water body owners is not possible and thus the assistance of the community is vital.

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