CHAPTER 2

CAUSES OF ALGAL BLOOMS

Introduction

2.1 A great deal of information has been gained in recent years about the chemical and physical features which promote the development of algal blooms, although significant information gaps still persist. It is essential that, if management strategies are to be developed enabling the cost effective control of algal blooms, further research be done into a number of critical areas which are still little understood. Areas such as the dynamic instream processes in relation to nitrogen to phosphorus gradients and the physio-chemical basis for environmental flow issues require further attention.

2.2 Blue-green algae can assimilate nutrients while near the bottom of the water body and have the capacity to form vacuoles (i.e. internal cavities) which float the organism to the upper zone where light is more abundant; the photosynthetic processes then collapse the vacuoles allowing the algae to sink to the lower nutrient rich zones. This enables these organisms to utilise optimum levels of both light and nutrients. Blue-green algae also have the capacity to 'overwinter' in the form of akinetes or other resting phases[12] which may remain viable during unfavourable conditions.[13] These features, as well as the capacity to fix nitrogen, give the cyanobacteria a strong competitive edge over other organisms, particularly under stratified conditions in calm, nutrient rich waters, enabling them to form blooms.

Chemical Features

2.3 The elements carbon, hydrogen and oxygen which are required for algal growth are readily available in water. Other essential elements include nitrogen and phosphorus. There is also evidence that nitrogen

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12 'Akinetes' are asexual reproductive or resting cells which develop a thick wall around a concentrated food reserve.
National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.8.

13 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae,* August 1992, p.36.

to phosphorus ratios are important.[14] Many blue-green algae can fix nitrogen but rely on dissolved phosphorus in the water. Genera such as *Anabaena* can fix atmospheric nitrogen, while *Microcystis* cannot. *Microcystis* blooms such as those in Lake Mokoan could be controlled by limiting the available nitrogen.[15] Phosphorus is, however, the main avenue of control because of the sensitivity of both nitrogen fixing and non-nitrogen fixing species.

Sources of Phosphorus

2.4 The principal sources of phosphorus are the sediments, soil erosion, agricultural runoff, fertiliser applications, industrial effluent, urban runoff and sewage treatment plants. Total phosphorus levels in New South Wales rivers increased 5 per cent annually for the past 18 years prior to 1992.[16] Horticulture, urbanisation and septic tanks have significantly contributed to the eutrophication of lakes in the Perth area.[17] Total phosphorus levels exceeded 200 μg/l (micrograms per litre) during the 1991-92 Darling/Barwon algal blooms.[18] There is considerable evidence that the development of algal blooms reflects the increased levels of phosphorus in waterways.

2.5 The control of phosphorus levels may be addressed from two approaches: the control of nutrients within the water body (sediment release, precipitation) or the control of sources within the catchment (soil erosion, fertiliser, sewage). In Japan, England and Germany both catchment and in-lake controls are used simultaneously.[19] In relation to the control of nutrients within the water body, Agriculture and

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14 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae,* August 1992, pp.42/70; Murray Darling Basin Commission *Algal Management Strategy. Technical Advisory Group Report,* April 1993, p.3.

15 Cullen, Submission No.42, p.3.

16 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae,* August 1992, p.119.

17 Environmental Protection Authority, Western Australia, Submission No.43, p.3.

18 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae,* August 1992, p.60.

19 Burns, Supplementary Submission 31(a), p.2.

Resource Management Council of Australia and New Zealand (ARMCANZ) workshop in 1993 considered there to be inadequate information to be able to predict the fluxes in nutrient levels in water bodies[20] thus making the control of sources within the catchment the primary avenue of control in many situations.

2.6 The critical levels of phosphorus sufficient to support the development of algal blooms appear to differ depending on the local environment. Professor Cullen was of the view that if the level of total phosphorus could be reduced to less than 50-80 micrograms per litre (μg/l) during the low flow periods in summer, this might reduce the frequency of algal blooms.[21] The Ballarat Water Board and the West Moorabool Water Board reported the possibility of algal bloom occurrence increasing when phosphorus levels exceeded 25 μg/l.[22] In Denmark, in shallow nonstratified water bodies, the threshold for algal blooms was five times that required in deep stratified water bodies where 20 μg/l was sufficient for algal bloom development.[23] Reducing the levels of phosphorus may not achieve a reduction in the incidence of algal blooms if the phosphorus levels achieved are still above the critical threshold[24] sufficient to support the development of algal blooms.

Point Sources

2.7 The Committee was told that point sources of phosphorus played a much greater role in the development of algal blooms in Australian inland waters than that released from the sediments.[25] The major point sources included sewerage works, septic tanks, urban runoff, irrigation drains, industrial waste and animal industries, such as feed lots, dairies, poultry farms and piggeries.

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20 Agriculture and Resource Management Council of Australia and New Zealand. *Priorities for National Algal Bloom Research*, April 1993, p.10.

21 Cullen, Submission No.42, p.2.

22 Ballarat Water Board and West Moorabool Water Board, Submission No.44, p.3.

23 Australian National Industries Ltd, Submission No.39, p.10.

24 Wealands, Evidence, 25 September 1992, p.222.

25 Bayly, Submission No.60, p.1.

(a) Sewerage Systems

2.8 Phosphorus from sewage is more readily available to the algae than that from non-point sources. In Western Australia, only 20 per cent of phosphorus in rivers is attributed to point sources[26] while almost 60 per cent of the phosphorus entering the Darling system in the dry season is from sewage.[27] Reduced phosphorus levels can be achieved by use of best available technology and improved operator strategies.[28] The technology of effluent treatment is available and it is now a matter for funding priorities.[29]

2.9 There are 69 sewage treatment plants on the Murray-Darling and some of the large municipalities contribute substantial amounts of phosphorus. For example, Toowoomba sewage produces 75 tonnes of phosphorus per annum.[30] Only three of these treatment plants have the capacity to remove phosphorus.[31] ANI-Kruger Pty Ltd estimated that the phosphorus input into the river system could be reduced by 374 tonnes by improved treatment plants at the ten cities which produced the most phosphorus.[32] The Federal and State/Territory governments are currently working on a joint program to upgrade these facilities.[33]

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26 Environmental Protection Authority, Western Australia, Submission No.43, p.2.

27 Bayly, Submission No.60, p.1.

28 National Water Quality Management Strategy. *Water Quality Management in the Rural Environment. A reference document.* August 1992. Australian Water Resources Council, p.16.

29 Australian National Parks and Wildlife Service, Submission No.82, p.6.

30 Clewitt, Evidence, 4 August 1993, p.675.

31 CSIRO, Submission No.72, p.11.

32 Towns, Evidence, 2 August 1993, p.519. The ten cities were: Toowoomba, Orange, Bathurst, Tamworth, Dubbo, Gunnedah, Moree, Inverell, Narrabri and Dalby.

33 Minister for Primary Industries and Energy, The Hon S Crean: Address to the AWRC and ANZECC National Conference on Water Quality Management and Ecologically Sustainable Development: Delivering the Opportunities. Adelaide 3-4 December 1992, p.6.

2.10 The Committee was told that there was a perception that various government monies would be available for the installation and upgrading of sewage treatment works and that decisions would not be made by councils until that was resolved.[34] The Committee was concerned that this might result in significant delays in the upgrading of sewage treatment works. It may be that the current funding mechanisms are acting as a disincentive to local governments to undertake preventative actions by delaying decisions until the situation is sufficiently critical to ensure Commonwealth and State/Territories financial assistance.

Recommendation 1

The Committee recommends in relation to sewage treatment works as a matter of urgency that:

- **relevant local authorities be advised by the Commonwealth and State/Territory governments of the amount of possible funding available and the realistic timeframe for the provision of government funds to upgrade sewerage systems; and**
- **current funding mechanisms be revised to ensure that local governments are encouraged to take preventative actions where it is economically and environmentally beneficial to do so.**

2.11 The Committee was also told that there was a tendency for governments to focus on the lowest installation cost rather than the operating aspects when deciding on a suitable treatment plant.[35] The Agriculture and Resource Management Council of Australia and New Zealand is preparing design and operations manuals for alternative low cost sewerage options. This approach will be effective in situations where the system will be adequate for future development in the area, where there is a low rate base and the community accepts alternative technologies.

34 Towns, Evidence, 2 August 1993, p.520.

35 Towns, Evidence, 2 August 1993, p.520.

Recommendation 2

The Committee recommends that, following receipt of the forthcoming ARMCANZ report, a review of policies at all levels of government be conducted to ensure the consideration of alternative sewage treatment options when upgrading sewerage systems.

2.12 The stipulation of an achievable minimum effluent standard is an outcome oriented approach which encourages the use of the best available technology for point sources.[36] Considerable success has been recorded with the Lower Molonglo sewage treatment works achieving a level of <0.3 milligrams per litre (mg/l) phosphorus.[37] Phosphorus removal can also be achieved by using ferric salts or lime but this is expensive and may be unsuitable because of the increased salinity.[38] Current biological techniques for phosphorus removal are unreliable but show future potential.[39]

Recommendation 3

The Committee recommends the implementation of policies by the relevant authorities at all levels of government stipulating achievable minimum effluent standards for point source nutrient pollution.

2.13 The Committee was told that the effectiveness of existing treatment works would also be improved if the operators could use the equipment more skilfully.[40] The National Water Quality Management Strategy includes guidelines for effluent from sewerage systems but the Committee is also concerned that should include a review of existing systems.

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36 The Response of the Queensland Government to the Industry Commission's Draft Report on Water Resources and Waste Water Disposal. May 1992, p.16.

37 Commonwealth Environment Protection Agency, Submission No.93, p.13.

38 Bayly, Submission No.60, p.1.

39 Bayly, Submission No.60, p.2-3.

40 Cullen, Evidence, 27 August 1993, p.859.

Recommendation 4

The Committee recommends that the development of the National Water Quality Management Strategy include an urgent review by the responsible authorities of the efficiency of existing sewerage systems to establish their performance levels relative to their capacity to remove nutrients.

2.14 There is also a need to consider effluent that is never treated but overflows or bypasses sewage treatment plants.[41] The Committee was also told that the Sydney sewerage system frequently overflows.[42] This problem is of particular concern to the Committee.

Recommendation 5

The Committee recommends that the development of the National Water Quality Management Strategy include urgent attention being given by responsible authorities to situations where effluent overflows or bypasses sewage treatment plants.

2.15 Other methods to deal with waste discharge include land disposal, such as irrigated wood lots. Towns such as Walgett and Collarenebri do not discharge sewage into the river system.[43] The Moree Plains Shire Council re-uses the effluent to irrigate Greenbah Oval and is looking at proposals for the golf course and other properties.[44] The Shepparton Water Board has trial agroforestry projects[45] and the Gunnedah Shire Council proposes to use effluent for irrigation of parks and fields and commercial ventures[46].

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41 Cullen, Evidence, 27 August 1993, p.860.

42 Higgins, Evidence, 2 August 1993, p.487.

43 Austin, Evidence, 3 August 1993, p.634.

44 Jones, Evidence, 5 August 1993, p. 697.

45 Shepparton Water Board, Submission No.97, p.10.

46 Gunnedah Shire Council, Submission No. 101, p.1.

Recommendation 6

The Committee recommends that the development of the National Water Quality Management Strategy include information relating to the successful use of treated sewage for irrigation being circulated to local communities who might take advantage of this approach.

2.16 Land disposal of sewage may not always be appropriate, as it may pollute ground water[47] and its suitability depends on the soil type and the height of the water table.[48] In situations where land disposal options are being contemplated, it is essential that the capacity of the receiving system be known and the sustainability of the system be considered to ensure that ground water supplies are not contaminated. There must be suitable land available in an appropriate location, and wet weather runoff must be able to be controlled.

Recommendation 7

The Committee recommends that the development of the National Water Quality Management Strategy include provision for a full environmental impact assessment being conducted prior to establishing any land disposal site for sewage.

2.17 The Australian Water Resources Council (AWRC) has looked at a number of alternative low cost sewerage options[49] for small communities, and Minister for Primary Industries and Energy, the Honourable Simon Crean has announced a program of stand-alone sewerage systems.[50] The Queensland Department of Primary

47 New South Wales Blue-Green Algae Task Force, Submission No.53, p.4.

48 Bayly, Submission No.60, p.1.

49 Wealands, Private Briefing, 26 November 1993, p.8.

50 McDonald, Private Briefing, 26 November 1993, p.7.

Industries and Zootech are researching the possible use of culture of zooplankton to sewage lagoons to produce fish food.[51]

(b) Detergents

2.18 A significant proportion of phosphorus in sewage comes from laundry detergents, and the national average level of phosphorus in Australian laundry detergents is 5.3 per cent.[52] The costs of removing phosphorus from effluent rise rapidly as target levels are lowered and quantities of phosphorus increase[53] and it may be less expensive to remove phosphorus from detergents rather than phosphates from effluent. New South Wales has taken steps to collect more data on the contribution of total phosphorus from detergents.[54] The Committee was told that 30-50 per cent of total phosphorus in sewage was from detergents, according to the Sydney Water Board's figures.[55] The New South Wales Government has now signed an agreement with the detergent industry in relation to truth in labelling, and a move towards new products entering the market not having more than the 5 per cent phosphorus level.[56]

2.19 Other countries have achieved lower phosphate levels through marketing strategies which apply public pressure on the manufacturing companies.[57] The New South Wales Government is undertaking a phosphorus awareness campaign which will involve all three levels of government and the community. In 1994 these programs will be launched in a number of centres throughout the state.

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51 Minister for Industry, Technology and Regional Development, Submission No.89, p.5; Zootech (Australia), Submission No.68, p.7.

52 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.125.

53 CSIRO, Submission No.72, p.11.

54 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.127.

55 Cullen, Evidence, 27 August 1993, p.859.

56 Minister for Land and Water Conservation, Media Release, 23 November 1993, p.1.

57 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.124.

Recommendation 8

The Committee recommends that existing and proposed campaigns to achieve lower phosphate levels in detergents through marketing strategies be continued.

2.20 Encouraging the voluntary use of low phosphorus detergents is a way of involving the community to 'do their bit' for the environment and can extend public awareness to the careful use of fertilisers, herbicides and pesticides. There is a concern, however, that if phosphorus is removed from detergents, communities may think that the problem is solved, particularly if there are successive years of high rainfall during which algal blooms are less frequent.[58]

2.21 There was some support for a national approach to the determination of acceptable levels of phosphates in detergents.[59] The ARMCANZ aims to develop a strategy by April 1995 to minimise the impact of phosphorus in detergents.[60] The Committee urges the hastening of the ARMCANZ-Australian and New Zealand Environment and Conservation Council (ANZECC) joint process to resolve this matter.[61] The Committee is concerned that continued publicising of opposing views by government agencies will confuse the public and have an adverse effect on the Integrated Catchment Management (ICM) movement.

2.22 The introduction of legislation in relation to phosphate levels in detergents may assist facilitation of a national standard determined by agreement between the States and Territories. Several countries have legislated for low phosphate levels in detergent. For example, an amendment to the *Canada Water Act* (RSC 1985C11) limiting phosphorus in laundry detergents to 2 per cent has resulted in

58 Blackmore, Evidence, 27 August 1993, p.912.

59 Blackmore, Evidence, 27 August 1993, p.913.

60 Agriculture and Resource Management Council of Australia and New Zealand *Phosphates in Detergents*. Report on ARMCANZ Resolutions, pp.1-2.

61 ARMCANZ and ANZECC are currently working together to develop a national approach to dealing with phosphorus levels in detergents.

significantly reduced algal blooms in Lake Erie.[62] In contrast the Committee was told that the banning of phosphates in detergents in Italy did not result in improved water quality.[63]

Recommendation 9

The Committee recommends that if a significant reduction in levels of phosphorus in detergents has not been achieved within two years then legislation be enacted to reduce levels or to ban phosphates in detergents.

2.23 The Committee was told that the removal of phosphorus from detergents is the quickest way of reducing the phosphorus input into waterways[64] and may provide savings on the additional treatment of sewage to remove phosphorus.[65] It was suggested to the Committee that the introduction of a levy on detergents was a possible source of revenue[66] which could be used for remedial work on research as well as act as a disincentive to use detergents with high phosphorus contents.

2.24 Algal blooms usually appear during low flow periods when the major source of nutrients is sewage treatment plants. The impact of reducing phosphorus levels in detergents may be greater than expected on the basis of average nutrient loads particularly if campaigns are targeted at communities in sensitive rural areas.[67] Before regulation could be implemented there would need to be sufficient information on the impacts and the cost benefits of that approach.

2.25 There was some concern that the removal of phosphate from detergents might be counter-productive if it required greater use of

62 Jones, Submission No.11, p.2.

63 Murray River Management Board and Murray Irrigation Area and Districts Management Board, Supplementary Submission No. 52(a), p.2.

64 Banens, Evidence, 27 August 1993. p.912.

65 Higgins, Evidence, 2 August 1993, p.485.

66 Lambert, Evidence, 27 August 1993, p.892.

67 Banens, Evidence, 27 August 1993, p.912.

surfactants which, might have detrimental environmental impacts.[68] However, Professor Jones reported that apparently environmentally safe substitutes had been used in Canada.[69] Some Australian detergents contain relatively safe substitutes such as zeolite, sodium silicate and sodium carbonate. There is some concern about the ecological implications of some alternative additives.[70]

2.26 Australian detergent manufacturers may need 3-4 years to develop their own phosphorus free detergent. They need to be sent a clear signal as soon as possible in relation to levels of phosphorus[71] and in relation to truth in labelling.[72] If suitable Australian products are to be developed, consideration should be given to the development of industries, such as the zeolite industry, which produce substitute products. The time needed for the industry to develop appropriate products does not preclude the implementation of legislation which could formalise a phasing in period.

Recommendation 10

The Committee recommends that if the reduction in the levels of phosphorus in detergents is to be addressed through legislation then the manufacturers be given reasonable time to develop new or improve existing products.

Recommendation 11

The Committee recommends that a national approach be adopted in relation to truth in labelling for detergent manufacturers in relation to phosphate levels.

68 Commonwealth Environment Protection Agency, Submission No.93, p.13.

69 Jones, Submission No.11, p.3.

70 Murray-Darling Basin Commission. *Algal Management Strategy. Technical Advisory Group Report.* April 1993, p.42.

71 Cullen, Evidence, 27 August 1993, p.875.

72 Agriculture and Resource Management Council of Australia and New Zealand. *Phosphates in Detergents.* Report in Progress on ARMCANZ Resolutions, p.3.

2.27 The debate over the best approach to dealing with phosphorus levels in detergents is very polarised and is causing considerable confusion within the community. Even if phosphorus is removed from detergents there will still need to be treatment of effluent to remove other phosphorus inputs, and the removal of phosphorus from detergents must be considered as part of an integrated management approach.

(c) Septic Tanks

2.28 Septic tanks were identified as one of the significant contributing factors to the eutrophication of lakes in the Perth area.[73] Professor Cullen pointed out that two thirds of the people in the Murray-Darling Basin used septic tanks.[74] The New South Wales State Algal Coordinating Committee is studying the impact of nutrient leakage from septic tanks on waterways.[75] Research is currently being done in Victoria to determine the impact of leakage from septic tanks on ground and surface waters.[76]

2.29 It was suggested to the Committee that there should be a mandatory pumping out of septic tanks and this could be policed by a requirement to show the receipt when paying the annual rates.[77] In Victoria, the *Water Act 1989* provides power to inspect and de-sludge septic tanks and to charge the cost to the owner. The policing of these operations is carried out by local councils and is effective where controls are enforced.

2.30 The Committee was told that part of the problem was that septic tanks fell under the jurisdiction of health and engineering agencies which are usually separate from the water and sewerage authorities, and the successful implementation of these controls depended on cooperation between these agencies. This situation should be addressed

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73 Environmental Protection Authority, Western Australia, Submission No. 43, p.3.

74 Cullen, Evidence, 27 August 1993, p.859.

75 New South Wales State Algal Coordinating Committee, Supplementary Submission No.53(a), p.10.

76 Blackmore, Evidence, 27 August 1993, p. 913.

77 Cullen, Evidence, 27 August 1993, p.876.

as soon as further information becomes available on the impact of leakage from septic tanks.

Recommendation 12

The Committee recommends that as part of the development of the National Water Quality Management Strategy, ARMCANZ take steps to ensure that there is a mandatory requirement to have septic tanks de-sludged on an annual basis as a condition of installation.

(d) Urban Runoff

2.31 There is now considerable concern about nutrient levels in urban runoff, and several approaches to potential use of stormwater are being considered. Urban water supplies are currently treated to a high standard but only 20 per cent is needed at this standard.[78] One approach to the re-use of runoff from domestic properties is to use 'grey water' to flush toilets and to water gardens. Dual reticulation systems are being installed for this purpose in new development areas, such as Rouse Hill in Sydney.[79]

Recommendation 13

The Committee recommends that as part of the development of the National Water Quality Management Strategy, the provision of dual reticulation systems for the use of 'grey water' be considered in the development of new housing estates on a national basis.

2.32 The first flush events clear the dirt from the roads, gutters and parks into stormwater drains which flow directly into waterways. It has been suggested that the diversion of storm water to sewers would reduce levels entering waterways from urban runoff. Nutrients

78 Clark R (1990) Water Resources Investigations, Engineering and Water Supply Department. *Water Conservation for Adelaide: Looking into the Future*, shortened version of Proceedings of 63rd National Conference Royal Australian Institute of Parks and Recreation, Adelaide, 30 September 1990.

79 Cauchi, Evidence, 3 August 1993, p.558.

associated with particulate material in storm water may be treated by slowing down the water and possibly passing it through wetlands, which would enable sedimentation to occur.[80] This could be achieved by constructing holding tanks sufficiently large to retain the first ten minutes of rainfall.[81]

2.33 Urban integrated catchment management may also reduce input levels from garden fertilisers.[82] Substantial amounts of water are involved in urban runoff. For example, it has been estimated that the total run off of Adelaide is about the same as the water used.[83] The Commonwealth Environment Protection Agency has produced a discussion paper which considers the nature and impacts of storm water, and management and the environmental values of the receiving water.[84]

Recommendation 14

The Committee recommends that as part of the development of the National Water Quality Management Strategy, adequate treatment of storm water runoff to prevent nutrient pollution of waterways be incorporated as an integral part of the planning of new urban developments.

(d) Other Point Sources

2.34 Significant reductions in input of nutrients to waterways can also be achieved as a result of the treatment of industrial waste and animal industries (feedlots, dairies, poultry farms, piggeries) by positioning polluting activities and aerial spraying of fertilisers away from waterways. Irrigation can also have a point source contribution

80 Hart, Evidence, 27 July 1993, p.418.

81 Cauchi, Evidence, 3 August 1993, p.542.

82 Waterways Commission, Western Australia, Supplementary Submission No. 56(a), p.2.

83 Australian Conservation Foundation, Supplementary Submission No.75(a), p.23.

84 Commonwealth Environment Protection Agency (1993) *Urban Storm Water a Resource to Valuable to Waste.* February 1993.

through irrigation return drains in addition to the diffuse contribution as runoff from irrigated fields.[85]

Diffuse Sources

2.35 The major diffuse sources of phosphorus include agriculture, farming and forestry. One of the gaps identified by ARMCANZ workshop in 1993 was the prediction of nutrient export characteristics in rural areas.[86] The Campaspe Region Water Authority also attributed significant nutrient input to fertilisers, farming methods (including overstocking) and the proximity of farms to waterways.[87]

(a) Sediments

2.36 Phosphorus can be released from the sediments, particularly in anoxic conditions, and through biological activity.[88] Substantial quantities of nutrients are leached from the sediments into the water for many years after the external supply of nutrients has ceased[89] and there may be a considerable time lapse between the introduction of nutrient to the water body and the development of algal blooms.[90] Near Bourke, the concentrations of phosphorus in the sediments of the Darling River could be 100-fold those in the water.[91] The major source of phosphorus in Chaffey Dam was found to be the tertiary basalts in

85 Wardle, Evidence, 2 August 1993, p.509.

86 Agriculture and Resource Management Council of Australia and New Zealand. *Priorities for National Algal Bloom Research*, April 1993, p.10.

87 Campaspe Region Water Authority, Submission No.32, p.2.

88 Cullen, Submission No. 42, p.3; CSIRO, Submission No.72, p.7.

89 Bowmer K (1981) Nutrient Enrichment Eutrophication: Cause of problem plant growth - possibilities for regulation. In: *Waterplants of New South Wales* (Ed G Sainty and S Jacobs), NSW Department of Water Resources, Sydney pp.491-501, p.493.

90 Engineering and Water Supply Department, South Australia, Submission No.49, p.7.

91 CSIRO, Submission No.72, p.7.

the uplands of the catchment.[92] High phosphorus levels may occur if a large catchment area drains into the water body.[93] In the Chaffey Dam catchment high phosphorus levels were said to occur in pristine native timber areas:[94] the soils in these areas are high in apatite (calcium fluorophosphate).[95]

2.37 Acceptable levels of phosphorus input will vary according to existing levels in the soil and the amount entering the system from other sources. The variation in freshwater ecosystems in Australia requires flexible guidelines to address the site specific assimilatory capacities for phosphorus rather than a single set of standards.[96] There may be situations where the amount of phosphorus entering the system from the sediments is sufficiently high that reduced input levels from other sources will have no impact on algal bloom development for decades.[97]

2.38 Research in South Australia indicates that an 80 per cent reduction in the amount of phosphorus transported from the soil can be achieved by the use of calcium salts to modify the soil chemistry.[98] The Committee was told that this project had not progressed to field trials due to the lack of funding.[99]

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92 Donnelly, T (1993) *The Major Sources in the Chaffey Catchment, NSW.* Consultancy Report No.92/20. Submitted to the Chaffey Dam Advisory Committee, March 1993, p.24.

93 Environmental Protection Authority, Western Australian Submission No.43, p.2.

94 Chaffey Dam Catchment Management Advisory Committee, Submission No.25, p.2.

95 Garrard, Evidence, 5 August 1993, p.737-8.

96 Hart, Submission No.61, p.4.

97 Bowmer, Submission No.63, p.1.

98 Bursill, Evidence, 12 August 1993, p.756.

99 Bursill, Evidence 12 August 1993, p.756.

(b) Fertilisers

2.39 The costs and benefits of fertiliser use are not widely known,[100] therefore an analysis of current farming practices may be beneficial in some localities. The rate of nutrient leaching from soil depends on seasonal water runoff, ground cover and slope and can therefore be reduced by improved farming practices.[101] A survey conducted by Rose, Southwell and Sledge in the Hawkesbury River catchment found that some local landowners rejected claims that agricultural runoff was a contributing factor, and some had little understanding of the causes and effects of algal blooms.[102] Most irrigators obtained their information on irrigation and fertilisation techniques from their equipment suppliers, rather than from consultants in the extension service.[103]

2.40 Substantial benefits can be gained by adjusting the frequency and quantity of fertiliser to match optimum plant usage, soil type and condition in order to minimise leaching of nutrients. The South Australian Farmers Federation suggested that the cost of fertiliser monitoring could be shared by community members.[104] CSIRO was using satellite imagery to determine superphosphate needs and it is expected that this type of technology would facilitate the process.[105]

2.41 Surveys in Western Australia have shown that farmers previously had little technical advice in determining optimum fertiliser use.[106] The Western Australian Government provides free soil testing and advice on timing and quantities of fertiliser use as a long term strategy

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100 Mues C and Collins D (1993) 'A review of Commonwealth land care initiatives - promoting sustainable farming systems'. *Outlook 93.* Canberra, 2-4 February 1993, p.1.

101 McClement, Evidence, 4 August 1993, p.678.

102 Rose, Southwell and Sledge, Submission No.1, p.5.

103 Wardle, Evidence, 2 August 1993, p.512.

104 Day, Evidence, 12 August 1993, p.817.

105 CSIRO, Submission No.72, p.9.

106 Western Australian Department of Agriculture Catchment Management, South Coast Estuaries Project Group, Catchment Landcare Centre, *Reducing the nutrient load from rural sources of Albany's Harbours.* p.i.

to address this problem, and up to 16 per cent reduction of phosphorus has been recorded in the Peel Harvey Estuary.[107] The Western Australian experience demonstrates the willingness of the farming community to participate when provided with factual information on their specific needs.[108]

2.42 The Committee was told that although a lot of plant nurseries, particularly the larger ones, were recycling water because of the increase in water rates, there was still a problem of nutrient input from small retail suburban nurseries because the runoff went into stormwater drains.[109] The Committee was told that the introduction of a slow release fertiliser by nurseries had significantly reduced fertiliser runoff[110] from those properties. The industry is approaching this problem through an accreditation program.[111]

2.43 The NSW Irrigators' Council pointed out that only 9 percent of combined phosphorus and nitrogen in waterways in the Murray-Darling Basin derived from irrigated agriculture and that improved practices designed to further reduce the amounts getting into waterways.[112] Irrigated agricultural production was estimated to be worth $4.5 billion annually[113] of which $2.7 billion was exported.[114] There is a strong economic argument for the continuation of irrigation as the multipliers for this industry are large compared with other sectors of the economy (output multiplier of 6.09, employment multiplier of 4.74).[115] Irrigated land is seven times more productive than dryland farming and may

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107 Environmental Protection Authority, Western Australia, Submission No.43, p.3.

108 CSIRO, Submission No.72, p.9.

109 Scott, Evidence, 2 August 1993, p.450.

110 Scott, Evidence, 2 August 1993, p. 463.

111 Peters, Evidence, 2 August 1993, p. 452.

112 NSW Irrigators' Council, Submission No.17, p.10.

113 NSW Irrigators' Council, Submission No.17, p.3.

114 Australian Irrigation Council, Submission No.58, p.1.

115 NSW Irrigators' Council, Submission No.17, p.3.

reduce development pressure on the 'more fragile and marginal agricultural lands'.[116]

2.44 On the other hand, phosphorus levels are significantly higher in irrigation areas than that in dry land pastures.[117] The Department of Water Resources in New South Wales has strict guidelines to prevent tail waters from re-entering the river.[118] Further, the Committee was told that the cotton industry does not use phosphorus in its farming procedures[119] and a significant proportion of tail waters from cotton farms is recirculated.[120] The irrigation industry is currently supporting research into storm water runoff from farms.[121]

2.45 The NSW Government provides rebates as incentives to develop 'whole farm plans'.[122] The concept of Best Management Practices is being promoted as part of the National Water Quality Management Strategy. It aims to maintain or improve agricultural viability while protecting the environment, and it covers nutrient runoff.[123] This concept encompasses 'the development of practical resource management guidelines for the sustainable management of natural resources at local and regional levels'.[124] The Committee was told that a lack of adequate information on the relative contributions of different nutrients to the waterways results in a reluctance to accept control

116 Australian Irrigation Council, Submission No.58, p.4.

117 Cullen, Submission No.42, p.4.

118 McCutcheon, Evidence, 3 August 1993, p. 608.

119 Baker, Evidence, 2 August 1993, p.492.

120 Australian Cotton Foundation, Submission No.66, pp.7, 11.

121 Macquarie Valley Irrigators Association, Submission No.65, p.9.

122 O'Kane, Evidence, 24 September 1992, p.154.

123 National Water Quality Management Strategy. *Water Quality Management in the Rural Environment. A reference document.* August 1992. Australian Water Resources Council, p.8.

124 National Water Quality Management Strategy. *Water Quality Management in the Rural Environment. A reference document.* August 1992, Australian Water Resources Council, p.9.

measures, particularly when the outcome of the controls is uncertain.[125]

(c) Soil Erosion

2.46 Soil erosion is a significant source of phosphorus. It was suggested to the Committee that incentives must be provided to encourage the implementation of measures to reduce soil erosion.[126] A good example of this was areas with intensive irrigated crop production which usually have gentle slopes to reduce soil movement.[127] It was suggested that appropriate measures might include tax incentives for landholders and funding for local and regional planning for conservation farming.[128] The Committee was given examples of farmers self-regulating in relation to the use of pesticides and feedlot complexes[129] and it was suggested that this approach could also be applied in this case. In South Australia, the *Soil Conservation and Landcare Act 1989* requires Soil Boards to prepare district plans by 1995.[130]

(d) Absence of Riparian Strips

2.47 Overgrazing of riverbanks was considered a significant problem in some areas.[131] Fencing of streams in sensitive catchments may reduce damage to stream bank vegetation.[132] Stock and pest grazing on floodplain vegetation have been able to destroy regenerating native

125 Agriculture and Resource Management Council of Australia and New Zealand. *Priorities for National Algal Bloom Research*, April 1993, p.10.

126 McClement, Evidence, 4 August 1993, p.679.

127 McClement, Evidence, 4 August 1993, p.678.

128 McClement, Evidence, 4 August 1993, p.679.

129 McClement, Evidence, 4 August 1993, p.679-80.

130 West Broughton Soil Conservation Board, *District Plan and Three Year Program*, June 1992, p.13.

131 Smith, Evidence, 5 August 1993, p.708.

132 Cullen, Evidence, 27 August 1993, p.871.

vegetation and reduce the capacity of the floodplain to utilise nutrients.[133] Nutrients are also added to the system by animals' defecation and released from mud by wallowing animals.[134] In order to be fully effective riparian strips must be of sufficient width and quality to ensure sustainability.[135]

2.48 In Denmark, the measure has been adopted of fencing off a 20 metre strip from stock;[136] however, the cost of this in Australia may be prohibitive. The situation may be partially addressed by providing stock with drinking troughs away from the river's edge. It was also suggested that the fencing of streams may have the economic benefit of fewer stock losses.[137]

2.49 Community groups could be encouraged to participate in planting programs, such as Landcare and the National Corridor of Green. The Commonwealth Government will provide $3.1 million over the next four years for a 'National Corridor of Green' along the Murray River.[138] The Committee was told that re-vegetating the river banks would not only help to assimilate nutrients but also reduce the erosion of banks, which can be exacerbated by rapid fluctuations in water levels associated with irrigation flows.[139] Bank erosion causes turbidity and nutrient input into waterways, and therefore the implementation of strategies to reduce or prevent this is highly desirable.

2.50 It was pointed out to the Committee that the allocation of buffer strips may cause economic problems on farms as it may mean the sacrifice of some productive land.[140] This raises the question of who

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133 South Australian River Murray Wetlands Management Committee, Submission No.51, p.2.

134 Queensland Herbarium, Submission No. 24, p.5.

135 Murray-Darling Basin Ministerial Council. *Algal Management Strategy for the Murray Darling Basin.* Draft August 1993, p.16.

136 Cullen, Submission No.42, p.5.

137 Cullen, Evidence, 27 August 1993, p.872.

138 Greening Australia Ltd, Supplementary Submission 99(a), p.2.

139 Snowy River Improvement Trust, Submission No.59, p.2.

140 Sinclair, Evidence, 5 August 1993, p.750.

pays for the fencing and any loss of productivity. In some situations they may serve as an effective option, and there are other benefits such as providing wildlife corridors.

(e) Loss of Wetlands

2.51 Wetlands can also play a substantial role in reducing nutrient levels in waterways while having aesthetic and wildlife conservation benefits. Wetlands established further up the catchment can reduce nutrients entering waterways, thus saving on water treatments.[141] In the wetlands on the Onkaparinga River (South Australia) it would appear that 90 per cent of the phosphorus may settle out with the particulate material or may be removed by bacteria.[142] In other areas, if the phosphorus is associated with very fine clay particles, then the amount of sedimentation would be less.[143]

2.52 Other areas are looking at the construction of wetlands. For example, wetlands were established at Carcoar in 1992.[144] The Moree Plains Shire Council has received funding to establish a wetland near the Mungindi treatment plant[145] but construction has been held up by the State.

2.53 The role of water plants in preventing algal blooms is not entirely clear, but they grew densely in the Darling River until recently.[146] Certain water plants, such as *Typha*, have been used successfully in the Netherlands for the treatment of waste water, and are capable of removing substantial amounts of nutrients as well as having a high value as stock fodder.[147] Water plants can also inhibit algal growth

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141 Hart, Evidence, 27 July 1993, p.420; Garrard, Evidence, 5 August 1993, p.750.

142 Bursill, Evidence, 12 August 1993, p.765.

143 Bursill, Evidence, 12 August 1993, p.765.

144 White, G (1992) *Carcoar Wetland - An instream wetland system for nutrient removal.* New South Wales Department of Water Resources.

145 Jones, Evidence, 5 August 1993, p.698.

146 Bowmer, Evidence, 11 September 1992, p.96.

147 Weir, Submission No. 21, p.3.

by producing allelopathic substances[148] and by competing for nutrients. Information is still needed on the best plant species, the best location within the catchment, whether to fence and what size the buffer zones should be.[149]

2.54 The acceptance of wetlands was not universal, and the Committee was told that the removal of phosphorus by wetlands might also be seen as producing a phosphate rich pothole which may cause a problem for the future.[150] Wetlands may remove nutrients from the waterway in summer and release them in winter when other conditions are less favourable for the development of algal blooms.[151] This type of problem must be addressed for each location.

2.55 Research is also needed into the relative effectiveness of permanent and temporary wetlands in nutrient uptake in various regions, as this has been shown to vary from one location to another.[152] Wetlands are not a suitable option in high flow areas.[153]

2.56 Wetlands also provide a refuge for zooplankton which feed on the algae,[154] and research has established a link between phosphorus recycling by zooplankton and blue-green algae.[155] The importance of

148 Moss B, Stanfield J and Irvine K (1990) 'Problems in the restoration of a hypertrophic lake by diversion of nutrient-rich inflow.' *Verhandlungen-Internationale Vereinigung für theoretische und angewandte Limnologie* 24:568-572. Stuttgart Germany

149 Hart, Submission No.61, p.5.

150 Sinclair, Evidence, 5 August 1993, p.749; CSIRO, Submission No.72, p.12.

151 Cullen, Evidence, 27 August 1993, p.868.

152 Suter, Evidence, 12 August 1993, p.784.

153 McComb, Evidence, 22 October 1992, p.353.

154 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae,* August 1992, p.51.

155 Ejsmont-Karabin J and Spodniewska I (1990) 'Influence on phytoplankton biomass in lakes of different trophy by phosphorus in lake water and its regeneration by zooplankton'. *Hydrobiologia* 191:123-128.

these phenomena in the overall scheme is not known, as wetlands can also provide a 'seed' source to the main waterways.[156]

Comments on Phosphorus Levels

2.57 Although phosphorus levels are believed to contribute significantly to algal bloom formation, there are significant gaps in the information available, including: whether phosphorus is always the primary cause; actual sources and relative contributions of various pollution sources; how much is derived from sediments; time taken for nutrients to accumulate; the chemical processes which release nutrients from sediments and whether anything can be done to purge the sediments to remove phosphorus.[157] The assimilatory capacity of the water body for the further introduction of phosphorus will vary according to the existing levels in the sediments and their solubility and the amount entering the system from other sources. Nutrient monitoring of water bodies should include known and potential contributors to the nutrient load.

2.58 The biological responses to the reduced levels of phosphorus vary significantly[158] and it is therefore difficult to predict the environmental impact of the strategies to reduce these levels. The reduction of phosphorus levels in many cases can be achieved by the awareness of facts and governments need to increase the level of public awareness of the potential sources of phosphorus. Communities must appreciate that algal blooms are the visible manifestation of the presence of high nutrient levels. To get the phosphorus levels below critical values there must be a multiple approach to nutrient reduction or there will be limited success. Some landholders will not cooperate unless there is an apparent equity. It is important that strategies do not divide the community into urban and rural factions, as a successful approach will need the cooperation of the entire community.

2.59 Too much emphasis should not be placed on any one phosphorus source and there is a need to identify the current levels and the contributions from different sources. The Committee was told that in Germany, Japan and England approaches to the control of phosphorus

156 Suter, Evidence, 12 August 1993, p.782.

157 CSIRO, Submission No.72, p.7.

158 Jones, Submission No.11, p.4.

levels in water bodies include legislative controls on phosphorus in detergents, land use and agricultural practices, licensing controls on industrial and sewage discharges and aeration of lakes and reservoirs.[159]

2.60 Further information may result in the development of new management strategies[160] or change in emphasis or priority. CSIRO's Catchment Management Support System provides training courses on the technology to determine the nutrient generation rates within a catchment, which provides information to determine the priorities for corrective action.[161] This computer simulation model provides useful information on annual loads in the system which will assist in the development of targets.[162]

2.61 BHP Company Limited were working on a system to continuously measure nutrients in water.[163] This would provide information on sources and identify key areas with nutrient problems. It would also give advanced warning of conditions conducive to bloom development where more intensive monitoring could be implemented.

Pesticides

2.62 The Australian Cotton Foundation research organisation spent $6 million per year, 40 per cent of which was devoted to environmental considerations.[164] One of the main concerns of the Australian Cotton Foundation was pesticide residues, but their effects on the food chain for blue-green algae was unknown. Most samples taken in the Upper Darling System had pesticide levels below the limit of detection and the

159 Burns, Supplementary Submission No.31(a), p.2.

160 CSIRO, Submission No.72, p.7.

161 Blackmore, Evidence, 27 August 1993, p.903.

162 Blackmore, Evidence, 27 August 1993, p.909.

163 Minister for Industry Technology and Regional Development, Submission No.89, p.7.

164 Baker, Evidence, 2 August 1993, p.493.

feasibility and economics of reducing levels would need to be investigated.[165]

Other Chemical Factors

2.63 Other factors may be important, such as trace elements, iron and molybdenum, because of their role in nitrate reduction and nitrogen fixation,[166] although little is known about their influence on blue-green algal blooms. High pH (range 8.6-9.7) also favours bloom development.[167]

Chemical Factors - Conclusions

2.64 There is still considerable work to be done to clarify the links between chemical attributes of water and the development of algal blooms under Australian conditions. There is a need to monitor the levels of nutrients, identify significant sources to enable the assessment of priorities, and implement strategies to reduce ambient levels in the most cost effective manner. There also is a need to establish the threshold levels at which nutrient levels are critical in a variety of water body types. The 1993 ARMCANZ workshop considered further research was needed to determine target nutrient levels for water bodies that would reduce or prevent the development of algal blooms.[168]

2.65 The CSIRO Catchment Management Support System provided a computer simulation of nutrient generation rates within catchments.[169] The next stage was to look at the longevity,

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165 Water Resources Technical Services Division. *Central and North Western Regions Water Quality Program 1991/92. Report on Pesticide Monitoring,* March 1993, p.28.

166 Rueter J and Peterson R (1987). 'Micronutrient effects on cyanobacterial growth and physiology'. *New Zealand Journal of Marine and Freshwater Research* 21: 435-445.

167 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae,* August 1992, p.22.

168 Agriculture and Resource Management Council of Australia and New Zealand. *Establishing Priorities for National Algal Bloom Research,* April 1993, p.11.

169 Blackmore, Evidence, 27 August 1993, p.909.

transportation and fate of those nutrients and subsequent availability and the influence of flow regimes.[170]

2.66 The Committee was concerned, however, that the Nepean Hawkesbury Catchment Management Council was unable to get information on nutrients in the river system, although this information had been collected by government instrumentalities. The extent to which other catchment committees had similar problems is not known. A vital part of the process is the release of information to the community to provide feedback on the success or failure of the steps taken in the implementation of the integrated catchment management approach.

Recommendation 15

The Committee recommends that all data collected by government instrumentalities in relation to nutrient levels be made available to other agencies and the public.

Physical Features

2.67 A number of physical environmental features also affect the development of algal blooms, and these include the flow rate of water, light, turbidity and temperature. Under certain physical conditions, blue-green algal species have a competitive advantage over other species of algae and therefore a number of these factors provide potential mechanisms for controlling these species.

Flow rates

2.68 Australian natural waterways are characterised by irregular and extreme flow regimes. Progressively flows have been determined more and more by irrigation, urban and industry requirements.[171] The control of the volume, duration and frequency of river flow also provides a mechanism for managing blue-green algae blooms as increased flow rate and turbulence inhibit bloom development. For example, the low

170 Blackmore, Evidence, 27 August 1993, p.909.

171 CSIRO, Submission No.72, p.10.

turnover of water in the Chaffey Dam is considered to contribute to the increased frequency of algal blooms[172] and the relative absence of algae in other storage dams was attributed to the high turnover rate.[173] The influence of retention time requires further research.[174]

Water Allocations

2.69 The National Resource Management Strategy which the Murray-Darling Basin Commission is currently implementing is the first time the four State governments (Queensland, New South Wales, Victoria and South Australia) have come up with a generic policy for flow management.[175]

2.70 The four States in the Murray-Darling Basin have had different policies on water allocation. Although South Australia stopped further allocations in 1968, and New South Wales and Victoria in the 1980s, there is quite a lot of water allocated which has not been used.[176] The Committee was told that there are also a number of outstanding applications for licenses.[177]

2.71 Up to 85 per cent of the average yearly volume of water in the Murray-Darling Basin may be diverted for irrigation.[178] The Committee was told that the over-allocation of water in the Dumaresq,

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172 Chaffey Dam Catchment Management Advisory Committee, Submission No.25, p.3.

173 Baker, Evidence, 2 August 1993, p.496.

174 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae* August 1992, p.135.

175 Blackmore, Evidence, 27 August 1993, p.910.

176 Blackmore, Evidence, 27 August 1993, p.910.

177 Culgoa-Balonne Minor Distributory System Water Users' Association, Supplementary Submission No.37(a), p.1.

178 Gutteridge, Haskins and Davey, *An Investigation of the Nutrient Pollution in the Murray-Darling River System*, Murray Darling Basin Commission, January 1992.

Barwon and MacIntyre rivers was so great that existing allocations were only realised in 35 per cent of years.[179]

2.72 Mr Bursill told the Committee:

> There are four points that I would like to make in relation to the blue-green algae issue. The first is on flow regulation. It is my belief that the flow issue is a critical one for managing this problem. I believe that the over-allocation of water to irrigation in the upstream areas of the Murray-Darling Basin has been the major factor that led to the bloom in 1991 and the continuing problems that they are having there.[180]

2.73 In order to reintroduce natural variability in river flow, New South Wales is reviewing future water allocations and mechanisms for managing unregulated flows.[181] In the interim, a moratorium could be imposed on additional abstraction licenses.[182] The effective measurement of water extraction would require a time/event/flow meter on every licence and other major water users[183] but may partially address the problems in the regulated sections of the river. The Committee was also told that in some areas there is a need to have surveillance for illegal pumping.[184]

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179 Blainey, Evidence, 2 August 1993, p.478.

180 Bursill, Evidence 12 August 1993, p.755.

181 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae,* August 1992, p.111-112.

182 National Fishing Industry Council Ltd, Submission No.64, p.1.

183 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae,* August 1992, p.113.

184 Doohan, Submission No. 28, p.4.

Recommendation 16

The Committee recommends that as part of the development of the National Water Quality Management Strategy, no further irrigation water entitlements be issued in any area until it has been established that there is adequate water available to meet the environmental requirements of the downstream sections of the waterway after existing allocations have been used.

2.74 The Cubbie Station project design enables the landholder to use flood waters under license to keep water on-farm in deep storages.[185] The 'off-allocation flows' are used by landholders in the Barwon/Darling; however, this is creating problems for farmers downstream, and the New South Wales Department of Water Resources has been requested to regulate the diversion of this water.[186] Unlimited off-allocation water use is considered no longer acceptable by some.[187]

Unregulated Sections

2.75 Only those sections of the river which can be reasonably supplied with water are currently being regulated[188] which can result in the uptake of environmental flows and the water to be used by consumers further downstream by users in the unregulated river sections. The New South Wales Department of Water Resources is developing an unregulated flows policy and an interim plan is being trialled for the north west rivers.[189] The use of unregulated flows is particularly a problem in some tributaries where it is used for on-farm storage and this was adding to the problems as summer freshes did not reach the lower catchments.[190]

185 Cubbie Station, Submission No.36, p.5

186 NSW Irrigators' Council, Submission No. 17, p.16.

187 New South Wales Blue-Green Algae Task Force, Submission No.53, p.4.

188 Arnott, Evidence, 5 August 1993, p.710.

189 New South Wales State Algal Coordinating Committee, Supplementary Submission No.53(a), p.8.

190 NSW Irrigators' Council, Submission No.17, p.16; Culgoa Balonne Minor Distributary System Water Users' Association, Submission No.37, p.6.

2.76 This raises the question as to whether governments need to guarantee water supplies to future water allocations, and whether the existing unregulated section should be subjected to similar restraints as the regulated sections. This would ensure the passage of environmental flows through those sections of the river.

Recommendation 17

The Committee recommends that the Commonwealth Government use its influence to facilitate the urgent consideration of further controls on the unregulated sections of major waterways to ensure the passage of environmental flows and water for downstream users.

Recommendation 18

The Committee recommends that as part of the development of the National Water Quality Management Strategy, urgent attention be given to feasibility of the continued use of off-allocation flows, and that the communities concerned be advised accordingly.

Recommendation 19

The Committee recommends that as part of the development of the National Water Quality Management Strategy, urgent attention be given by the responsible authorities to the feasibility of meeting existing water allocations in the future, including those that have been granted but not yet used, and that the communities concerned be advised accordingly.

Environmental Flows

2.77 In determining optimal flow rates, environmental factors such as fish breeding riverine corridors, floodplains and wetland requirements should be considered. The timing of water releases can be critical for the survival of these ecosystems. One aspect of environmental flows is the flow rate of water required to prevent and to flush developing algal

blooms. The use of environmental flows raises the question of who owns and polices the environmental flows.[191]

2.78 The Murray-Darling Basin Commission and the States are developing a policy on instream environmental requirements within the concept of integrated catchment management.[192] The New South Wales Department of Water Resources is also developing an environmental flows policy[193] and is implementing a program of Environmental Contingency Allowance which will provide water for environmental and water quality requirements.[194]

2.79 The Committee appreciates that the environmental requirements may not be synonymous with the flushing of algal blooms and an ecosystem approach is essential. The long term flow regime must be able to sustain the riverine ecosystem, and the improved health of the water ways and riverine corridors should reduce the need for flushes to deal with algal blooms.

Recommendation 20

The Committee recommends that the Commonwealth Government use its influence where possible to facilitate the introduction of environmental allocations nationally after consideration of the legal, social and economic implications.

Flood Plains

2.80 The Committee was told that little is known about the needs of flood plains for inundation.[195] Floods have been shown to boost the populations of key species on the river plains, and in the absence of

191 Heeps, Evidence, 25 September 1992, p.205

192 Blackmore, Evidence, 27 August 1993, p.910.

193 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.110.

194 New South Wales State Algal Coordinating Committee, Supplementary Submission No.53(a), p.8.

195 Donovan, Evidence, 2 August 1993, p.480.

regular flooding gaps in the population structure are becoming apparent.[196] The Western Total Catchment Management Committee in New South Wales is looking at the effects of flooding on the economic and social activities of the community downstream from Whyenbah.[197] Further developments which impact on the quality or quantity of water flow should only be permitted after the impact on downstream flood plains is assessed.

Recommendation 21

The Committee recommends that as part of the development of the National Water Quality Management Strategy, the approval of future developments be dependent on an assessment of the impact on downstream flood plains.

Additional Flows

2.81 Additional flows have been used for flushing of blooms or potential blooms. However, there is a need to adopt flexible management strategies for individual flow events.[198] It is considered that 2 000 ML/day for five days is sufficient for the Barwon-Darling system;[199] 10 000 ML/day in the River Murray in South Australia reduced algal blooms which still occurred at 7 000 ML/day.[200] The duration of the protection resulting from 'flushing' is not known and this mechanism depends on water availability.[201] Adequate flow rates are necessary after an algal bloom to purge the area of the nutrients

196 Jensen, Evidence, 12 August 1993, p.777.

197 Treweeke, Evidence, 4 August 1993, p.661.

198 Culgoa-Balonne Minor Distributary Water Users' Association, Submission No.37, p.11.

199 New South Wales Government, Submission No.53, p.5.

200 Engineering and Water Supply Department, South Australia, Submission No.49, p.6.

201 New South Wales Blue-Green Algae Task Force, Submission No.53, p.5-6.

which will be released on the decay of the algal mass and which would otherwise be available for a future bloom.[202]

2.82 This approach can also have disadvantages: for example, significant changes in the water height e.g. 1-3 metres, stress aquatic organisms through temperature and chemical changes.[203]
The District Council of Meningie, however, reported that despite high flow rates in the Murray River and the use of dilution flows, there had been subsequent occurrences of toxic algae.[204] The use of additional flows is expensive and may not be efficient, even if sufficient water is available. The time delay in getting the water to the affected area may make this approach unworkable, and if the water needs to pass through unregulated sections of the river it may not reach the intended area.

2.83 The Committee was given the example of where Pian Creek has been identified as a source of blue-green algae and requests were made to the Department of Water Resources to ensure continuous flows in that waterway.[205] The potential to meet the demand for these additional flows is dependent on the amount of water available. In most areas of Australia, water is not available and the potential to expand water storage capacity is restricted to the less economically viable dam sites.[206] This approach would impose environmental costs, such as the loss of valley areas and a reduction in natural flows.[207]

Future Requirements

2.84 Nationally, 75 per cent of harnessed water is used by irrigators,[208] who have outlayed substantial capital in the expectation of future levels of water supply.[209] Water allocation to irrigators is

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202 Jones, Submission No.11, p.4.

203 Bowmer, Evidence, 11 September 1992, p.141.

204 District Council of Meningie, Submission No.3, p.4.

205 Austin, Evidence, 3 August 1993, p.627.

206 Australian Irrigation Council, Submission No.58, p.6.

207 Australian Irrigation Council, Submission No.58, p.8.

208 Australian Irrigation Council, Submission No.58, p.6.

209 MacIntyre Valley Cotton Growers Association Inc, Submission No.96, p.1.

becoming increasingly restricted by the environmental and community needs, and the irrigators are concerned that previous over-allocation of water may have jeopardised the reliability of future supplies in some catchments.[210] There was, therefore, an expectation on the part of irrigators that the requests for environmental flows should be scientifically justified.[211] The Council of Australian Governments will consider the question of environmental flows in February 1994, and the ARMCANZ is preparing a report on the issue which outlines what each State/Territory is doing.

2.85 The Dumaresq-Barwon Border Rivers Commission is currently using a daily step integrated quality-quantity model of the border rivers. After the completion of the community consultation process currently being undertaken, this model will enable the prediction of economic and environmental impacts of various resource development scenarios.[212] This will enable the Commission to determine flow allocations for the intersecting streams while taking into account the social, economic and environmental needs of the wider Murray-Darling Basin.[213]

2.86 Future requirements may need to be met through the trading of transferable water entitlements, which have been introduced in some areas.[214] Other possible reforms include water pricing policies with lower tariffs or rebates as incentives for improved farming practices; surcharges for environmental flows required to dilute discharges; and the use of integrated planning in which water surplus can be used by adjacent farms.[215]

2.87 Improved agricultural techniques will reduce water wastage, and through increased productivity will provide social and economic benefits.[216] The Committee was told that many plant nurseries are

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210 NSW Irrigators' Council Submission, No.17, p.13.

211 Australian Irrigation Council, Submission No.58, p.3.

212 Hutton, Evidence, 27 August 1993, p.917.

213 Hutton, Evidence, 27 August 1993, p.917.

214 NSW Irrigators' Council, Submission No.17, p.15.

215 Campaspe Region Water Authority, Submission No.32, p.6.

216 Engineering and Water Supply Department, South Australia, Submission No.49, p.9.

already recycling water because of the rise in water rates.[217] Some taxation incentives are available under Sections 51(1) and 75(b) and (d) of the *Income Tax Assessment Act 1936* to assist primary producers with soil and water conservation management.

2.88 The irrigation and farming industries have been doing a great deal of research into the most efficient use of the water available. The National Irrigation Research Fund has produced a national strategy, *Irrigation Research and Development in Australia,* which suggests that a national levy on water used by irrigators could provide some of the funds for research and development.[218] For example, developments such as the use of neutron probe moisture meters, enabling more efficient water scheduling, have been introduced by some irrigators.[219]

Urban Water Users

2.89 A great deal can also be done to reduce water use in urban areas. Education awareness may be beneficial but other measures include appropriate pricing schemes, use of 'grey' water for gardens and toilets, imposing stricter water restrictions during droughts, and encouraging the use of water-efficient appliances, such as shower roses and installation of tanks. The Committee was told that property based charges should be replaced with access plus usage charge[220] as this would provide a greater incentive to use less water.

Flow Rates - Conclusions

2.90 In some circumstances, increased flow rates may provide a quick short term solution once more is known about the environmental requirements and tolerance of each waterway. However, this approach may also be politically more difficult and may be at risk during drought as it reduces the amount of water available for agricultural needs.

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217 Scott, Evidence, 2 August 1993, p.449.

218 National Irrigation Research Fund. *Irrigation Research and Development in Australia. A National Research Strategy.* Prepared by S Wood and L Banks, June 1991, p.21.

219 Australian Cotton Foundation, Submission No.66, p.6.

220 The Response of the Queensland Government to the Industry Commission's Draft Report on Water Resources and Waste Water Disposal. May 1992,p.10.

Adequate flow rates are environmentally beneficial in a number of other respects: maintaining fish populations; maintaining wetlands which stabilise river banks and reduce soil erosion; preventing the formation of intermittent pools of low quality, deoxygenated water suitable for breeding mosquitos and other pests requiring the use of insecticides;[221] and increasing the nutrient capacity of the ecosystem.[222]

2.91 The flow rates required to prevent algal blooms is an important consideration in determining environmental flow requirements. Flow rates suitable for flushing blue-green algae may not be conducive to the other environmental requirements. In the Macquarie Valley, requirements for environmental flows have been given priority access to surplus flows.[223] Insufficient is known of the benefits of floods to the environment and to agriculture, and a multidisciplinary approach to the whole system is needed to ensure adequate water is available for flood plains.[224]

2.92 Given the variability of the structure of river beds there are a number of factors to be considered in determining optimal flow regimes. There are also 'fundamental questions' to be answered in relation to the flow rates required to prevent the development of anoxic sediments[225] and the Committee was told that a better understanding of the relationship between algal growth and flow rates is needed. Changes in flow regimes in the Murray River have expanded the permanent wetlands but reduced the extent of the 'more productive temporary wetlands'.[226] The environmental flow requirements for the downstream sections can be used as dilution flows or wetlands

221 Weir, Submission No.21, p.1.

222 Humphries, Evidence, 22 October 1992, p.340.

223 Macquarie Valley Irrigators Association, Submission No.65, p.7.

224 Culgoa-Balonne Minor Distributary System Water Users' Association, Submission No.37, p.7.

225 National Project Manager, Algal Bloom Research ARMCANZ, Submission No.33, p.7.

226 South Australian River Murray Wetlands Management Committee, Submission No.51, p.2.

throughflow in upstream areas,[227] provided the timing is suitable for both uses.

Temperature

2.93 Blue-green algal bloom development is also usually associated with warmer temperatures, which may increase the buoyancy of some species,[228] although this is not always the case. The tolerance of blue-green algae species to temperature extremes differs markedly.[229] A toxic algae bloom was recorded at Melton Reservoir at 8° C,[230] and in Ballarat while snow was falling.[231] Blooms have been recorded in ice covered lakes in Canada and Finland.[232]

2.94 High temperatures can cause thermal stratification of deeper water bodies, which locks nutrients in the bottom layer where they can be accessed by blue-green algae.[233] Temperature also affects the solubility of gases and hence algal growth.[234] In Danish lakes, temperature and turbulence have been found to influence the persistence of algal blooms.[235] Temperature changes may act

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227 Engineering and Water Supply Department, South Australia, Submission No. 49, p.5.

228 Klemer A and Barko J (1991) 'Effects of mixing and silica enrichment on phytoplankton seasonal succession'. *Hydrobiologia* 210:171-181.

229 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.37.

230 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.7.

231 Ballarat Water Board and West Moorabool Water Board, Submission No.44, p.3.

232 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.17.

233 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae,* August 1992, p.41.

234 Boney A (1989) *Phytoplankton* (2nd Ed), Edward Arnold Publishers Melbourne.

235 Australian National Industries Ltd, Submission No.39, p.11.

synergistically with other factors such as light.[236] Although algal blooms occur more frequently in the summer months they can also occur in winter during low flow conditions.

Light

2.95 Algal photosynthesis is dependent on the angle, duration and intensity of sunlight. Blue-green algae form phycobiliprotein pigments which are suited for the light regime under water,[237] so lower light levels may be advantageous to these genera of algae. Floating blue-green algal cells shade competitors. However, in high light intensity the algae on the surface are killed by photooxidation.[238] A shallow photic zone may also benefit zooplankton, which may hide from predatory fish in the low light depths.[239] However, light control has limited potential as a mechanism for algal bloom prevention. Shading of rivers by planting trees in riverbanks or covering small water bodies may have limited success.

Turbulence

2.96 Turbulence depends on the morphology of the water body, wind and water currents. Blue-green algal blooms are more buoyant and can remain near the surface in calmer waters[240] and the degree of turbulence determines the length of time the algal cells remain in the photic zone,[241] and therefore affects the growth rate. Turbulence may also increase nutrient uptake by the algal cells, and therefore growth

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236 Robarts R and Zoharty T (1987) 'Temperature effects on photosynthetic capacity, respiration and growth rates of bloom-forming cyanobacteria'. *New Zealand Journal of Freshwater Research* 21:391-399.

237 Bowmer K (1981) 'Nutrient Enrichment Eutrophication cause of problem plant growth - possibilities for regulation'. In: *Waterplants of New South Wales* (Ed G Sainty and S Jacobs) NSW Department of Water Resources, Sydney pp.491-501, p.496.

238 Water Studies Centre, Submission No.30, p.2.

239 Shapiro, J (1990) 'Biomanipulation: the next phase - making it stable'. *Hydrobiologia* 200/201:13-27.

240 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae,* August 1992, p.40.

241 'What can be done about algal blooms' *Ecos* 72 Winter 1992 pp.14-19, p.15.

may occur at lower nutrient concentrations than in static water bodies.[242] In Danish lakes, the degree of turbulence was also found to influence the persistence of algal blooms.[243] The ARMCANZ workshop considered that insufficient was known about the sensitivity of blue-green algae to turbulence.[244]

Turbidity

2.97 Turbidity is a major factor in limiting algal growth rates because it reduces the amount of light available but contributes significant levels of nutrient. The clearing of land should require prior approval by catchment management authorities. Sedimentation will reduce turbidity levels in slow flowing waterways, creating more suitable conditions for algal growth.[245] Turbidity levels most favourable to algal growth are 30-50 NTU.[246] Saline ground waters may clear turbidity thus promoting algal growth when seeping into water bodies.[247]

Comments

2.98 Research is being done to identify the extent and causes of algal blooms to enable the monitoring of trends which will assist in the

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242 Bowmer K (1981) 'Nutrient Enrichment Eutrophication cause of problem plant growth - possibilities for regulation'. In: *Waterplants of New South Wales* (Ed G Sainty and S Jacobs) NSW Department of Water Resources, Sydney pp.491-501, p.496.

243 Australian National Industries Ltd, Submission No.39, p.11.

244 Agriculture and Resource Management Council of Australia and New Zealand. *Priorities for National Algal Bloom Research*, April 1993, p.10.

245 Meningie Progress Association, Submission No.22, p.3.

246 NTU: Nepholometric Turbidity Unit (a measure of turbidity).
Bain D (1992) *Algae and Low Flows in the River Murray* Extract p.7; National Rivers Authority (1990) *Toxic Blue Green Algae* Water Quality Services No.2. pp.128; Geddes M (1988) 'The role of turbidity in the limnology of Lake Alexandria, River Murray, South Australia; comparisons between clear and turbid phases', *Australian Journal of Marine and Freshwater Research* 39:201-209.

247 CSIRO, Submission No.72, p.7.

prediction and management of future blooms. A more accurate estimation of the extent of the problem will assist in risk assessment and the allocation of resources. There is a need to define the relationship between algal growth and flow rates, the interaction between flow rate and nutrient levels and a minimum threshold flow rate to make this a successful approach. The Murray-Darling Basin Agreement specifies a minimum monthly expected or entitlement flow, but this is not guaranteed in adverse conditions.[248]

2.99 There is a need for an integrated approach to considering the chemical, physical and biological environmental facts in researching the cause of algae bloom development in a range of water bodies.[249] Many of the chemical and physical factors discussed in this section have a significant effect on blue-green algal growth, and therefore offer potential avenues for management and control. This should be balanced against the needs of the entire range of environmental processes and life history of fauna and flora utilising the aquatic ecosystems.

2.100 The piecemeal approach to water allocation is a historical problem. The role of all levels of government is now to ensure the use of resources in the interests of society as a whole.[250] The aim should be clean, healthy and resilient water systems within an acceptable timeframe, although different environmental targets may be appropriate for different uses. Nutrients stored in the sediments will continue to support toxic blooms even when the pollution levels are markedly reduced, but this must not be used to justify inaction.

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248 Engineering and Water Supply Department, South Australia, Submission No.49, p.4-5.

249 Australian Water Resources Council, Algal Bloom Research Management. *Algal bloom research in Australia: a progress report of current status and key issues.* November 1992, p.9.

250 National Landcare Program Discussion Paper. *Sustainable National Resource Management - Integration of Primary Industries and Energy Programs.* Department of Primary Industries and Energy. April 1992, p.7.