

## CHAPTER 3

# IMPLICATIONS AND MANAGEMENT OF ALGAL BLOOMS

### Effects of Algal Blooms

3.1 In the year 1992/93, a total of 140 algal blooms were recorded in Queensland, New South Wales, Victoria and South Australia.<sup>251</sup> Monitoring at Chaffey Dam, for example, has shown that blooms are not only increasing in frequency, but also duration and toxicity.<sup>252</sup>

3.2 The disruptive impact of algal blooms appeared to be less in 1992/93 than in previous years, although recreational areas were closed more frequently.<sup>253</sup> Domestic water supplies still have different levels of treatment, some of which are able to remove the algal cells while others merely disinfect the water, thus killing the algae and releasing the toxins.<sup>254</sup> The Committee was told that the Aboriginal community at Cummeragunja pump their water supply directly from the river.<sup>255</sup>

3.3 The effects of algal blooms include the aesthetic effects, the taste and odours in water supplies. Taste can be detected at 2000 cells/ml.<sup>256</sup> Odours and taste of blue-green algae are difficult to remove in conventional sewage treatment plants.<sup>257</sup> The 1993 ARMCANZ workshop pointed out that insufficient is known about the factors which control the production of taste and odour compounds and

---

251 *National Algal Scoreboard 1992/93*. Water Forum. Agriculture and Resource Management Council of Australia and New Zealand, p.1.

252 Sinclair, Evidence, 5 August 1993, p.736, 747.

253 *National Algal Scoreboard 1992/93*. Water Forum. Agriculture and Resource Management Council of Australia and New Zealand, p.4.

254 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.76.

255 Bailey, Evidence, 2 August 1993, p.527.

256 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.99.

257 Gutteridge Haskins and Davey Pty Ltd, Submission No.18, p.1.

the potential effects of measures implemented to reduce algal growth on the production of taste and odour compounds.<sup>258</sup>

3.4 Other effects of algal blooms include the clogging of filters and other equipment, and changes in water pH may interfere with the efficiency of the water treatment process. The deoxygenation of water bodies can also be a problem after the more severe blooms. During the decay process, non-toxic algae can also deoxygenate the water and sulfur compounds, such as rotten egg gas may be formed causing the discolouration of water and producing pungent odours which discourage the recreational use of water bodies and may result in fish kills.<sup>259</sup>

3.5 Of greater consequence, however, is the formation of toxins. There are three types of toxins produced by blue-green algae - neurotoxins, hepatotoxins and lipopolysaccharides. *Anabaena* and *Aphanizomenon* may produce neurotoxins while *Nodularia*, *Anabaena*, *Cylindrospermopsis*, *Microcystis*, and *Oscillatoria* may produce hepatotoxins.<sup>260</sup> Neurotoxins need to be above a threshold level to cause paralysis, but hepatotoxins cause cumulative damage to the liver.<sup>261</sup>

3.6 Gastroenteritis, hepatitis and hepatoenteritis in humans in Australia, North America and Africa have been attributed to toxins present in *Microcystis*, a blue-green algae<sup>262</sup> which has been recorded

---

258 Agriculture and Resource Management Council of Australia and New Zealand. *Priorities for National Algal Bloom Research*, April 1993, p.12.

259 Australian Water Resources Council, *Freshwater Algal Blooms Occasional Paper* prepared by the Water Resources Management Committee of the Australian Water Resources Council, November 1991, p.2.

260 Falconer I (1991) 'Tumor Promotion and Liver Injury Caused by Oral Consumption of Cyanobacteria' *Environmental Toxicology and Water Quality: An International Journal* 6:177-184, p.179.

261 Burch, Evidence, 12 August 1993, p.763.

262 Falconer I (1991) 'Tumour Promotion and Liver Injury caused by Oral Consumption of Cyanobacteria'. *Environmental Toxicology and Water Quality: An International Journal* Volume 6: 177-184, p.177.

in the Armidale water supply.<sup>263</sup> The toxin microcystin is also being studied for its potential to promote tumour formation.<sup>264</sup>

3.7 One case of gastroenteritis was reported in Toowoomba in 1903<sup>265</sup> although there were reports as early as 1887.<sup>266</sup> A major outbreak was reported on Palm Island<sup>267</sup> which may have been due to species of *Cylindrospermopsis*.<sup>268</sup> Gastroenteritis and hepatoenteritis cases have been reported after both accidental intake during recreation and drinking infected water.<sup>269</sup>

3.8 Swimmers have reported respiratory allergies, rashes and lesions and eye irritations, and *Nodularia* lipopolysaccharides are known to cause dermatitis and respiratory allergy.<sup>270</sup> During the Darling-Barwon algal bloom there was only one reported case of a male suffering from skin rash, conjunctivitis, diarrhoea and respiratory problems.<sup>271</sup> There have also been cases of atypical pneumonias as a result of people breathing aerosols from blooms.<sup>272</sup>

---

263 Falconer, Submission No.16, p.1.

264 Falconer I (1991) 'Tumour Promotion and Liver Injury Caused by Oral Consumption of Cyanobacteria'. *Environmental Toxicology and Water Quality: An International Journal* 6: 177-184.

265 Queensland Water Quality Task Force, *Interim Report of Freshwater Algal Blooms in Queensland*, 31 July 1992, p.7.

266 Proclu P (1993) 'Algal toxins and bellyaches beyond the Barcoo'. *Medical Journal of Australia* 158:433-434, p.433.

267 Falconer I (1988) 'Eutrophication by toxic blue-green algae. An increasing hazard in Australia'. *Australian Biologist* 1(4): 10-12, p.11; Byth S (1980) 'Palm Island mystery disease'. *Medical Journal of Australia* 2:40-42..

268 Falconer I (1993) Letters to the Editor. *Medical Journal of Australia* 158:433-4, p.434.

269 Falconer, Evidence, 12 August 1993, p.789.

270 Soong, F, Maynard E, Kirke K and C Luke (1992) 'Illness associated with blue-green algae'. *Medical Journal of Australia* 156: 67.

271 New South Wales Blue-Green Algae Task Force, Final Report, *Blue-Green Algae*, August 1992, p.32.

272 Cullen, Evidence, 27 August 1993, p.863.

3.9 Serious blooms in Queensland in 1992/93 resulted in the closure of a number of water storages for several months.<sup>273</sup> Water supply operators in the past needed to unnecessarily close down supplies as a precaution because they were unable to test toxicity.<sup>274</sup> The availability of an effective toxin measuring procedure may also result in undue public alarm when algal blooms are nontoxic, or lead to the use of unsafe and expensive treatments, such as copper sulfate.<sup>275</sup>

3.10 There are substantial gaps in our knowledge in relation to the identification and detection of toxins. Some toxins have not been identified or their levels of toxicity are still unknown; for other toxins adequate toxicity measurements are not available.<sup>276</sup> There have been some recent advances in toxin detection methods, such as the identification of saxitoxins in *Anabaena*, and the methods of detecting hepatotoxins enable communities to better deal with those situations.<sup>277</sup> Geosmin, microcystin and nodularin now have a detection threshold of  $<1\mu\text{g/L}$ .<sup>278</sup> Temperature, light and nutrients may affect toxin production<sup>279</sup> although light and nitrogen levels may have the strongest effects.<sup>280</sup> The ability to detect and measure toxins in water bodies will enable research into the factors promoting their formation and therefore allow the prediction of toxic conditions.

---

273 Queensland Water Quality Task Force. *Interim Report on Freshwater Algal Blooms in Queensland*. 31 July 1992, p.11.

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

275 Burns, Submission No.31, p.4.

276 National Project Manager, Algal Bloom Research ARMCANZ, Submission No.33, p.10.

277 Bursill, Evidence, 12 August 1993, p.754.

278 'What can be done about toxic algal blooms'. *Ecos* (Winter 1992) 72:14-19, p.16; Murray-Darling Basin Commission. *Algal Management Strategy. Technical Advisory Group Report*. April 1993, p.21.

279 Sivonen K (1990) 'Effects of Light, Temperature, Nitrate, Orthophosphate and Bacteria on the Growth of and Hepatotoxin production of *Oscillatoria agardii* strains'. *Applied and Environmental Microbiology* 56(9):2658-2666.

280 Murray-Darling Basin Commission (1993) *Algal Management Strategy. Technical Advisory Group Report*. April 1993, p.17.

3.11 It was also pointed out that to test water for algal toxins the samples were taken from a highly concentrated scum which was not necessarily representative of the water being used in the domestic supply, a procedure which may result in the unnecessary closure of water supplies.<sup>281</sup> Canadian toxicity testing has shown that there can be a 'mosaic of toxicity' where adjacent samples may give differing toxicity results.<sup>282</sup> The reliability of limited testing may therefore not be sufficient to measure the potential danger. Accordingly, algal density may only be used as an indication of the potential danger.

3.12 Toxicity levels may change with the age of the blooms and with different environmental conditions. For example, the Committee was told that when water was released from Chaffey Dam toxins disappeared in the natural flow of the river.<sup>283</sup> Further research is needed into the degradation rates of toxins released during the decay of the cells for Australian algal species.<sup>284</sup> Work is also needed into the longevity of toxins in the water supply to determine when it is safe to start using the water again and for which uses it is safe. There is evidence that microcystins can persist in water without microflora for months and in the presence of bacteria for up to three weeks.<sup>285</sup>

3.13 There is some information available on the effects of acute doses of algal toxins, although more work needs to be done on the individual effects of specific toxins on humans. The National Health and Medical Research Council is currently preparing a report on the health effects of toxic algae, which will consider areas for further research and list these in order of priority.<sup>286</sup>

---

281 van Dok, Evidence, 27 July 1993, p.409.

282 National Herbarium of New South Wales, Supplementary Submission No.4(a), p.1.

283 Garrard, Evidence, 5 August 1993, p.748.

284 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.15.

285 Murray-Darling Basin Commission (1993) *Algal Management Strategy. Technical Advisory Group Report.* April 1993, p.18.

286 Agriculture and Resource Management Council of Australia and New Zealand. *Priorities for National Algal Bloom Research,* April 1993, p.12.

3.14 Further research is also needed on the factors promoting the formation of toxins;<sup>287</sup> the effects of long term ingestion of low level algal toxins;<sup>288</sup> the increased hypersensitivity to subsequent doses,<sup>289</sup> and the effects of total exposure may be as critical as acute exposure.<sup>290</sup>

3.15 The measurement of toxicity levels enables the development of better strategies for managing algal blooms. The most effective method of toxin concentration determination in the past has been by mouse bioassay, which can only be performed in a few laboratories. Bioassay, immunoassay, enzyme assay and chemical methods may also be used<sup>291</sup> and can give an indication of toxicity in less than a day.<sup>292</sup> The Committee was told that it took up to a week to obtain toxicity results, but Professor Falconer pointed out that samples were usually transported by bus<sup>293</sup> and the laboratory time was less than 24 hours. Research needs to be done into means of enabling field identification of toxic strains. The New South Wales State Algal Coordinating Committee is preparing an algal toxins data base.<sup>294</sup>

3.16 The effect of algal blooms on potable water supplies is diminishing as water treatment methods are improved, and there is less need to turn off water supplies.<sup>295</sup> A greater awareness has led to much closer

---

287 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.11.

288 Australian Water Resources Council. *Freshwater Algal Blooms*. Occasional Paper prepared by the Water Resources Management Committee of the Australian Water Resources Council, November 1991, p.9.

289 Soong F, Maynard E, Kirke K and C Luke (1992) 'Illness associated with blue green algae'. *Medical Journal of Australia* 156: 67.

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

291 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.86.

292 Burch, Evidence, 12 August 1993, p.764.

293 Falconer, Evidence, 12 August 1993, p.791.

294 New South Wales State Algal Coordinating Committee, Supplementary Submission No.53(a), p.7.

295 Johnstone, Evidence, 27 July 1993, p.395.

monitoring, which has enabled treatment of blooms before they reach levels which threaten public health.<sup>296</sup> The Australian Centre for Water Quality Research is looking at the effectiveness of chlorination treatments on hepatoxins<sup>297</sup>; activated carbon treatments are sometimes used, and research is being done into ozone treatment of microcystins.<sup>298</sup>

**3.17** Insufficient is known of the thresholds and dose response relationships of algal toxins.

**3.18** Extensive deaths in wild and domestic birds and animals have been attributed to *Anabaena* blooms in Canada and North America, but most species of *Anabaena* in Australia are non-toxic, although toxic compounds may develop with time.<sup>299</sup> There was little evidence of wildlife kills in the Darling River 1991-92 bloom, which may have been due to their tolerance, the removal of carcasses by carrion feeders, alternative water supplies, the small volume ingested, low toxicity levels, the susceptibility and age of the animals.<sup>300</sup> Seasonal loss of condition or the effects of drought may also affect the tolerance levels of wildlife and stock. Little research has been conducted into the environmental implications of algal blooms other than the obvious fish kills and wild life losses.

**3.19** Stock losses of 1600 sheep and cattle were attributed to the blue-green algal bloom in the Darling-Barwon 1991 blooms.<sup>301</sup> These types of stock losses have received considerable publicity. However, information on the adverse effects of the condition of stock and on

---

296 Johnstone, Evidence, 27 July 1993, p. 395.

297 Nicholson B, Rositano J, Humpage A and Burch M, (1993). 'Removal of algal toxins in water treatment processes'. Proceedings of Australian Waters and Waste Water Association Convention, 15, 18-23 April 1993. Gold Coast, Queensland.

298 Murray-Darling Basin Commission. *Algal Management Strategy. Technical Advisory Group Report*. April 1993, p.23.

299 Falconer, I (1988) 'Eutrophication by toxic blue-green algae. An increasing hazard in Australia'. *Australian Biologist* 1(4): 10-12, p.11.

300 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.84.

301 Ibid, p.82.

reduced productivity, particularly resulting from long term exposure at sub-bloom levels, is required. Stock can also lose condition by avoiding nearby water during algal blooms,<sup>302</sup> and from having to walk considerable distances in search of clean water. Free range stock are difficult to move away from the river.<sup>303</sup> Liver damage has been found in sheep which may be linked to the algal bloom.<sup>304</sup> There are also concerns in relation to reduced milk production and residual toxins in meat products, fruit and vegetables.<sup>305</sup> Other than the possibility of residuals in produce, the presence of algae does not appear to have any adverse effect on irrigation operations other than clogging the pumps, and may even contribute nutrients.<sup>306</sup>

**3.20** Toxin accumulation in fish and shellfish and in other foods consumed by humans requires further investigation. Little is known about their toxicity to these animals and other wildlife, or their potential threat to humans ingesting these. Recent research has shown that mussels should not be consumed during toxic algae blooms.<sup>307</sup> It is also reasonable to expect that liver of stock would accumulate toxins.<sup>308</sup>

### *Public concerns*

**3.21** Serious health effects are relatively rare and can be largely avoided by providing appropriate and timely advice to the public. The Committee was told that warnings released by the New South Wales Environment Protection Authority (EPA) in June 1993 about toxic

---

302 Ibid, p.82.

303 McCutcheon, Evidence, 4 August 1993, p.673-4.

304 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.82.

305 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.11.

306 Blainey, Evidence, 2 August 1993, p.477.

307 Falconer I, Choice A and Hosja W, (1992) "Toxicity of Edible Mussels (*Mytilus edulis*) Growing naturally in an Estuary During a Water Bloom of the Blue-Green Alga *Nodularia spumigena*." *Environmental Toxicology and Water Quality: An International Journal* 17: 119-123, p.119.

308 Falconer, Evidence, 12 August 1993, p.796.



algae in the Hawkesbury area did not reach the community.<sup>309</sup> Further, the Department of Health only received edited information that was two weeks old and on this basis felt they could not make a decision.<sup>310</sup> This situation has now been rectified by the New South Wales State Algal Coordinating Committee requiring the regional committees to report on a weekly basis.<sup>311</sup>

**3.22** The Committee is concerned that an effective public health warning system is not in place in all regions which have potential threat from blue-green algal blooms. Responsible authorities must have sufficient timely information to enable the appropriate management decisions to be taken. The community must have confidence in decisions taken and should be informed of the reasons for those decisions. Contingency plans should provide procedures that may be necessary at the local, regional, State/Territory and national level. The most successful approach will be based on a local sense of 'ownership' and cooperation.<sup>312</sup>

**Recommendation 22**

**The Committee recommends that contingency plans be required to outline the procedures to be carried out at local, State/Territory and Commonwealth levels in the event of algal blooms.**

**Recommendation 23**

**The Committee recommends that as part of the development of the National Water Quality Management Strategy, water managers and health departments be provided with sufficient information in relation to the treatment of algal blooms for them to be able to make timely decisions in relation to the management of water bodies.**

309 Cauchi, Evidence, 3 August 1993, p.554.

310 Cauchi, Evidence, 3 August 1993, p.554.

311 Smalls, Private Briefing, 26 November 1993, p.54.

312 Anderson, Evidence, 25 September 1992, p.202.

**Recommendation 24**

**The Committee recommends that communities be informed of the reasons for decisions taken by water managers and health departments to address toxic algal blooms in their areas.**

3.23 Media coverage is largely responsible for informing the public of the occurrence of blue-green algal blooms, and cooperation could be sought from television and radio stations to provide information on the subsidence of the blooms to alleviate local concerns and to assist the tourism and recreation industries. Media attention on algal blooms has focussed the community attention on the issue, enabling greater participation in remedial measures.

3.24 Some States have produced information sheets to inform the community on the possible risks and necessary action.<sup>313</sup> Some popular misconceptions may still need to be addressed in some areas, for example, there is a misconception that boiling water removes the toxins.<sup>314</sup> The Committee was told that public concerns are also being addressed by holding local meetings and seminars and having a 008 number available for the public in some areas.

**Management of Algal Blooms**

3.25 There is a need to manage algal blooms in the interim while long term management strategies are implemented and become effective. Short term strategies include the use of alternative water supplies, additional water treatment or the restrictive use of water storages.<sup>315</sup> There have been recent improvements in the management of algal blooms in water supplies which have alleviated the need to close down these supplies. There are particular difficulties, however, in managing

---

313 Engineering and Water Supply Department, South Australia, Submission No.49, Appendix; New South Wales Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.29.

314 'What can be done about toxic algae blooms'. *Ecos.* 72 Winter 1992:14-19. p. 16.

315 Queensland Water Quality Task Force, *Interim Report on Freshwater Algal Blooms in Queensland*, 31 July 1992, p.18.

recreation areas and determining whether the entire area should be closed if the scum only covers part of the area, because this may change with weather conditions.<sup>316</sup> The Committee was told that warning signs and verbal advice are often ignored.<sup>317</sup>

### *Public Warning Systems*

3.26 There is currently no common approach to providing a public warning system, as was evident in the Hawkesbury Nepean situation (discussed in 3.20). The failure to make the public aware of a toxic algae bloom may make authorities more liable for negligence. It is essential that there be a process in place which would clearly identify those responsible for particular actions.

3.27 Research needs to be done into the effectiveness of various warning mechanisms, such as the erection of signs or issue of press releases. The appropriate mechanism may vary from locality to locality.

#### **Recommendation 25**

**The Committee recommends that:**

- **a set of guidelines outlining the procedures and responsibilities of water managers and health authorities to provide adequate public warnings be developed; and**
- **a comparative study of the effectiveness of various warning mechanisms be undertaken and water managers be advised of the full range of options available.**

3.28 It is also important that the public be advised when the danger from the bloom has subsided. Tourist businesses and those having to find alternative water for stock may suffer substantial financial disadvantages during the duration of the bloom and should be advised when it is safe to use the water.

---

316 Johnstone, Evidence, 27 July 1993, p.393.

317 Johnstone, Evidence, 27 July 1993, p.402.

**Recommendation 26**

The Committee recommends that it be part of the procedures for advising the public of the presence of algal blooms that notification should also be given when the danger has subsided.

*Monitoring*

**3.29** Long and short term strategies to control algal blooms cannot be successful without an adequate monitoring program. Early prediction of developing blooms is important, especially if the algae are to be treated with lower concentrations of algicides to avoid the release of substantial amounts of toxins on the death of cells.<sup>318</sup> The early detection of a developing bloom in the Lower Darling River in mid January 1992 was treated by flushing, preventing the onset of the bloom.<sup>319</sup>

**3.30** The Committee is concerned at the lack of coordination between and cooperation from government instrumentalities. For example, the Committee was told that in the Hawkesbury-Nepean catchment, the New South Wales EPA did water tests once a month, and the Water Board tested once a fortnight. The EPA results were not available to the local water management authority, and the Water Board released only edited information.<sup>320</sup> The Committee strongly supports the current New South Wales State Algal Coordinating Committee's program to develop an extensive algal data base which will provide a formal mechanism for reporting algal blooms across the State.

**3.31** ARMCANZ has a national data base on its agenda. The Committee is mindful that there may be problems with any attempt to maintain a central data base. Some agencies may be reluctant to provide information that may cause alarm in the public arena or may implicate the management practices of the agency. Agencies may also

---

318 Australian Water Resources Council *Freshwater Algal Blooms* Occasional Paper prepared by the Water Resources Management Committee of the Australian Water Resources Council, November 1991, p.5.

319 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.34.

320 Cauchi, Evidence, 3 August 1993, p.539.

---

be reluctant to fund monitoring programs which will be public for other authorities to use at no cost.

**3.32** There is the issue of who owns the data; the group which collects it or the agency that funded the collection of the data. Should the public have an automatic right to access information collected with public funds, and who should pay the costs involved in making this information available to the public?

**3.33** This situation may be different in the case of private companies which also collect data in situations where sewerage or irrigation systems are privatised. In cases where government instrumentalities have been corporatised or privatised could a user pays system be used as a mechanism to offset the costs of collecting the information as well as the costs of distributing the information? Costs of extensive monitoring programs are prohibitive. The possibility of an independent data collector who would make results available to agencies and the public was suggested to the Committee.<sup>321</sup>

**3.34** There was little change reported in the monitoring techniques over the last year, although some programs were expanded and intensified.<sup>322</sup> There is currently a great deal of disparity between and within monitoring programs in the States.<sup>323</sup> The Commonwealth Environment Protection Agency has instigated a review of water quality monitoring in Australia with the aim of developing an effective and uniform monitoring network.<sup>324</sup> Money will be available to the States/Territories involved in an integrated approach, which will monitor a common set of parameters.<sup>325</sup> A national agreement on a set of guidelines for monitoring would significantly increase the analytic value of data available as well as establishing operational procedures.

---

321 Cullen, Evidence, 27 August 1993, p.862.

322 *National Algal Scoreboard 1992/93*. Water Forum. Agriculture and Resource Management Council of Australia and New Zealand, p.3.

323 Alexandra, Evidence, 27 July 1993, p.429.

324 Lambert, Evidence 27 August 1993, p.884.

325 Lambert, Evidence, 27 August 1993, p.884.

3.35 There should be a standard process of data collection, reporting, and evaluation in relation to frequency and position of blooms i.e. surface, subsurface, at the edge or centre of water bodies, to enable more meaningful comparisons, including error estimates. Data collection strategies should include more intensive monitoring during blooms to provide information for future research and management. An essential feature of successful monitoring programs is a quick turnaround for results if they are to be used for predictive and interactive management.<sup>326</sup> Training of staff to identify and count algal cells will give immediate information rather than having to wait for reports from a central laboratory.

**Recommendation 27**

**The Committee recommends that a national set of guidelines in relation to the monitoring of algal blooms be adopted as soon as practicable.**

3.36 The New South Wales State algal coordinating committees make weekly reports on media coverage, public warnings, monitoring, availability of water supplies containing blooms at high alert levels. Some States have already issued detailed guidelines on sampling methods and specific actions required.<sup>327</sup>

3.37 The research into algal bloom causal factors will be assisted by the development of a comprehensive data base of comparative information on the frequency and location of blooms. There is a need for more comprehensive on site testing in some areas and for efficient procedures for laboratory identification of toxic species. Monitoring programs should include relevant data for water authorities, and where possible accommodate research needs and other water users.<sup>328</sup>

---

326 Murray-Darling Basin Commission. *Algal Management Strategy. Technical Advisory Group Report.* April 1993, p.33.

327 Clewitt, Evidence, 4 August 1993, p.691.

328 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.5-6.

3.38 It was suggested to the Committee that monitoring could extend to water phosphorus and nitrogen levels and pH, turbidity, odour, taste, temperature, light penetration and dissolved oxygen and other environmental factors which may assist in the prediction of algal bloom development. CSIRO is currently working on a solar powered automatic water quality analysis<sup>329</sup> which may assist in this process. This will detect the presence of appropriate conditions for the development of algal blooms, and will provide information on phosphorus sources and other factors that may be useful indicators.<sup>330</sup>

3.39 The type of monitoring program will also depend on the intended use of the data. Information collected for the daily care of water supplies will not necessarily provide adequate information for assessing long term trends or for monitoring the effectiveness of management strategies. The objectives of monitoring programs should include measurement of nutrient levels and in-stream processes and feedback on the success or otherwise of management strategies.

3.40 There appears to be very little long term data available, and much of what is available has been collected and kept by individuals and authorities. Although the Committee appreciates the extent of the resources required to develop a central historic data base, this may provide a valuable insight to the cause and management of existing blooms and preventative strategies.

#### **Recommendation 28**

**The Committee recommends that the Commonwealth Government give consideration to providing the necessary resources for the collation and analysis of the available historical data on algal blooms, nutrient levels and flow rates.**

3.41 The existing network of permanent monitoring sites in the Murray-Darling Basin does not provide sufficient information on the development of algal blooms.<sup>331</sup> In some situations there may only

---

329 Commonwealth Environment Protection Agency, Submission No.93, p.8.

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

331 Murray-Darling Basin Commission (1993) *Algal Management Strategy. Technical Advisory Group Report*, April 1993, p.34.

need to be selective increases in the quality of existing monitoring programs to include long term data. Difficulties may be experienced in convincing managers of the benefits of long term monitoring, especially during a period of tight short term budgets. The Committee considers that potential benefits could be gained from establishing a number of sites nationally as references for long term monitoring. Analysis of existing long term data may be sufficient to justify the establishment of the reference sites.

**Recommendation 29**

**The Committee recommends that consideration be given to the establishment of a number of long-term national reference monitoring sites.**

3.42 Algal blooms might only become visible when wind concentrates the cells.<sup>332</sup> Local community participation can be effective in the early detection of blooms if people are fully informed and equipped with suitable testing kits and appropriate steps are taken to avoid unnecessary public alarm. The New South Wales State Algal Coordinating Committee is financing the development of an algal watch kit. Monitoring programs can play a significant role in community education through the data provided and their participation in the monitoring programs.

3.43 There have been successful community monitoring programs established in some states. The Ribbons of Blue Program is operating in Western Australia, Streamwatch in New South Wales and other groups in South Australia, Queensland and Tasmania.<sup>333</sup>

3.44 Another effective method of determining the extent of blooms is aerial photography.<sup>334</sup> CSIRO also consider that it is possible to use airborne remote sensing to monitor the environmental conditions

---

332 Queensland Herbarium, Submission No.24, p.4.

333 Phillips, Evidence, 27 August 1993, p.895.

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



leading to the development of blooms, and their extent and intensity.<sup>335</sup>

**3.45** There is a need to develop more knowledge about the potential use of biological indicators which can give advance warnings of the deteriorating/improving health of our waterways. The use of biological indicators may require fewer resources and may be a feasible alternative to traditional expensive monitoring programs. Studies are currently being conducted by students from the Cooperative Research Centre for Freshwater Ecology, University of Canberra.<sup>336</sup>

#### *Water Treatment*

**3.46** Comparative work is needed into the relative capacity of various techniques for the removal of toxins, odours and tastes from the water supply. Adsorption by activated carbon can be used to remove toxins<sup>337</sup> but this may be costly.<sup>338</sup> Further, the Engineering and Water Supply Department in South Australia tested the activated carbon filters used in the Darling bloom in 1991 and found them to be ineffective. They cautioned that the type of carbon, the manufacturing process, raw materials used and the possible interference by natural organic materials determined the effectiveness of these treatments.<sup>339</sup> Measurement of the effectiveness of toxin removal can only be done when accurate toxin quantifying processes are in place.<sup>340</sup>

**3.47** Contingency plans are now in place for many water supplies, and the nature of these depends on the availability of an alternative water

---

335 CSIRO. *Waterlink*. CSIRO Division of Water Resources Industry News. No. 12, August/November 1992, p. 5.

336 Cullen, Private Briefing, 26 November 1993, p.40.

337 Falconer I, Runnegar M, Builday T, Van L Huhn and Bradshaw P (1989) 'Using activated carbon to remove toxicity from drinking water containing cyanobacterial blooms'. *American Water Works Association Journal* 18: 102-105.

338 Gutteridge Haskins and Davey, Submission No.18, p.3.

339 Bursill, Evidence, 12 August 1993, p.757.

340 Australian Water Resources Council *Freshwater Algal Blooms* Occasional Paper prepared by Water Resources Management Committee of the Australian Water Resources Council, November 1991, p.6.

supply, an effective water treatment system, the type of algae and the type and use of water.<sup>341</sup> For example, the Riverland Region in South Australia has produced a contingency plan with guidelines as to the action necessary depending on algal biomass.<sup>342</sup> Water authorities with adequate training can now monitor for potential problems and if concerned can send samples to experts for confirmation, thus providing a longer lead time to deal with developing blooms. It is essential that water managers who are responsible for the control of water supplies are provided with adequate information on water treatment as it becomes available to enable them to improve and refine existing management practices.

**3.48** There is now general agreement on what level of algal density constitutes a bloom.<sup>343</sup> Alert levels should be defined and monitoring should be sufficient to detect blooms in the early stages of development. Some quantitative guidelines have emerged on what levels of algal density constitutes a risk to the health of humans and stock, and these should include high and low concentrations as well as short term and long term effects.<sup>344</sup> The risk and consequences of failure of potential algal control mechanisms was raised as a significant gap in knowledge in relation to the management of water bodies.<sup>345</sup>

**3.49** Further progress will be made in risk assessment as measurements of toxin concentrations, an understanding of the factors that affect their development, their effects on stock and humans and the quick identification of toxic strains of algae become available.<sup>346</sup>

---

341 Australian Water Resources Council *Freshwater Algal Blooms* Occasional paper prepared by Water Resources Management Committee of the Australian Water Resources Council, November 1991, p.7.

342 Engineering and Water Supply Department, South Australia, Submission No. 49, Appendix VIII, p.3.

343 Johnstone, Evidence, 27 July 1993, p.398.

344 Australian Water Resources Council *Freshwater Algal Blooms* Occasional Paper prepared by Water Resources Management Committee of the Australia Water Resources Council, November 1991, p.11.

345 Johnstone P, (1993) *Establishing Priorities for National Algal Bloom Research*, April 1993, p.18.

346 Engineering and Water Supply Department, South Australia, Submission No. 49, Appendix VI, p.3.

---

Risk analysis is also hindered by inadequate knowledge of the ecology of many of Australia's waterways.

### **Cost of Algal Blooms**

**3.50** The cost of algal blooms in Australia in 1992/93 was estimated to be about \$10 million and in most states was comparable to the previous year.<sup>347</sup> These costs relate to the treatment and prevention of blooms but the difficulties in determining the costs for health, agriculture, tourism and the environment meant that these are not usually included in estimates.<sup>348</sup>

**3.51** A comprehensive cost benefit analysis is urgently needed to provide an indication of the type of data required on the social, environmental and economic costs of algal blooms. Very little reliable information is available about their true costs to governments, individuals, communities, and research organisations, and this information is essential before a reliable cost benefit analysis can be carried out.

**3.52** During the November 1991 algal bloom in the Darling system, the Australian Embassy in Japan had inquiries about whether it was safe to eat Australian beef, and inquiries were made in Germany in relation to the safety of tourists wishing to visit Australia.<sup>349</sup> Professor Cullen warned of the possible catastrophic effect of such fears on our primary industries in a competitive agricultural export market,<sup>350</sup> and these types of costs should be factored into the equation.

**3.53** Increased cost can be incurred through the additional water treatment; filter clogging, pH changes and interference with the coagulation process; the use and construction of additional water supplies; upgrading of sewerage works; more intensive monitoring programs; implementing appropriate farm management practices;

---

347 *National Algal Scoreboard 1992/93*. Agriculture and Resource Management Council of Australia and New Zealand, p.4.

348 *National Algal Scoreboard 1992/93*. Agriculture and Resource Management Council of Australia and New Zealand, p.4.

349 Cullen, Evidence, 27 August 1993, p.856-7.

350 Cullen, Evidence, 27 August 1993, p.857.

measures taken to reduce soil erosion; construction projects, such as the Dawesville Channel (Peel Harvey Inlet); stock deaths and loss of condition; provision of an alternative water supply for stock; human health problems; losses for industries which require acceptable water quality such as fishing; losses to export and domestic trade in produce; adverse effects on industrial investments; loss of real estate values; loss of tourist income and subsequent unemployment; social costs including disruption to water supplies and recreational use; off setting opportunity costs of local government funds which could have addressed other community needs; environmental costs, including loss of biodiversity and loss of ecosystems; and loss of wildlife and native flora.

3.54 Progressively figures are becoming available on known costs. The bloom in the Darling River cost the New South Wales Government \$1.3 million, but the expense to the community was much higher and concerns were expressed by the tourist industry and meat export market.<sup>351</sup> New South Wales lost an estimated \$10 million in tourist revenue in 1991 as a result of the algal blooms.<sup>352</sup> At Mungindi the cost during the 1991 algal bloom was about \$70 000.<sup>353</sup>

3.55 The Committee was also given some examples such as the dairy industry in the Lake Albert area in South Australia which was worth \$7.5 million annually, and the fishing industry in the same area which was worth up to \$4 million; these industries were under threat of severe losses resulting from algal blooms.<sup>354</sup> An estimated \$6.5 million was lost in tourist revenue in the Gippsland Lakes area in 1990.<sup>355</sup> At Edenhope in Victoria (population 1000), \$70 000 was required for a drilling program and water cartage due to a blue-green algal bloom in Lake Wallace; as well there was a negative impact on tourism.<sup>356</sup> It would cost \$40 000 a day to use activated carbon at the Happy Valley

---

351 New South Wales Blue-Green Algae Task Force, Submission No.53, p.8.

352 Verhoeven, Evidence, 11 September 1992, p.134.

353 Davison, Evidence, 5 August 1993, p.703.

354 Meningie Progress Association, Submission No.22, p.5.

355 Department of Primary Industries and Energy, Submission No.91, p.4.

356 Hall, Submission No.14, p.1.

filtration plant in South Australia.<sup>357</sup> To flush an algal bloom in the Hawkesbury-Nepean River, the retail value of the drinking water released was \$45 million, with an additional potential cost of \$5.8 million to replace this water.<sup>358</sup> At Cessnock dam there was an additional cost of \$20 000 to pump from alternative supplies for six weeks as a result of an algal bloom.<sup>359</sup>

3.56 Some towns, such as Moree, have alternative water supplies and there is less concern in these situations.<sup>360</sup> Also, there was some social cost but big costs arise when there is no alternative water supply and water needs to be trucked in.<sup>361</sup> The Committee was told that some households at Narran had no rain water and had to move out if water was unavailable as it was too expensive and too far to cart it in.<sup>362</sup>

3.57 To date the costs of algal blooms have been substantial. Some of these costs will decrease as more is known about how to manage and control algal blooms. It is essential that adequate funds be available to enable research to continue into areas of concern which enable improved management of our waterways.

## Control of Algal Blooms

### *Contingency Plans*

3.58 Contingency plans for dealing with algal blooms are now being developed which define the powers, roles, objectives and actions of all participants. These now clarify the responsibility of authorities/agencies for monitoring, reporting and control in relation to total catchment management practices. These plans define lines of responsibility for actions and funding between different levels of government, the community and industry, although these may differ in each location.

---

357 Bursill, Evidence, 12 August 1993, p.764.

358 New South Wales Blue-Green Algae Task Force, Submission No.53, p.8.

359 Clewitt, Evidence, 4 August 1993, p.689.

360 O'Reilly, Evidence, 5 August 1993, p.703.

361 Clewitt, Evidence, 4 August 1993, p.689.

362 Treweeke, Evidence, 4 August 1993, p.669.

**3.59** Contingency plans must be realistic and affordable. Any contingency plan implemented should be closely monitored and have an automatic feedback mechanism on its success and effectiveness in catchment management at the State/Territory level and to the national network. The effectiveness of various monitoring techniques and the success of community participation approaches should be assessed against performance indicators. Research organisations should have an input into the monitoring programs.

**3.60** Plans should be reviewed as new information becomes available, and there should be a comparative assessment of alternative strategies being used in the regional areas. It is important that all potential contributors be given the opportunity to participate in the development of local policy and be kept informed. There has been an increase in the number of training programs and the dissemination of information through schools, colleges and Landcare groups and the release of public information which is designed to ensure appropriate information is available for the local communities and agencies involved in water resource management.

**3.61** An integral part of contingency planning is risk assessment based on dose-response data of humans at probable exposure levels. Acceptable daily intake is not known for algal toxins and is dependent on the uses which will determine the potential for human exposure.<sup>363</sup> The results of recent research into the effects of toxins on humans could be distributed to the water managers when positive results are found in laboratory tests. This would ensure that the water managers and local health authorities had the relevant information on which to base their risk assessment decisions.

### *Biological Control Mechanisms*

**3.62** The revegetation of river banks to reduce erosion and increased numbers of water plants will reduce the levels of nutrients in the waterways. The European Union requires that 15 per cent of farm land be set aside to accommodate buffer strips, woodlands and native pasture

---

363 *Health Effects of Toxic Cyanobacteria (Blue-green algae). Report to the Environmental Health Standing Committee on the National Health and Medical Research Council.* University of Adelaide and South Australian Health Commission. June 1993, pp.57-63.

areas.<sup>364</sup> This approach may not be appropriate in many Australia ecosystems, and programs such as the National Corridors of Green are designed to address this situation.

**3.63** Little is known about the survival of toxic algae in the dormant stages of their life cycle,<sup>365</sup> and there may be a possibility of a control mechanism at this stage. Research is currently being conducted in the Water Studies Centre, Monash University.<sup>366</sup>

**3.64** In sufficient numbers, bacteria can control blue-green algae.<sup>367</sup> Dried bacterial cultures have the potential to be used as a low cost alternative treatment for algal blooms in closed water systems. However, these are most effective under aerobic conditions and require temperatures between 25 and 30 degrees celsius and it may take 28 days to reach the environmental balance.<sup>368</sup> Work is being done at Melbourne University on bacteria which will ingest the toxins.<sup>369</sup> The use of viruses that infect blue-green algae is another possibility.<sup>370</sup>

#### *Barley Straw*

**3.65** It has been suggested that the use of barley straw may produce substances that inhibit the development of algal blooms and also provide a habitat for zooplankton which feed on the algae,<sup>371</sup> but further research is needed into its potential use on a larger scale. The

---

364 Hindmarsh, Submission No.95, p.3.

365 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.8.

366 van Dok W (1993) *The Importance of Resting Cells in Seeding Algal Blooms*. Water Studies Centre. Monash University. Doctorate Research 1992-95.

367 May V, (1972) 'Blue green algal blooms at Braidwood, NSW (Australia)'. *Science Bulletin* No.82. NSW Department of Agriculture; Fraleigh P and Burnham J (1988) 'Myxococcal predation on cyanobacterial populations: nutrient effects'. *Limnology and Oceanography* 33(3):476-483.

368 Organic Waste Recyclers (Australia) Pty Ltd, Submission No.20, p.4.

369 'What can be done about blue green algal blooms'. *Ecos* (Winter 1992) 72:14-19, p.18.

370 CSIRO, Submission No.72, p.12.

371 Hindmarsh, Submission No.95(b), p.3.

Committee was told that about one tonne of barley straw has the potential to clear 100 megalitres of water.<sup>372</sup> The Committee was also told that the use of barley straw had the potential to enable the interim treatment of algal blooms without severe environmental damage,<sup>373</sup> and it was suggested that the existing weirs could be used for barley straw treatments.<sup>374</sup>

**3.66** The New South Wales Department of Water Resources is conducting trials with barley straw at Penrith,<sup>375</sup> and other trials are being conducted in Victoria and at Murdoch University.<sup>376</sup> The trials in Victoria have, however, shown varied results, and there is concern about the additional organic material in waterways which could increase the levels of trihalomethanes, which are potential carcinogens.<sup>377</sup> Further research is needed into the conditions under which the use of barley straw is effective,<sup>378</sup> and into the environmental safety of the use of this approach.<sup>379</sup>

**3.67** Competition by predators and other organisms may inhibit the development of algal blooms if these organisms are present in sufficiently large numbers; alternatively, the presence of synergistic organisms may enhance the development of blooms.<sup>380</sup> Insufficient

---

372 Hindmarsh, Evidence, 3 August 1993, p.618.

373 Hindmarsh, Evidence, 3 August 1993, p.619.

374 Austin, Evidence, 3 August 1993, p.629.

375 Hindmarsh, Evidence, 3 August 1993, p.618.

376 Government of Victoria Department of Conservation and Natural Resources, Victoria, Supplementary Submission No. 81(a), Attachment 6, p.1.

377 Government of Victoria Department of Conservation and Natural Resources, Victoria, Supplementary Submission No. 81(a), Attachment 6, p.1.

378 Jelbart J and Abbott G (1993) *An Investigation of the Effect of Rotting Barley Straw on the Cyanobacterium Microcystis aeruginosa*. Paper presented to the 56th Water Industry Engineers and Operators Conference, Ballarat, September 1993.

379 Jelbert, J (1993) 'Effect of Rotting Barley Straw on Cyanobacteria. A Laboratory Investigation'. *Water*. October 1993: 31-32, p.32.

380 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.5.



information is available in relation to Australian ecosystems to enable this to be a feasible alternative at this stage.

**3.68** Zooplankton which feed on the blue-green algae may also survive in the bottom strata where oxygen levels are lower and not suitable for predatory fish. Herbivorous zooplankton have been used in Danish lakes during the recovery period after a bloom.<sup>381</sup> Blue-green algae can benefit from the grazing pressure on other more palatable algae species.<sup>382</sup> Some algal toxins can kill predatory zooplankton and may inhibit competitors.<sup>383</sup> Small zooplankton may also be unable to graze on large filaments or colonies of blue-green algae.<sup>384</sup> Therefore the introduction of zooplankton may favour the large species of blue-green at the expense of other phytoplankton and create a further imbalance. Further, healthy zooplankton populations were found during the algal bloom in the Darling River,<sup>385</sup> casting doubt on the effectiveness of this method of control.

### *Wetlands*

**3.69** The Committee has been told that wetlands can substantially reduce the levels of phosphorus entering the waterways. For example, at Lake Apopka in Florida, USA, there is a proposal to recycle water from the lake through wetlands to reduce nutrient levels.<sup>386</sup> Wetlands also provide a refuge for zooplankton which feed on the algae. In 1991 a workshop was held on wetland conservation and management which considered the conservation policies and programs, the threats to and

---

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

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

383 Carmichael, W (1981) *The water environment: algal toxins and human health*. Plenum Press, New York.

384 Lynch M and Shapiro J (1981) 'Predation enrichment and phytoplankton community structure.' *Limnology and Oceanography* 26(1):86-102; Edmonson W and Litt A (1982) 'Daphnia in Lake Washington.' *Limnology and Oceanography* 27(2):272-293.

385 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.55.

386 Higgins, Evidence, 2 August 1993, p.483.

the wise use of wetlands.<sup>387</sup> There is no comprehensive survey of Australian wetlands despite their importance in flood control, ground water recharge, erosion control and water purification.<sup>388</sup>

3.70 It has been pointed out, however, that blue-green algae living in wetlands provide a seed source to the main waterway, and in South Australia trials are being conducted into the use of booms to prevent the algae from entering the waterways.<sup>389</sup>

### *European Carp*

3.71 The role of the carp is not clearly understood,<sup>390</sup> but, there is a common perception that the European carp (*Cyprinus carpio*) plays a significant role in the development of algal blooms.<sup>391</sup> If this is the case then the regulation of fish populations has the potential to be used to keep algal growth under control. Carp may increase nutrient levels in water by disturbing the sediments, thus increasing turbidity levels as well as well as having an impact on the food chain.<sup>392</sup> Carp can feed on the water fleas which graze on the blue-green algae, and it was suggested to the Committee that the removal of carp from the Murray-Darling would reduce of algal blooms.<sup>393</sup>

3.72 The effectiveness of this approach will depend on an appropriate method of eradicating this species. The Victorian Government declared the carp a noxious animal, but the Victorian Fisheries and Wildlife

---

387 Australian National Parks and Wildlife Service, *Educating and Managing for Wetland Conservation*. Proceedings of the Wetlands Conservation and Management Workshop. University of Newcastle and the Wetlands Centre, Shortland. Edited by P Donohue and B Phillips. 11-15 February 1991.

388 Australian Conservation Foundation, Supplementary Submission No.75(a), p.20.

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

390 Bowmer, Submission No.63, p.2.

391 Arnott, Evidence, 5 August 1993, p.707.

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

393 Hindmarsh, Evidence, 3 August 1993, p.615.

Department were unsuccessful in their attempt to eradicate the species.<sup>394</sup> Research is currently being done in Victoria with a carp virus called *spring viraemia*, which appears to have no deleterious effect on native fish species.<sup>395</sup>

**3.73** There are divided opinions as to the extent to which carp cause irreparable damage.<sup>396</sup> The encouragement of native species and the reduction of carp numbers<sup>397</sup> may be desirable for a number of environmental reasons, but the complexity of the ecosystem makes the prediction of the outcome difficult. These methods of control are not usually attractive to regulatory bodies because they are difficult to control.<sup>398</sup>

### *Chemical Control Mechanisms*

**3.74** Reliance on water treatment to remove algal toxins is not wise due to the difficulties in detection of toxins present and the possibility of mechanical failure during the treatment process, or inefficiencies in the equipment due to the clogging of filters by the algal biomass, or changes in water properties due to the presence of algae. For example, photosynthesis increases the pH of the water and this may alter the necessary treatment.<sup>399</sup>

**3.75** Further research is needed into the effects of various water treatments on the full range of algal toxins, such as the use of

---

394 Williams, Evidence, 12 August 1993, p.809.

395 Hindmarsh, Evidence, 3 August 1993, p.617.

396 Williams, Evidence, 12 August 1993, p.809.

397 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.15.

398 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) New South Wales Department of Water Resources pp.491-501, p.494.

399 Australian Water Resources Council, *Freshwater Algal Blooms*. Occasional paper prepared by the Water Resources Management Committee of the Australian Water Resources Council. November 1991, p.2.

chlorination for the treatment of hepatotoxins.<sup>400</sup> It has been found that hepatotoxins can be degraded by low dose rates of chlorine, which provides a low cost practical treatment for water to be used by stock.<sup>401</sup> However, the chlorination of water containing blue-green algae can lead to the formation of trihalomethanes and other undesirable organic compounds<sup>402</sup> and therefore may have adverse health implications.<sup>403</sup>

3.76 Algicides are not usually biospecific and the adverse effects on other organisms are not always known. Copper-based algicides are the only ones registered in Australia for use in water supplies.<sup>404</sup> The Committee was told that the use of this algicide can cause greater environmental degradation than an untreated algal bloom<sup>405</sup> and the degree of success depends on the chemistry of the water.<sup>406</sup> As well, the residual copper may remain in the water supply for some time, and the use of copper sulfate releases the algal toxins into the water supply.<sup>407</sup> Copper sulfate also kills water fleas that feed on the algae.<sup>408</sup> Lower copper toxicity has been reported for siderophore producing species of blue-green algae.<sup>409</sup>

- 
- 400 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.15.
- 401 Bursill, Evidence, 12 August 1993, p.753-4.
- 402 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.78.
- 403 Australian Water Resources Council *Freshwater Algal Blooms Occasional Paper* prepared by the Water Resources Management Committee of the Australian Water Resources Council, November 1991, p.5.
- 404 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.14.
- 405 Water Studies Centre, Submission No.30, p.1.
- 406 National Project Manager, Algal Bloom Research, ARMCANZ, Submission No.33, p.14.
- 407 Burns, Submission No.31, p.3.
- 408 Hindmarsh, Evidence, 3 August 1993, p.619.
- 409 Clarke S, Stuart J and Saunders-Loehr J (1987) 'Induction of siderophore activity in *Anabaena* spp. and its moderation of copper toxicity'. *Applied and Environmental Microbiology* 53(5):917-922.

3.77 On Palm Island, over 140 people were hospitalised after the water supply was treated with copper sulfate releasing the toxins into the drinking water.<sup>410</sup> The use of copper sulfate should be restricted to situations where there are low cell counts.<sup>411</sup> Mass algae kills with algicides also result in the deoxygenation of the water during the decay of large masses of plant material which release nutrients which can be used by subsequent algal blooms. Further research is needed into the degradation rates of toxins released during the decay of the cells for Australian algal species, as some may take two weeks to break down.<sup>412</sup>

3.78 The Committee was told that copper sulfate was being used by managers who felt under political pressure to be seen to be doing something.<sup>413</sup> As the water supply needs to be closed down after treatment with copper sulfate, it may be better to leave the bloom untreated.<sup>414</sup> Research is needed into alternative compounds in relation to their potential (possibly latent) effects on humans and biota. Research is also currently being done into the possible use of chelated forms of copper.<sup>415</sup>

3.79 The other chemical approach is to reduce the nutrient levels in the water to retard the development of algal blooms. The mineral zeolite can be used to remove nutrients from water as it absorbs up to 5 kilograms of phosphate per tonne of zeolite and has the advantage that it can be re-used as a slow release fertiliser.<sup>416</sup> The Committee was told that there is a concern that zeolite-based products may release heavy metals into the environment, but so does the conventional sludge

---

410 Falconer, Evidence, 12 August 1993, p.789.

411 Falconer, Evidence, 12 August 1993, p.793.

412 National Project Manager, Algal Bloom Research ARMCANZ, Submission No.33, p.15; CSIRO, Submission No.72, p.6.

413 van Dok, Evidence, 27 July 1993, p.409.

414 van Dok, Evidence, 27 July 1993, p.409.

415 Engineering and Water Supply Department, South Australia, Submission No.49, Appendix VI, p.1.

416 Zeolite Applications Group Pty Ltd, Submission No.40, p.1.

which is currently being used for agriculture.<sup>417</sup> The Murray-Darling Basin Commission Technical Advisory Group on Domestic Use of Polyphosphates stated that zeolites were considered to be the most viable alternative to phosphates in detergents in Australia.<sup>418</sup>

**3.80** Chemicals such as alum and gypsum may also be used for phosphate removal in farm dams<sup>419</sup> but may introduce other unacceptable impurities.<sup>420</sup> These chemicals precipitate phosphorus out and therefore inhibit the development of blooms but they do not remove it from the system and the Committee was told that this may create potential problems in 10-15 years.<sup>421</sup>

### *Herbicides*

**3.81** Herbicides may reduce the development of algal blooms. There is no regular monitoring program for agricultural products such as herbicides on a long-term basis<sup>422</sup> and work is needed to establish ambient levels in waterways and their role in the inhibition of algal bloom development. A reduction of herbicide levels in drainage channels may permit weed growth and therefore reduce nutrients reaching the water bodies.

### *Pesticides*

**3.82** Pesticides from domestic and agricultural land may adversely affect the zooplankton which feed on toxic blue-green algae, but the actual effect on algal blooms is not known. Millipore Australia Pty Ltd,

---

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

418 Murray-Darling Basin Commission. *Algal Management Strategy. Technical Advisory Group Report*. April 1993, p.41.

419 May V and Baker H (1978) *Reduction of Toxic Algae in Farm Dams by Ferric Alum*. Technical Bulletin 19 January 1978. Department of Agriculture NSW.

420 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.117.

421 Muntisov, Evidence, 25 September 1992, p.253.

422 Cullen, Submission No.42, p.6.

---

CSIRO and the Australian Government Analytical Laboratories are developing test kits to detect pesticides under field conditions.<sup>423</sup>

### *Physical Control Mechanisms*

**3.83** The use of flow rates to control algal blooms has been discussed in Chapter 2. There are, however, a number of other physical mechanisms that can be used in appropriate circumstances.

**3.84** Artificial aeration of reservoirs may inhibit algal bloom development by increasing turbulence and preventing stratification, and reducing the release of nutrients from the sediments which promote the growth of toxic algae.<sup>424</sup> The Committee was told that intermittent aeration techniques are now available which are automatically controlled by the conditions in the water body and provide an effective low cost phosphorus control mechanism.<sup>425</sup> Aeration techniques have been applied in Japan, England and Germany and have been shown to be effective if used in conjunction with other phosphorus removal techniques.<sup>426</sup> Destratification by mixing can also stimulate increased chlorophyll formation in deeper water because of the lower light levels, and hence increase the levels of geosmin.<sup>427</sup> Aeration is being considered as a short term solution at Chaffey Dam, which can be severely stratified<sup>428</sup> and has high phosphorus levels in the sediments.<sup>429</sup>

**3.85** A number of other physical controls may be appropriate in some circumstances. For example, the monitoring of algal cells at different levels may enable selective pumping of water. The New South Wales Department of Water Resources is trialing the use of harvesters and

---

423 Minister for Industry, Technology and Regional Development, Submission No.89, p.11.

424 Burns, Submission No.31, p.2.

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

426 Ibid, p.3-4.

427 'What can be done about toxic algal blooms?' *Ecos* (Winter 1992) 72:14-19, p.18.

428 Sinclair, Evidence, 5 August 1993, p.737.

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

floating booms.<sup>430</sup> Explosives have been used in the United States but this does not remove nutrients or toxins.<sup>431</sup> The practical and environmental implications of dredging the sediments prohibits this approach in some situations, but it may be useful in some lakes or reservoirs. Experimental work is being conducted on the use of calcium salts to prevent the transport of phosphorus from the sediments.<sup>432</sup>

### *Economic Instruments*

3.86 A user pays system for water could cover the costs of the supply, distribution and disposal, including the consequences of the disposal method. The effects of user pays on consumers and the effect on environmental allocations, sustainable management of resources and adequate economic models must be considered.<sup>433</sup> The Minister for Primary Industries and Energy, the Hon Simon Crean, has supported the introduction of market based measures subject to consultation with those affected, but only if these economic measures contribute to a solution.<sup>434</sup>

3.87 With the move to a user pays system there must be an appropriate pricing structure. Water users can be persuaded to accept price increases if there is an associated improvement in service.<sup>435</sup> The issue of water pricing must be based on a need for social responsibility with the necessary adaptation and adjustment processes.<sup>436</sup> Problems arising in respect of low income consumers must be addressed.

---

430 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.117.

431 Humphries, Evidence, 22 October 1992, p.343.

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

433 The Response of the Queensland Government to the Industry Commission's Draft Report on Water Resources and Waste Water Disposal. May 1992, p.1.

434 Minister for Primary Industries. 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.4.

435 Wardle, Evidence, 2 August 1993, p.513.

436 Alexandra, Evidence, 27 July 1993, p.440.



**3.88** The introduction of user pays requires efficient management of water as consumers cannot be expected to pay for inefficient practices by authorities. In determining the price of water consideration should be given to addressing the inappropriate use of potable water and to encouraging reuse of water.<sup>437</sup>

**3.89** The use of water for the purpose which provides the highest financial return cannot always be justified and must be balanced against any social and environmental benefits.<sup>438</sup> The impact of pricing on industry development or maintenance must also be considered. The landholders make commercial decisions based on their allocation of water; if the rules are changed then it should be subject to appeal.<sup>439</sup> The Dumaresq-Barwon Border Rivers Commission believes that start up flows should be allocated on a merit basis.<sup>440</sup>

**3.90** The question also arises whether the community is expected to pay for major capital works, and what sort of consultation processes are necessary. There was a concern that with the introduction of a user pays system the farming community would need to find a substantial amount of money in a short period. If the beneficiary should pay, the question arises whether that means all Australians because of the wider benefits of irrigation to the country.<sup>441</sup> The user pays system would be unfair in situations in which there was a critical need to upgrade an asset. The price of irrigation water would need to increase 5-10 fold to cover the full costs of building, repairing and operating irrigation infrastructure, and would nearly equal the profit per megalitre for dairy and rice growers.<sup>442</sup>

---

437 Nature Conservation Council of New South Wales (1993). Submission to the Joint Select Committee upon the Water Board, 2 August 1993, p.32.

438 Murray-Darling Association Inc (formerly Murray Valley League for Development and Conservation Inc), Submission No.54, p.5.

439 Hutton, Evidence, 27 August 1993, p.920.

440 Hutton, Evidence, 27 August 1993, p.921.

441 Roberts, Evidence, 11 September 1992, p.22-23.

442 Australian Conservation Foundation, Supplementary Submission No.75(a), p.37.

**3.91** The Committee was told that it would be fairer to upgrade the asset and then account for depreciation in charging policies.<sup>443</sup> The point was also made that in some situations the upgrade was necessary because of poor planning by government agencies.<sup>444</sup> The potential impact of the privatisation of irrigation infrastructure may be substantial if water users are required to pay the full costs of building, repairing and operating. These issues all need further consideration.

**3.92** The baseline is to determine how much people are prepared to pay for a safe water supply, and an analysis of the risks involved. The estimated cost of improvement to the Darling River sewage treatment works to remove nutrients is \$200 million plus the increased operational costs.<sup>445</sup> The Sydney Water Board will spend \$600 million reducing nutrient discharge into the Nepean Hawkesbury River System.<sup>446</sup> Money for updating of sewage treatment works may be needed as grants or long term loans to upgrade plants in small communities.<sup>447</sup> Subsidies may be considered in some situations.<sup>448</sup> In particular, communities with low rate bases should have sufficient information on alternatives available, although many communities could benefit from this information.

**3.93** The low interest rates which are available in some States provide incentives for the implementation of improved farming techniques.<sup>449</sup> The use of modern technologies such as recirculation systems, off-river storage and laser grading have significantly improved the efficiency of water use.<sup>450</sup> The rice industry, for example, has a target for reducing

---

443 Donovan, Evidence, 2 August 1993, p.475.

444 Donovan, Evidence, 2 August 1993, p.475.

445 New South Wales Blue-Green Algae Task Force, Submission No.53, p.8.

446 Industry Commission, *Water Resources and Waste Water Disposal*, Report No.26, 17 July 1992, p.153.

447 Murray River Management Board and the Murray Irrigation Area and Districts Management Board, Submission No.52, p.1.

448 The Response of the Queensland Government to the Industry Commission's Draft Report on Water Resources and Waste Water Disposal. May 1992, p.5.

449 Australian Irrigation Council, Submission No.58, p.11.

450 Australian Irrigation Council, Submission No.58, p.15.

---

the water used by one megalitre per hectare per year, and for the most part has been able to achieve this.<sup>451</sup>

**3.94** There needs to be a move away from the assumption that water has an opportunity cost of zero, and there needs to be an appreciation of the environmental value of water as well as its industrial and urban uses.<sup>452</sup> The environment and water resources are not free goods because there is a significant maintenance cost,<sup>453</sup> and it may be useful to evaluate the environment in terms of its replacement cost.<sup>454</sup> Major industries and regional communities are based on subsidised water.<sup>455</sup>

**3.95** If there are to be reductions in the allocation of water for irrigation, the New South Wales Irrigators' Council expressed the concern that there should be a balance between the community's economic needs and environmental considerations. Values in terms of lost productivity can often exceed the costs of sustaining the environment, and other benefits are bonuses.<sup>456</sup> For example, the Committee was told that a bale of cotton required a megalitre of water to produce and had a value of \$400.<sup>457</sup> Riparian flows should be considered in terms of the value of the water to farmers. The cost to farmers/irrigators if reallocation of water was introduced may require compensation.<sup>458</sup>

---

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

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

453 Humphries, Evidence, 22 October 1993, p.331.

454 Humphries, Evidence, 22 October 1992, p.330

455 Australian Conservation Foundation, Supplementary Submission No.75(a), p.36.

456 Humphries, Evidence, 22 October 1992, p.331-32.

457 Arnott, Evidence, 5 August 1993, p.706.

458 Environmental Protection Authority, Western Australia, Submission No.85, p.5.

**3.96** The major cost of water is currently that of fuel or electricity to pump the water,<sup>459</sup> and this does not reflect the true value of a scarce resource. Increased charges for water would have an immediate effect on irrigators and other rural users and this may result in dislocation of local communities. Increased water costs will encourage recycling of water on land and this may reduce input into the streams.<sup>460</sup> The New South Wales Irrigators' Council told the Committee that there had always been economic imperatives to use water efficiently, particularly in times of low water availability.<sup>461</sup> The Council of Australian Governments found that reforms are taking place in all jurisdictions but the speed and direction of reforms differ.<sup>462</sup>

**3.97** Some other suggestions have been made to reduce excessive water use. These include tax incentives for the installation of efficient irrigation systems,<sup>463</sup> and increased prices for irrigation water for those who are not using modern efficient farming methods.<sup>464</sup> The New South Wales Department of Water Resources in its monitoring program receives a levy from the irrigators on a per megalitre basis.<sup>465</sup> There is a concern that any government charges in relation to water use should be used for water services and not as a general revenue source.

**3.98** There is a gradual move to user pays, with the increased prices providing a signal to the community.<sup>466</sup> As the price of water increases, serious consideration may need to be given to the reuse of

---

459 Blainey, Evidence, 2 August 1993, p.476.

460 Industry Commission (1992) *Water Resources and Waste Water Disposal* Report No.26, 17 July 1992, p.159.

461 Donovan, Evidence, 2 August 1993, p.475.

462 Environment, Sport and Territories Portfolio, Supplementary Submission No.92(b), p.3.

463 Lower Darling-Murray Water Users Association, Submission No.26, p.4; Murray-Darling Association Inc (formerly Murray Valley League for Development and Conservation Inc), Submission No.54, p.6.

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

465 Corish, Evidence, 5 August 1993, p.730-31.

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

water. Domestic sewage is suitable to treat and recycle if it can be kept separate from industrial effluent and hazardous substances. The possible introduction of 'grey water' for watering gardens and flushing toilets must be seriously considered<sup>467</sup> as discussed in Chapter 2. Only 25 per cent of household water may need to be potable.<sup>468</sup>

**3.99** Melbourne and Sydney are investigating the use of grey water and dual supplies in new land developments.<sup>469</sup> Land developments in outer Sydney, such as Rouse Hill, will have dual reticulation systems for the use of grey water.<sup>470</sup> The Nursery Industry Association of New South Wales has discussed the possible use of grey water with the Sydney Water Board as a means of keeping costs down.<sup>471</sup> People could be allowed to install tanks instead of this water going down the storm water drain.<sup>472</sup>

### *Transferable Water Entitlements*

**3.100** The use of transferable water entitlements is an effective way of improving efficiency levels and therefore moving closer to a sustainable water resource.<sup>473</sup> The Committee was told that tradeable water entitlements would be taken up by the most efficient user, thus lowering the overall demand for water, making more available for the environment.<sup>474</sup> Industrial and urban water users may have a greater ability to pay than rural users and may result in the dislocation of rural

---

467 Australian Construction Services Aboriginal Projects Group, Submission No.78, p.2.

468 Williams, Evidence, 24 September 1992, p.172.

469 Cullen, Evidence, 27 August 1993, p.878.

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

471 Peters, Evidence, 2 August 1993, p.459.

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

473 Department of Primary Industries and Energy, Submission No.91, p.8.

474 Wardle, Evidence, 2 August 1993, p.503.

economies.<sup>475</sup> If marginal irrigation enterprises were charged on a full cost recovery basis they would be uneconomic.<sup>476</sup>

**3.101** This system would, however, enable the Government and environmental groups to purchase water for environmental flows<sup>477</sup> and would also enable the sale of unwanted water.<sup>478</sup> The introduction of tradeable water rights would also enable compensation to be paid.<sup>479</sup> The Minister for Natural Resources and the Treasurer of Victoria have announced a task force to develop a framework for the introduction of tradeable water entitlements.<sup>480</sup>

**3.102** The trading of water entitlements may also help put a market value on the worth of water<sup>481</sup> and enforce a disciplined approach to assigning environmental values. There is, however, some uncertainty in respect to environmental outcomes of a market based approach.<sup>482</sup> It was stressed that the environmental allocation should be purchased and water not used for the environment could be traded back to the irrigators for the end of season top up.<sup>483</sup> It was pointed out that the cotton industry would pay a substantial amount for the last application at the end of the season.<sup>484</sup>

---

475 Australian Conservation Foundation, Supplementary Submission No. 75(a), p.34.

476 Australian Conservation Foundation, Supplementary Submission No. 75(a), p.37.

477 Murray River Management Board and Murray Irrigation Area and Districts Management Board, Submission No.52, p.1.

478 Industry Commission, *Water Resources and Waste Water Disposal*, Report No.26, 17 July 1992, p.160.

479 Donovan, Evidence, 2 August 1993, p.472.

480 Minister for Natural Resources and the Treasurer. News Release, 18 October 1993. *Water Reforms to Improve Service and Performance*.

481 Heeps, Evidence, 25 September 1992, p.206.

482 Department of Primary Industries and Energy, Submission No.91, p.8.

483 Wardle, Evidence, 2 August 1993, p.505.

484 Wardle, Evidence, 2 August 1993, p.505.

3.103 The introduction of tradeable water rights assumes that water is available and this may not be the case in situations where water is already over-allocated. Most States/Territories are moving towards transferable water entitlements, but these will only work if there is security of supply.<sup>485</sup> Selling allocations to downstream irrigators may be inefficient because of transmission losses, and this aspect may need further consideration.<sup>486</sup> The Committee was told that the introduction of transferable allocations on the River Murray has led to some implementation problems rather than problems with the concept.<sup>487</sup>

### *Pollution Measures*

3.104 The introduction of tradeable pollution rights enables polluters to buy more permits rather than treating their waste,<sup>488</sup> but assumes that there is something to trade. When pollution levels are too high then trading will exacerbate the situation.<sup>489</sup> The use of tradeable rights to discharge nutrients into the waterways is still under investigation.<sup>490</sup> Any such scheme should reflect the quantity and potential impact of discharge.

3.105 The Committee was told that in principle the tax level should reflect the damage caused,<sup>491</sup> which will reflect the assimilatory capacity of the particular environment, rather than the level of pollution discharged. Pollution taxes for non-point sources may be

---

485 Australian Irrigation Council, Submission No.58, p.12-13.

486 Turner, Evidence, 5 August 1993, p.729

487 Barratt, Evidence, 12 August 1993, p.830.

488 Industry Commission, *Water Resources and Waste Water Disposal*, Report No.26, 17 July 1992, p.162.

489 Humphries, Evidence, 22 October 1992, p.329.

490 New South Wales Blue-Green Algae Task Force, Final Report, *Blue Green Algae*, August 1992, p.129.

491 Industry Commission *Water Resources and Waste Water Disposal* Report No.26, 17 July 1992, p.164.

impossible to implement.<sup>492</sup> These will affect the practical application of this mechanism.

**3.106** The implementation of a polluter pays system will be difficult because of the politics of the issue and its social unacceptability,<sup>493</sup> and could be costly and difficult to monitor and enforce. Enforcement is essential in this type of system. The implementation of a pollution tax would ideally need to be able to determine which phosphorus compounds are present and their varying solubility,<sup>494</sup> and may need a permit for each type of pollution. Imposing a pollution tax does not necessarily reduce the amount of pollution, and money may be better spent on reducing levels by other means. If pollution taxes are to be imposed, there is a need to consider the ability of the industry, agriculture or community to pay.

**3.107** Another suggestion was a levy on detergents.<sup>495</sup> The Horticultural Research Development Corporation, which is a major source of research funding in the industry, derives funds from a nursery pot levy which provides about \$600,000 per year.<sup>496</sup> If levies are imposed, they should be used for a specific purpose and should not be seen as an additional general revenue measure.

## Comments

**3.108** The issues of who pays and who determines the apportionment of costs across agencies and the community need to be clarified.<sup>497</sup> The costs must be equitably distributed to consumers, urban communities, land owners and industrial users. Further research is needed into the effects of water pricing policies on the welfare of consumers because of the difficulties in quantifying these outcomes. The

---

492 Australian Irrigation Council, Submission No.58, p.10.

493 Humphries, Evidence, 22 October 1992, p.319.

494 CSIRO, Submission No.72, p.12.

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

496 Peters, Evidence, 2 August 1993, p.456.

497 Anderson, Evidence, 25 September 1992, p.201.



rural community is already in recession and there has been an increased demand for welfare assistance.<sup>498</sup>

**3.109** Corporatisation of water supply authorities should address conflict of interests between commercial and other objectives.<sup>499</sup> For example, the financial constraints on corporations may prevent authorities carrying out fringe activities that are more beneficial to other agencies.<sup>500</sup>

**3.110** If a user pays system is to be introduced, there needs to be a system of accountability to ensure that the most efficient services are provided and that inefficient management practices do not financially penalise the local community. This may also mean that governments may in some situations need to assist with larger projects, and may provide funds with low interest rates or tied grants. There is an 'interesting public policy issue on rationing of a scarce resource made available from a public investment ... providing water for one use does introduce [the question of] the opportunity cost from the alternative uses of water'.<sup>501</sup>

**3.111** The benefits of implementing strategies to control algal blooms must outweigh any environmental, social and economic costs of leaving them untreated.<sup>502</sup> The most economic solutions are not always best, as it is cheapest for industry to discharge into rivers,<sup>503</sup> and there is a need to look at the ethics and legality of the issue. Despite the economics, it comes down to a matter of what the community is prepared to put up with. Now that blue-green algae have focussed attention on water quality, the community may be prepared to pay more.

---

498 Government of Victoria, Submission No.81, p.9.

499 The Response of the Queensland Government to the Industry Commission's Draft Report on Water Resources and Waste Water Disposal. May 1992, p.5.

500 Robinson, Evidence, 22 October 1992, p.368.

501 Cullen, Submission No.42, p.6.

502 New South Wales Blue-Green Algae Task Force, Submission No.53, Letter p.1.

503 Humphries, Evidence, 22 October 1992, p.346.

3.112 Encouragement of Best Management Practices and Codes of Practice may well be used with a mix of regulatory and market based approaches.<sup>504</sup> A market based approach would need to reflect the value of sustainable land use practices, recognising that current productivity may not be indicative of future yields.<sup>505</sup>

3.113 Management strategies should be cost effective, and they need to cost various control options. The New South Wales State Algal Coordinating Committee is preparing a report on the options available for water supply treatment and the costs.<sup>506</sup> Strategies should address both the long and short term situation. While some of these strategies may primarily reduce the frequency or severity of algal blooms, there are also substantial other social and environmental benefits in having healthy waterways and in the reduction of soil degradation, which should be entered into the cost equation.

3.114 There needs to be a balance between the costs of monitoring, control and research against the agricultural, tourism and ecological and other values of the catchment. It is not merely a balance between the cost of treatment for algal blooms and improved catchment management, but must consider the general health of the water bodies and their environs. Inadequate information is available on the impact of toxic algae on the ecosystem and its resilience, to enable costing to be applied. For a cost benefit analysis some of the benefits include a reliable water supply, healthy waterways, savings on water treatments and improved agricultural industry.<sup>507</sup> There is also a need to estimate the costs of rehabilitation of degraded lands and production losses.

---

504 CSIRO, Submission No.72, p.12.

505 Mues C and Collins D, (1993) A review of Commonwealth landcare initiatives - promoting sustainable farming systems. *Outlook 93*, Canberra, 2-4 February 1993, p.5.

506 New South Wales State Algal Coordinating Committee, Supplementary Submission 53(a), p.6.

507 New South Wales Blue-Green Algae Task Force, Submission No.53, p.9.