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# *LakeScience Rotorua*

## *A newsletter about research on the Rotorua Lakes*

*Produced as an occasional publication by the LakesWater Quality Society Inc., in association with the Royal Society of NZ (Rotorua Branch)*

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Welcome to the second issue of our email newsletter for those involved in or interested in scientific or management work on the Rotorua Lakes. It is up to **you** to make this informal newsletter a success by providing it with copy – our Society is merely providing the vehicle. We intend to email it free of charge to all those who attended the Rotorua Lakes 2001 Symposium and are on email, and also to anyone else who requests it. We will snail mail it on request. The newsletters will also be posted on the Royal Society (Rotorua Branch) website at www.rsnz.govt.nz/clan/rotorua. If you are interested in, or working on lakes, but not the Rotorua Lakes, we are still very happy to receive material from you and to send you newsletters.

The more copy we receive, the more frequently we will be able to send this newsletter out. Electronic copy is preferred but not essential. We hope to send another issue out in March 2002 – given sufficient copy.
Only minimal editing will be carried out. **Technical content of all contributions is essentially the responsibility of the authors**

**Material from this newsletter may be used provided that proper attribution is given.**
All material and correspondence relating to *LakeScience Rotorua* to Nick Miller, millern@wave.co.nz, 91 Te Akau Road, R D 4, ROTORUA.

The committee of the LWQS wish you all a happy and peaceful Christmas and a prosperous New Year. Hopefully some of our readers will be able to get out on the Rotorua Lakes over the holiday season and enjoy these splendid waterways.

## DEVELOPMENTS FROM THE SYMPOSIUM.

The Proceedings have been produced and mailed out. If you wish to receive a copy, we still have limited numbers left. . If you have not ordered a copy but wish to do so, they can be ordered on the special Order Form in this newsletter. Just print it out and post with a cheque for $25 made out to the LakesWater Quality Society. Complimentary copies will shortly be sent to various libraries and institutions.

Some members of our committee were happy to attend the formal launch of the Chair of Lake Studies at Waikato University, endowed by Environment BOP for a minimum period of 5 years. Special research areas will include lakes watershed management and lake rehabilitation. Our Chairman, Ian McLean, was among those who gave addresses at this very cheerful and pleasing occasion.

## GLEANINGS – a few interesting papers seen recently (other contributions to this section are welcome.) These slightly abridged abstracts are of papers delivered at the recent Fifth International Conference on Toxic Cyanobacteria , held in Noosa, Queensland during July 2001. The research topics abstracted below could have interesting implications on the local scene.

### The effects of food-associated microcystins on *Daphnia* and other potential grazers of cyanobacteria

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Cyanobacteria produce a diverse range of potentially bioactive compounds of less defined functions and unclear ecological significance. The present study describes how the most dominant of these substances, the microcystins, can affect animals, which feed on cyanobacterial cells. The experimental basis of the study is a comparison of effects caused by microcystin-producing *Microcystis* strains and their genetically engineered or natural mutants, which have lost the ability to produce microcystins. All tested *Daphnia* species and other invertebrate grazers of cyanobacteria can be poisoned by microcystins ingested with living cyanobacterial cells. The toxic effect on *Daphnia* is strongly correlated to the rate with which the animals ingest the toxins. This correlation could be described by a reciprocal power function, which is valid regardless whether different *Daphnia* species or *Microcystis* strains have been tested and which may allow to predict the microcystin-based toxicity of cyanobacteria in future experiments. Further insight of how microcystins function on invertebrates has been obtained from continuous video observations of *Daphnia* feeding on microcystin-containing cyanobacteria. These studies have shown that an intoxication by microcystins has a very distinct course characterized by an unique combination of symptoms. The main symptoms occur suddenly and are simultaneous changes in the activity of almost all major muscles systems and a destruction of the midgut. These aspects of effects caused by microcystins are new and may help to understand previous contradicting findings.

**Sorption to natural heterogeneous Scottish freshwater sediments as an environmental fate of the cyanobacterial hepatotoxin microcystin-LR.**

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Structures of the microcystin family of hepatotoxins are highly resistant to physical, chemical and biological extremes. This potential for stability and long-term persistence can prove problematic for drinking water treatment and raises important questions regarding the environmental fate of microcystins. Sorption, to date, is the most under investigated environmental fate of cyanobacterial toxins and there is increasing evidence that abiotic removal of microcystins by sediments will account for a percentage of the total toxin pool released upon lysis. Freshwater loch sediments were collected from waterbodies where toxic cyanobacterial blooms have been known to occur. Removal of microcystin-LR by sediments was investigated over a range of toxin and sediment concentrations. Sorption by sterile sediments high in organic matter resulted in the removal of more than 70% of a *5* □g ml-1 microcystin-LR solution from both distilled water and sterile loch water. Sorption followed a characteristic bi-phasic pattern of an initial fast phase (< 1 hour), followed by a second slower phase (days). However, sorption was absent in low organic matter sediment and removal of organic matter by combustion resulted in a decrease in sorption. Incubation of sediment with a microcystin-containing extract of *Microcystis* PCC 7813 did not affect the sediment's potential to scavenge microcystin-LR by sorption. The results indicate that sorption of microcystinLR is likely to occur in diverse aquatic environments and that it is a potentially important environmental sink for which information on residence time and toxicity is lacking.

**Microcystin content and toxicity of bloom-forming, benthic and small unicellular (picoplanctic) cyanobacteria in the Czech republic**

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Beside water-blooms forming cyanobacteria, several surface reservoirs contain small unicelular (picoplanctic) species; many species of cyanobacteria also occur in benthic periphyton (biofilms). Massive biomass of periphyton was found in several surface reservoirs and rivers in the Czech Republic, as well as in the systems of drinking water treatment plants. We have studied production of microcystins and assessed several types of toxic effects of both isolated cyanobacterial strains and complex environmental samples of 1) water blooms, 2) separated nano- and picoplanctic species and 3) benthic (periphyton) cyanobacteria. Significant concentrations of microcystins were found within all above mentioned cyanobacterial samples. Our results show, that not only water-bloom forming cyanobacteria, but also other ecological types (small unicelular species, periphyton) can represent significant source of microcystins for surface reservoirs. Beside the chemical analyses of microcystins, battery of the ecotoxicological biotests was used to characterize cyanobacterial toxicity. Toxicity toward mammalian cells *in vitro,* invertebrate - zooplankton biotests, phytotoxicity and mutagenicity assays were used. The results of complex toxicity testing revealed, that 1) several non-microcystin producers can possess toxic risks, especially toward plants and zooplankton, or 2) can contain other metabolites with mutagenic and/or immunosuppressive activities.

*Planktothrix prolifica a* **potent microcystin-producing cyanophyte. Accumulation of toxin in the aquatic food-web and in irrigated vegetables.**

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Toxin-producing cyanophytes are recorded in about 50 % of investigated water- blooming lakes in Sweden (n‰ 160). Blooms of *Planktothrix prolifica*, which are red- coloured, are only detected in a few lakes. Very conspicuois metalimnic summer-blooms are formed in a deep (>50 m) groundwater fed basin of Lake Malaren, a reserve water supply to a suburb of the capital Stockholm. These blooms continue also during winter but then concentrated under the ice which then is coloured in a conspicuous reddish-brown way. High microcystin concentrtions are generally recorded in connection with the development of this species summer and winter. In the summer of 1998 liver and dorsal fish muscle from different fish species were collected in this basin together with samples of phytoplankton, zooplankton and benthic invertebrates. All samples were tested for microcystin content with the ELISA test. The samples of benthos were positive ( max. 9 ug microcystin/g d.w.) as well as 50% of the fish liver samples and 1/3 of the fish muscles. In another test *Planktothrix prolifica*-rich water (microcystin concentration 8 µg/l) was used for irrigation of radish and lettuce. In hydrocultures there was an uptake through the root system and a further transport to the leaves. The toxin concentration in radish as well as lettuce reached 0.2 µg/g d.w.

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***Symposium Proceedings***
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Our first contribution is from Vivienne Cassie Cooper, an algologist at Landcare Research and Waikato University. Vivienne is now pursuing her researches in an honorary capacity. We think it appropriate at this point to reprint comments made by Dr John Clayton (NIWA) in his paper presented at the Rotorua Lakes 2001 Symposium;
*I must acknowledge two people that are here today, particularly Vivienne Cassie, who would probably be the oldest person who worked longest on these lakes of anyone that's here and she's still, in retirement, working very effectively and volunteering her time and services. I think that's quite a remarkable performance – thank you Vivienne*. (Applause).

## ALGAE IN THE ROTORUA LAKES: PREVIOUS SURVEYS

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Most researchers approach the study of microscopic algae firstly from an ecological point of view. As the need to put accurate names on the confusing multitude of taxa becomes more pressing, only a few are motivated to become involved in perusing the morass of literature surrounding algal identification and taxonomy.

### Ecological studies

The first detailed study of the plankton of the Rotorua lakes was carried out by that intrepid pioneer of New Zealand limnology, Violet Hilary Jolly (PhD thesis, unpublished 1959). Single-handed, she dragged her boat and equipment around her thesis area and other New Zealand lakes, and gave us a record of the physical, chemical and biological details of their phyto- and zooplankton populations as they appeared in her samples in the 1950s. Subsequent papers were published from this work in 1968, and with the aid of Ann Chapman, her loyal friend before and after her death, in 1977.

The first concerted body of information on lakes in the Rotorua district was contained in the definitive book "*New Zealand Lakes*" (Jolly & Brown, Eds, 1975). This marked a milestone in presenting limnological studies across New Zealand: paleoecological, physical, chemical and biological, to the general public. During this period, planktonic microalgae were investigated by New Zealand researchers Vivienne Cassie (1969, 1975, 1978), and by Drs Jolly and Flint (1975). An unpublished survey of Lakes Rotorua and Okareka was carried out is 1976 by **J**oke Baars-Kloos. As a result of all these studies, a reasonably comprehensive picture was built up of seasonal variations in populations of floating microscopic algae inhabiting some of the Rotorua lakes.

Much less information was available however on benthic and periphytic algae, which are also vital components of the ecosystem, and intimately tied up with conditions prevailing in the sediments and macrophytes. This aspect of algal research

has been greatly enhanced recently by Barry Biggs and Cathy Kilroy, NIWA, in their illustrated *Guide to monitoring Periphyton* (2000). Picoplankton, earlier an unknown quantity, was first highlighted by Hans Paerl, who discussed relationships of nitrogen-fixing blue-green algae with bacteria attached to polar regions of heterocysts (1976); and also the more general significance of 'ultraplankton' biomass in Lakes Rotongaio and Rotoaira (1977). Effects of thermal conditions on the algal taxa are still not widely understood.

**Taxonomic studies**

Initially, taxonomic information of algae of the Rotorua lakes came from the work of Professor Otto Nordstedt in Sweden (1888), who investigated samples from Lakes Rotomahana and Tarawera, as well as from other localities in New Zealand.
The work of A. Nash in 1938, although unpublished, is none-the-less of significance to taxonomy of thermal algae in the Rotorua district. Significant contribution to our knowledge of the microalgae present in monomictic Lakes Rotorua and other waterways in the Taupo Volcanic Zone was published in the 1960s and 1970s by Kuno Thomasson from Sweden (1960, 1972, 1973, 1974a, 1974b), notably on the desmid populations. Not only were his publications of great assistance for future workers faced with difficult identifications, but it was also basic to the later production of the "*Flora of New Zealand Desmids:*" by Hannah Croasdale, Elizabeth A. Flint and Marilyn Racine (1986, 1988, 1991), and to the assembling of revised checklists of the freshwater algae of New Zealand (Cassie 1984a, 1984b, 1989. 2001). From a series of random net samples, Thomasson identified over 400 taxa from 10 lakes in the Rotorua district, including Lake Taupo.

Another definitive work on the taxonomy of New Zealand freshwater algae is that on planktonic blue-greens (Cyanophyta/Cyanobacteria) by M.K. Etheredge and R.D. Pridmore (1987), including a number of species known to be toxic at times in the Rotorua lakes. A new variety of *Anabaena minutissima* was described from Lake Rotongaio (Pridmore & Reynolds 1989). The Chaetophorales, an Order about which little was known in New Zealand, apart from the orange-red growths of sub aerial *Trentepohlia aurea* on old wooden telegraph poles, was the subject of an intensive investigation for a PhD by Pranjit Sarma (1986). Despite his propensity for naming new taxa after his friends, the work remains the definitive account on this group of branched filamentous algae, at least until further research sheds more light on its constituents.

**Thermally associated algae**

An early study was that of A. Nash (unpublished 1938) who compared the occurrence of 40 cyanobacteria from Rotorua and Whakarewarewa with their counterparts at Yellowstone National Park, USA. Another American, R.W. Castenholz (1976) emphasized the importance of sulphide in determining the presence of different cyanobacterial taxa.
Some years after Thomas and Louise Brock were investigating microbial mysteries of thermal habitats in the Central Volcanic Region (Brock & Brock 1970, 1971) Bioresearches Ltd. investigated the water quality of Puarenga Stream and Sulphur Bay for the Rotorua City Council (1978a, 1978b). Data on algae inhabiting thermal areas of the Central Volcanic Region was further documented by Cassie (1989) and Cassie and Cooper 1989).

A non-technical summary of this work is contained in the recent book entitled *Botany of Rotorua* (Clarkson, Smale & Eckroyd, Eds: 1991).

**Recent surveys**

The last two decades have seen a number of publications dealing primarily with algae in the area - including several from the former DSIR laboratory at Taupo (Pridmore 1987a, 1987b, Vincent, Gibbs & Dryden 1984, Vincent & Dryden 1989, Viner 1989). Much of this work is summarized in the definitive publication *Inland Waters of New Zealand* (Viner 1987). During the 1990s, longer-term detailed surveys of the phytoplankton in several Rotorua lakes have been carried out by members of Environment Bay of Plenty (Donald 1996, Wilding 2000). In some of the lakes, notably Rotoiti, Rotoehu, Okareka and Okaro, water quality has deteriorated markedly from time to time; as indicated by the occurrence of sometimes dense and potentially harmful blooms of blue-green cyanobacteria. In addition there have been outbreaks of a mass of white foam billowing shorewards like white detergent during March 1999 in Lakes Rotorua, Rotoiti and the Kaituna River - apparently caused by an unusual upsurgence of a green, moon-shaped unicell called *Kirchneriella lunaris* (Wilding 2000).

A less well known group is that of the chrysophytes (golden brown algae). Electron microscope studies are essential for their accurate identification. Two such studies have been made: by Monica Dürrschmidt (1986) and Daniel Wujek and Charles O'Kelly (1992). Their work has demonstrated the occurrence of 23 species in New Zealand waters, including some species from the Central Volcanic Region, mostly recorded for the first time.

Contrary to accepted opinion, recent ecological studies on the impact of water net, *Hydrodictyon reticulatum* (Wells et al 1999, Wells & Clayton 2001) have shown that its effect may even be beneficial to certain organisms at times.

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*Also of interest was an illustrated account of phytoplankton in Lake Rotoiti published by Julie Carr (1966),* s*ee reference below. - Ed*

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**Our next contribution is from Dr Bill Vant, Environment Waikato. Some of our readers will have heard his paper, delivered at the recent 2001 Conference of the New Zealand Limnological Society. Here is the abstract of that paper, which seems to have distinct relevance to the situation in the Rotorua Lakes.**

## Changes at Lake Taupo: the early warning signs?

Bill Vant
*Environment Waikato, Box 4010, Hamilton*

There have recently been a number of signs that Lake Taupo's near-pristine condition has begun to deteriorate. These include increases in the levels of nitrogen and phytoplankton biomass in the lake, and a small but significant reduction in water clarity. In addition, an unprecedented bloom of the potentially-toxic blue-green *Anabaena circinalis* occurred in the lake in February 2001.

Comparison of historic (1970s) and recent records of water quality in some of the rivers and streams flowing into the lake also shows some important patterns. In five rivers draining catchments that are predominantly in native or exotic forest, average concentrations of inorganic nitrogen have generally not altered much over the past 25–30 years. By contrast, in rivers draining catchments with large areas of pasture, we find that average concentrations now are substantially higher than in the years immediately after land development. Concentrations are now 50–100% higher in four rivers in the western part of the catchment, and 4–7 times higher in two streams in the northern part of the catchment.

In the two northern streams, our recent water dating analyses show that only about one-third or less of today's baseflow water is young enough to have been affected by the conversion to pasture that occurred 30 and more years ago. The changes in water quality that we are now seeing in the streams and the lake are therefore probably a delayed response to land use changes that were made in the catchment several decades ago.

With the benefit of hindsight, is it interesting to speculate whether the delayed deterioration of the lake that we're currently seeing could have been better anticipated? Rather than looking-out for changes in lake water quality, could we perhaps have been monitoring processes or activities in the catchment, and thus have received earlier warning that deterioration had begun?

**Dr Phil Shoemack, Medical Officer of Health, Pacific Health, has the following message for lake users.**

"It is anticipated that cyanobacteria blooms in some of the Rotorua lakes will again be a feature of the coming summer months. Based on the experience of the past few years blooms can be expected to start prior to Christmas, particularly in Lake Rotoehu. People living round lake shores and others using them should be alert for discolouration of the water, the smell of dying biomass, and globules suspended in the water any of which could signify a cyanobacteria bloom.

As in past years Environment Bay of Plenty will be working with Toi te Ora Public Health to conduct regular surveillance of water quality in the lakes. Obviously there are resource constraints on how much sampling can be done and users of the lakes are encouraged to phone either organisation if they suspect a previously unrecognised bloom has occurred. Extra sampling can then be initiated to confirm the situation.

Once a bloom is confirmed appropriate signage will be erected by Rotorua District Council and a general health warning will be issued to the public by the Medical Officer of Health using the media."

*On Monday 3 December 2001 the* Daily Post *reported that the recurrent cyanobacterial bloom on Lake Rotoehu was again present. - Ed.*

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**Lakes report**

Environmental Scientist, John Gibbons-Davies, of Environment B·O·P has reported the latest lake data for the year ending July 2001. The report concludes by placing the data in terms of the Trophic Level Index (TLI). The index is made up of four factors, clarity, total nitrogen, total phosphorus and chlorophyll a level. It is found that where the TLI exceeds a certain level then environmental quality problems ensue eg we have seen the incidence of blue-green algal blooms in recent years. In addition, although the measurements are taken at the deepest part of the lake the environmental issues can occur anywhere on the lake and frequently this is at the edges.

This index is one of the parameters that Environment B·O·P has used to classify lake waters in the Proposed Regional Water & Land Plan. The Plan provides a framework for lake management and the TLI is included in the Plan as a trigger to move into an action mode.

In effect action mode is activation of Rule 11 of the proposed Plan and a series of public meetings are being organised to explain the relevance of this rule.

Five lakes of the region would be deemed to be in this activated state if the Plan was operative at the moment. They are Lakes Rotorua, Rotoiti, Okareka, Rotoehu and Okaro.

For each of these lakes, except Lake Okaro, land use management decisions have been taken and implemented, to reduce the nutrient load on the lake. At Lakes Rotorua and Rotoiti, the diversion of treated sewage effluent from discharge to the lake in 1990 is expected to result in both lakes reaching the target TLI. Retirement of land from grazing is proceeding around the margins of Lake Rotoehu, which is expected to bring benefits in nutrient reduction. Rotorua District Council is currently investigating methods of reducing the load of nutrients from septic tanks at Lake Okareka. Environment B·O·P is assisting this process by contracting NIWA to examine nutrient outputs from different land uses around the catchment.

*Lake Rerewhakaaitu*

The results of Environment B·O·P's year-long study of Lake Rerewhakaaitu will be released to the Regulation & Resource Management Committee at the end of November.

Lake Rerewhakaaitu meets its target Trophic Level Index so no extraordinary land use management measures are called for. However, with intensification of agriculture in the future, Environment B·O·P and the local community will have to work together to manage the nutrient load on the lake.