Lake Dynamics

Introduction

Water quality in the Rotorua lakes is governed by complex interactions between physical, chemical and biological processes.

Physical processes determine the transport and mixing of substances in a lake.

Chemical processes determine the availability of solutes, including nutrients, for plant growth.

Biological processes affect the way that different organisms interact and how they respond to the physical and chemical environment.

Lake mixing

The deeper Rotorua lakes such as Tarawera, Rotoiti and Rotoma mix fully from top to bottom in winter, but stratify into two layers during warm, calm periods in summer and autumn. This stratification occurs because surface waters become warmer and buoyant when they are heated by the sun, while bottom waters remain cool and dense. In winter as the surface waters cool, the water column mixes fully again.

In the shallow Rotorua lakes, such as Rotorua, Rotoehu and Rerewhakaaitu, mixing occurs almost continuously, though in warm, calm periods there may be brief periods of stratification.

When temperature stratification occurs, substances are dispersed across a lake many times faster than they are dispersed through the lake depth. This often results in large gradients in the concentration of organisms and chemical substances over the depth of the lake.

Oxygen levels

With the exception of specialised anaerobic organisms, all life depends on the presence of dissolved oxygen. Oxygen in the surface waters of a lake usually remains stable because losses from respiration are replenished by gains from the atmosphere or photosynthesis, the process used by plants and algae to capture light energy and convert inorganic nutrients (e.g. phosphorus and nitrogen) into organic material. When lakes stratify, however, oxygen in the bottom waters is not replenished adequately because atmospheric inputs are cut off and there is insufficient light for photosynthesis in the deeper, dark waters. The rate that oxygen is depleted from the bottom waters when a lake stratifies is determined strongly by the supply of organic matter arising as algae settle out of the water column and die. This supply of organic matter acts as food for bacteria, which use oxygen to break it down.

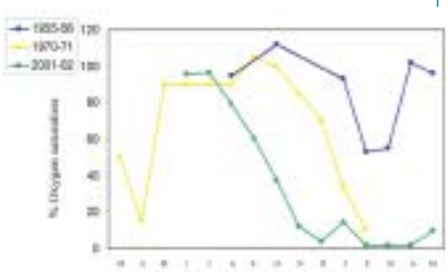
If high levels of nutrients stimulate the growth of algae in the surface layer and result in an oversupply of organic matter, then all of the oxygen in the bottom waters of a lake may be consumed before being restored by winter mixing in deep lakes or wind action in shallower lakes.

Aerial view of Lake Rotoiti

Nutrients from bottom sediments

The loss of oxygen from the bottom waters of a lake leads to a chain of chemical reactions as bacteria 'scavenge' material for oxygen. Oxygenated forms of iron and manganese are scavenged by bacteria, which change these compounds from particle-bound forms in the bottom sediments to dissolved forms that diffuse into the water. Nutrients such as phosphorus that were previously bound to the iron and manganese, also dissolve and diffuse into the water.

This complex cycle is dangerous for the health of the lake, since the loss of oxygen from the bottom waters can mobilise large quantities of nutrients such as phosphorus, that were previously locked up in the bottom sediments.

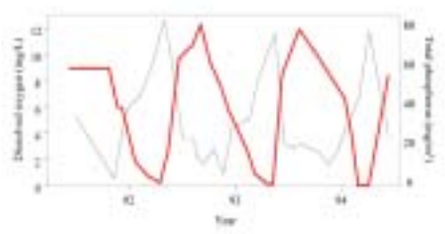


Declining levels of oxygen during the stratefied period in Lake Tikitapu are cause for concern because of nutrients that may be released from the bottom sediments and stimulate algal blooms.

Feedback to growth of algae

Very large quantities of phosphorus are being released from the bottom sediments of Lakes Rotoiti and Okaro when these lakes stratify and oxygen is lost from bottom waters. As the nutrients released from the bottom sediments are mixed through the water column, with each annual cycle they stimulate further algal growth.

This perpetuates a vicious cycle of loss of oxygen, nutrient release and more algal growth, which characterises the dynamics of Lakes Rotoiti and Okaro.



Dissolved oxygen (red line) and phosphorus levels (black line) in the bottom waters of Lake Rotoiti, showing how seasonal loss of oxygen leads to a large increase in phosphorus concentrations through release from the bottom sediments. More than 15 tonnes of phosphorus may be released each year when the oxygen levels are reduced.

Monitoring and research

Environment Bay of Plenty conducts routine monitoring of 12 Rotorua lakes to detect changes in nutrient and phytoplankton levels and water transparency. It has also funded a Chairperson in Lakes Management and Restoration at the University of Waikato, to provide independent scientific support for managing the Rotorua lakes.

Research conducted at the University of Waikato has identified clearly that while oxygen levels have remained stable in the bottom waters of some lakes (e.g. Tarawera and Rotoma), it has declined progressively for a number of years in others (e.g. Lakes Tikitapu and Okareka). In some lakes expensive engineering works may be required to restore oxygen levels to bottom waters, so that people can continue to enjoy the lake the way they have been accustomed to in the past.

Action also needs to be taken to prevent more nutrients getting to the lakes. This will ensure that the Rotorua lakes continue to provide a valuable tourism and recreational resource for years to come.

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