

## CHAPTER 3

# PROBLEMS OF LAKES AND RESERVOIRS

### 3.1 OVERVIEW

Problems of lakes and reservoirs are caused by the anthropogenic use of these ecosystems. Most lakes have multiple uses and the problems are related to the conflict between these uses, for instance a lake is used for discharge of waste water and as well as recreational area. The solutions to the problems obviously must take into consideration *all* the uses and attempt to *solve* the conflicts between them. It is hardly possible to find the optimum solution to each of the lake uses, but it is necessary in practical lake management to find a compromise between two or more uses, which of course render the management problem more complex. Many lakes are, for instance, used for production of drinking water as well as for discharge of waste water. The conflict between these two uses is obvious.

Modelling is a particularly useful tool in lake management, see also chapter 6, because a model is able to synthesize the knowledge of the system and the problems.

Lakes and Reservoirs are utilized by man for:

- 1) Production of drinking water
- 2) Production of electricity
- 3) Recreation
- 4) Fishery
- 5) Aquaculture
- 5) Discharge of waste water

Information on the cause of a lake problem is needed to be able to find a solution to the problem. Here the application of mass balances, see chapter 5, is very important to reveal the source.

The sources or causes of lake problems may be summarized as follows:

1. Discharge of organic biodegradable wastes.
2. Discharge of nutrients from waste water.
3. Non-point pollution of nutrients, mainly coming from agriculture.
4. Acid rain (caused by air pollutants : SO<sub>2</sub> and NO<sub>x</sub>)
5. Discharge of toxic substances from industries or agriculture.
6. Thermal discharges.

### 3.2 RELATION BETWEEN PROBLEM AND CAUSE

The basis of a sound lake management strategy is a clear definition of the problem(s) and its (their) cause(s). Table 3.1 attempts to set up a problem/cause matrix to survey the relationship between the environmental problems and their sources. The selection of remedial techniques is, see also chapter 7, closely related to the sources. It is therefore a substantial part of the management strategy to reveal in details all the sources. The problem often may be caused by more than one source, as illustrated by the pollution tetrahedron in Figure 3.1.

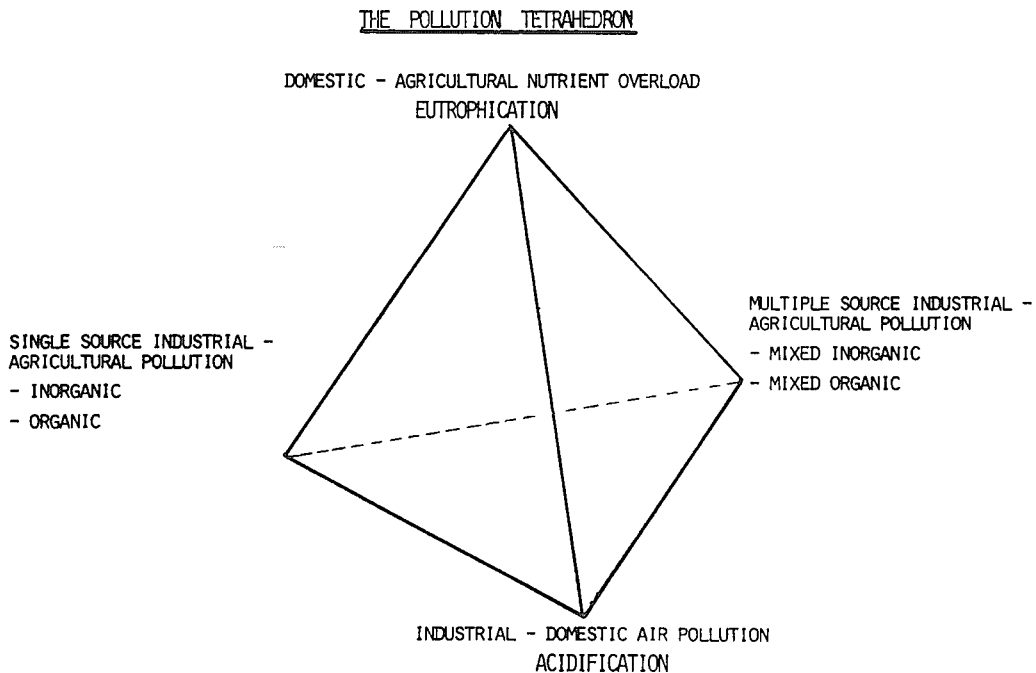
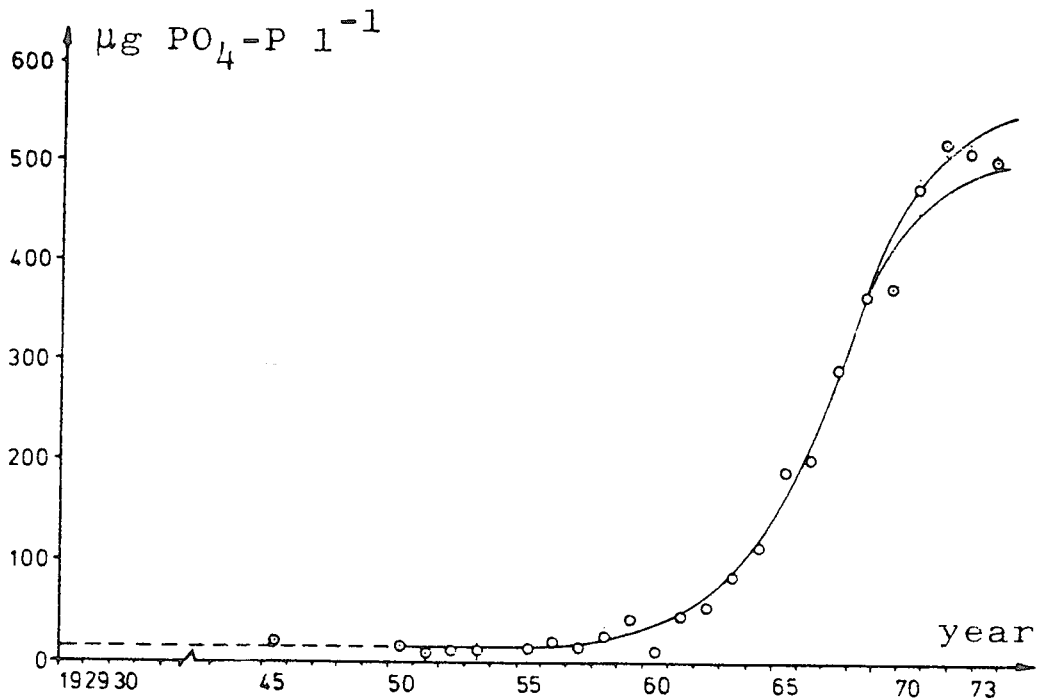


Figure 3.1 Pollution tetrahedron.

Lakes have buffer capacities, it means that they are able to resist a certain level of pollutants. However, the buffer capacities are limited and the outbreak of a problem may therefore occur during a relatively short period of time, while the input of pollutants to the lake has lasted for a considerable longer period, see Figure 3.2. The ability of sediment to accumulate pollutants may often explain this buffer capacity. At a certain level of accumulation the capacity of the sediment has been exhausted and further input of pollutants will increase the concentration in the water phase significantly. If the condition of a lake is not followed carefully, it may therefore look like the problems emerge suddenly, but the cause of the

entire complex of problems may have started several years ago. Consequently, it is of significant importance to perceive a lake problem at the earliest possible stage. It is much easier to solve the problem, when it is possible in the management strategy to take advantage of a certain buffer capacity than when the buffer capacity has been exhausted.



**Figure 3.2** Phosphorus concentration in Lake Fure versus time. The phosphorus loading has increased linearly during the period.

Considerations on lake management strategies include therefore application of lake restoration methods - also called ecotechnology - to attempt to bring the lake faster back to an "equilibrium of reduced problems". As discussed in chapter 7, more remedial methods must work hand in hand to solve most practical lake management problems. In other words lakes have multiple problems caused by multiple sources and their solutions require use of multiple remedial techniques, see also chapter 7.

The problems listed in Table 3.1. are interactive in the sense that one problem may often give rise to other problems, because a lake is a system, where all the components are linked.

**Table 3.1**  
**Problems associated with lakes and reservoirs**

Problem areas	Caused by, or indirectly depending on			
	Excessive nutrient discharges leading to		Inorganic and organic waste discharges	Acid rain
	Algal blooms & shifts in species composition	Excessive macrophyte & littoral algal growth		
1. Water Quality Impairment				
- taste & odours, colour, filtration, flocculation, sedimentation and other treatment difficulties	x x x	x	x	-
- hypolimnetic oxygen depletion, PH changes, Fe, Mn, CO <sub>2</sub> , CH <sub>4</sub> , H <sub>2</sub> S	x x x	x x	x x	x
- toxicity	x	x	x	-
- occlusion and corrosion problems in pipes and other man-made structures	x x	x	x	x
2. Recreational Impairment				
- unsightliness	x x	x	x x	-
- hazard to bathers	-	x x	-	-
- increased health hazards	x	x	x	-
3. Fisheries Impairment				
- fish mortality	x x	x	x x	x x
- undersirable fish stocks	x x	x	-	x
4. Aging and reduced holding capacity and flow				
	x	x x	-	-

Frequency and/or importance: xxx very high, xx high, x occasional, - not applicable

A development of a complex of problems may occur and can be demonstrated by the following example:

1. Excessive nutrient discharges originated from waste water and agricultural run off lead to algal bloom. The transparency is reduced causing recreational impairment.
2. Oxygen depletion in hypolimnion due to oxygen consumption by mineralization of detritus originated from the algal biomass. Water quality impairment is recorded.
3. Continuous oxygen depletion implies formation of hydrogen sulfide. The results are further recreational and water quality impairment.
4. The formation of hydrogen sulfide causes high fish mortality. Impairment of fishery.

**Table 3.1 (continued)**  
**Problems associated with lakes and reservoirs**

Problem areas	Caused by, or indirectly depending on		
	Others		
	Turbidity and silting	Low dissolved solids and humic substances	Thermal discharges
<b>1. Water Quality Impairment</b>			
- taste & odours, colour, filtration, flocculation, sedimentation and other treatment difficulties	x	x	-
- hypolimnetic oxygen depletion, PH changes, Fe, Mn, CO <sub>2</sub> , CH <sub>4</sub> , H <sub>2</sub> S	-	x	x
- toxicity	-	-	-
- occlusion and corrosion problems in pipes and other man-made structures	x	x	-
<b>2. Recreational Impairment</b>			
- unsightlyness	x	-	-
- hazard to bathers	-	-	-
- increased health hazards	-	-	x
<b>3. Fisheries Impairment</b>			
- fish mortality	x	-	x
- undersirable fish stocks	-	-	x
<b>4. Aging and reduced holding capacity and flow</b>			
	x x	-	-

Frequency and/or importance: xxx very high, xx high, x occasional, - not applicable

The four stages described above illustrate a stepwise deterioration of a lake ecosystem. It may even be possible to observe a "run away" effect. If the sediment gets anaerobic the release of phosphorus from the sediment is accelerated, which causes an increased algal bloom, which causes a further oxygen depletion in the hypolimnion and so on.

The conclusion is very clear: recognition of a environmental lake problem at the earliest possible stage followed by application of a sound and consequent environmental mangement strategy not only prevents deterioration of the lake, but renders the environmental management so much easier, cheaper and controllable.