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Reduced Inputs of Phosphorus to Loch Leven: Effects on Nutrient Concentrations and Phytoplankton

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INTRODUCTION

This interim report concerns the period December 1989 to the present and comments on how conditions for that time compare with previous years. The sampling schedule for the information indicated in **Table 1** has been maintained. Good progress has been made regarding the phytoplankton analyses and the computer logging of these algal data, along with the nutrient results.

Table 1: Sampling schedules and determinands - Loch Leven restoration programme (1990)

Sampling site	Sampling frequency	Determinands
On the South Queich: upstream of the mill	every 8 days	dissolved and particulate fractions of phosphorus; dissolved and diatom silica; nitrate; water temperature; pH (on most occasions); river height (for flow calculation)
downstream of the mill	"	
In the loch: public pier at Kirkgate	every 8 days	as above but loch height at outflow only; also, chlorophyll concentration and the species and population numbers of algae and rotifers
sluices outflow	"	
open water in West Bay	commenced 26 March at 2-3 week intervals	Secchi disc reading and water temperature only

Some of the results presented below refer to data collected as recently as late October 1990, but there has been no major attempt at analysing or interpreting them. Firstly, the project set out to secure a 24-month run of information before commenting on the behaviour of the loch following the reduction of external phosphorus (P) inputs, and this period does not end until 31 December this year. Secondly, the attribution of any physical, chemical and biological changes, to the nutrient reduction, as opposed to the unusual climatic/weather conditions experienced in northern Britain over this study period, cannot be established until we have collated data on flushing rate. Nevertheless, we have a good general idea of (a) the reduction achieved as regards the P content of the South Queich previously receiving P-rich industrial effluent, (b) the clarity and nutrient content of the loch water and, (c) changes in the abundance and species composition of the phytoplankton.

RESULTS

The phosphorus content of the South Queich

The factory that produced the P-rich effluent which is the main focus of attempts to reduce the external loading to the loch, is situated on the side of the South Queich. Effluent is still discharged into the stream between our sampling points above and below the mill, but *via* a treatment plant rather than through the original pipe. For present purposes, results on total soluble P (TSP) are sufficient to illustrate that the company involved, has reduced considerably its output of phosphorus. **Table 2** compares the mean values for the January-to-August periods of 1985 and each year 1988 to 1990, and shows that the P concentrations upstream have remained at a more or less constant low value since 1985, and downstream concentrations are now virtually the same as the upstream levels, having fallen to approximately 1-twentieth of the 1985 figure.

Table 2. Mean TSP concentrations (μg P l^{-1}) in the South Queich, at points upstream (u) and downstream (d) of the bankside mill; values refer to the period January to August of each year shown.

Year	1985	1988	1989	1990
Site u	13	19	17	15
Site d	358	37	20	17

This point source of P appears thus to have been eliminated. In 1985, it comprised slightly more than 50% of the total point-source inputs of P. If the annual supplies of all other sources of P during the present study period prove to be the same as those calculated for 1985, the total loading (i.e. of all fractions of P) to the loch now, would be approximately 70% of that found in 1985. Although rainfall - which controls the loadings of diffuse, runoff P - and the inputs of water have not yet been calculated, it is probable that these will prove to be considerably less than those found in the extraordinarily wet year of 1985. As a consequence, the loadings are likely to be even less than 70% of the 1985 total.

Concentrations of phosphorus in the loch

The mean level of total P over the first 8 months of the current year is 71 µg P l^{-1} which is slightly less than, but not significantly different from the value found for the same period of 1989 (**Table 3**). It is well in excess of the mean concentration for the January-to-August period of 1985 (56 µg l^{-1}) i.e. pre-P reduction, but this is not so surprising, bearing in mind the likely low flushing rate experienced in 1990. This would increase the time available for algae to accumulate biomass - as reflected in particulate P average values of 49 µg l^{-1} (*cf* 50 in dry 1989, and 36 in the wet 1985); also, because 1990 was warm, the release of soluble P from the sediments is likely to have been more marked than in 1985, for example. Such releases can be masked by algal uptake and use by other plants, but it is interesting to note that the mean concentration of soluble reactive phosphorus (SRP) in January to August 1990 is remarkably low, at 9 µg l^{-1}.

Table 3. Phosphorus concentrations (µg P l^{-1}) in Loch Leven; the figures which refer to the sampling site near the outflow, are the mean values for the period January to August for the years shown.

	Year			
Phosphorus fraction	1985	1988	1989	1990
total P	56	62	74	71
particulate P	36	46	50	49
soluble reactive P	10	5	12	9

The work illustrates well the importance of weather conditions in influencing the nutrient dynamics of lake systems. In the present case, low rainfall in successive years 1989 and 1990 have undoubtedly tempered the effects of reduced P loading. It needs more time, or at least a year of more usual flushing regime, to establish whether the existing reduction is affected.

Phytoplankton concentrations

Chlorophyll levels are used as an overall index of phytoplankton abundance and the mean value obtained for the first 10 months of 1990 is 42 µg l^{-1} (**Table 4**). This is slightly less than, but not significantly different from the value of 44 µg l^{-1} for the same period of 1989. While these figures indicate double the average biomass recorded in 1985, they too, reflect the low flushing rate (i.e. long residence time of the water). Significantly, although "classic" blue-green algal blooms occurred in 1990,

they did not persist on the timescales of weeks, even months, characteristic of both this loch in earlier, drier years, and of many UK waters in 1989 and 1990. Also, the mean Secchi disc readings for the period referred to in Table 1, is 1.7 m - a tolerably good value for Loch Leven, particularly considering how conducive recent weather has been for phytoplankton growth.

Table 4. Phytoplankton levels (expressed as µg chlorophyll l^{-1}) in Loch Leven; figures refer to the outflow sampling site and are means for the period January to October of each year shown

Year	µg chlorophyll l^{-1}
1985	19
1988	37
1989	42
1990	44

Concluding remarks

The issue regarding the effects of P reduction is not simple, but the data analyses are incomplete and the all-important information on water residence time has yet to be collated. However, in spite of the weather regime having in all likelihood delayed any major beneficial effects of loading reduction, it is encouraging that this year has seen few protracted blooms of algae, has exhibited reasonable water clarity and shown signs of recovery *vis a vis* macrophytic growth. Some form of limnological surveillance of the loch over the next year or two is vital. Without this, the value of the applied scientific work to date cannot be assessed, nor can the worthiness of proposals to remove P from conventionally-treated sewage be scientifically adjudged. What is more, the work has considerable implications for the management of freshwaters nation- and world-wide.