Institute of Freshwater Ecology

Phosphorus Analysis of Pennington Flash Sediments

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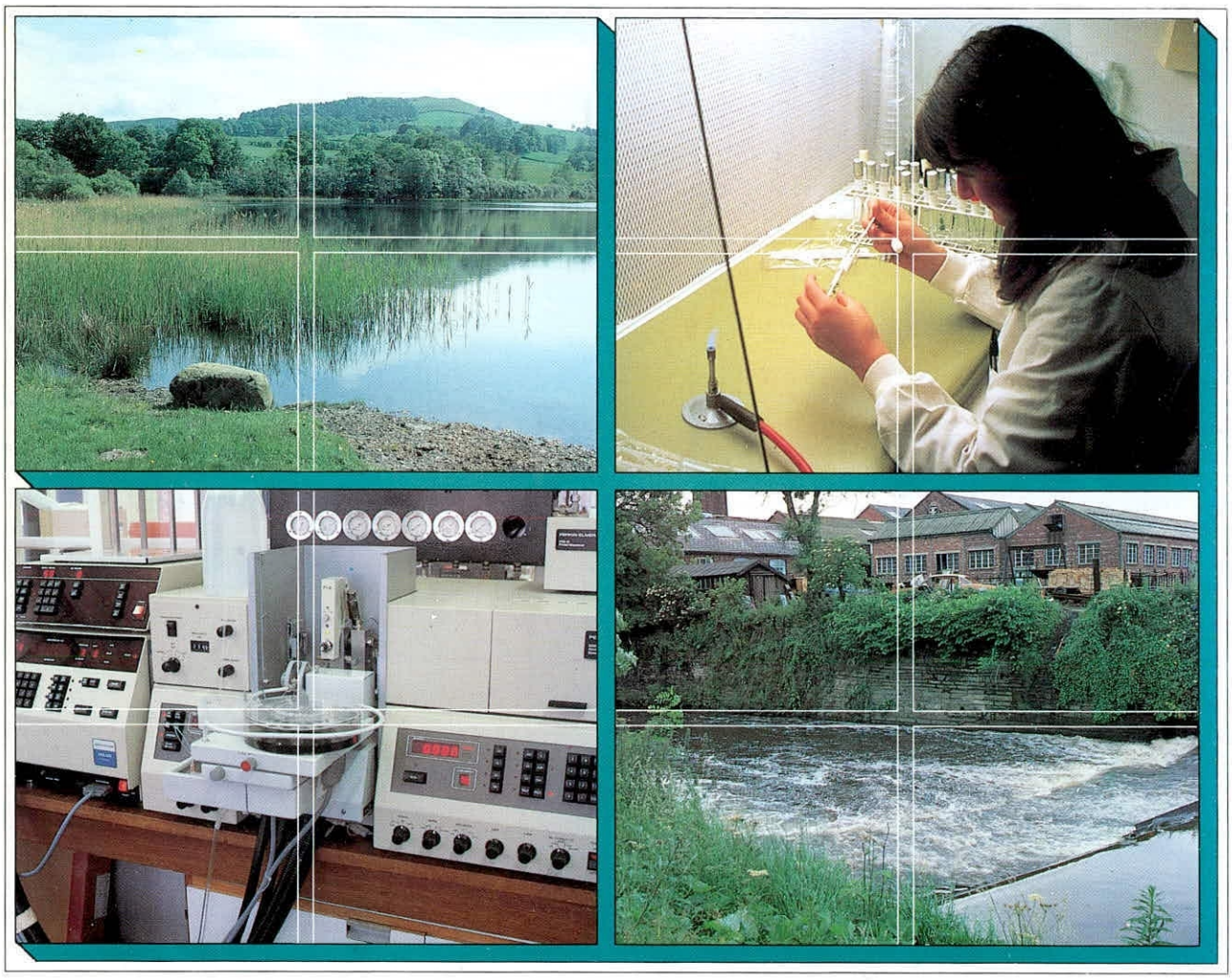

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SUMMARY

The report details the results of the chemical analysis of sediments from Pennington Flash taken in the middle of May 1997. Determinations were made for phosphorus extracted with ammonium chloride (loosely bound) and sodium hydroxide (oxide bound) and for total phosphorus concentrations after digestion with nitric acid, hydrogen peroxide and hydrofluoric acid.

Previous work at IFE Windermere has shown that the level of remobilisable phosphorus (loosely bound + oxide bound) can give an indication of the trophic status of a lake. Sediments sampled in the middle of Pennington Flash are most like those found in the Lake District lakes in terms of composition. Analysis of the phosphorus speciation data indicate a degree of nutrient enrichment which would place Pennington Flash towards the more eutrophic (nutrient rich) end of a series of Lake District lakes.

The loose P and oxide P fractions are considered to represent a potentially remobilisable pool of nutrient; remaining phosphorus is assumed to be unavailable. Up to one quarter of the phosphorus contained in the Pennington Flash sediments may be potentially available and therefore in the short term any remedial actions undertaken to improve water quality may be offset.

CONTENTS

BACKGROUND

The Environment Agency, North West Region has requested information regarding the speciation and potential availability of phosphorus within the surficial sediments of Pennington Flash. Previous work at IFE Windermere (Cranwell et al., 1995) has shown that sequential chemical extraction of lake sediments can provide this type of information and furthermore indicate the extent of nutrient enrichment within a lake.

Sediment samples from the inlet, middle and outlet of Pennington Flash were taken by EA staff in mid May 1997 and delivered to IFE Windermere for analysis on the same day. Subsamples were extracted in duplicate for loose and oxide bound phosphorus and digested for total phosphorus.

METHODS

Phosphorus speciation and analysis

(a) Wet sediment was successively extracted twice with 1M ammonium chloride adjusted to pH 7 with sodium hydroxide, by shaking for 2 hours, centrifuging, decanting the supernatant, filtering it through a 0.45 μm membrane filter and analysing the combined filtrates for soluble reactive phosphorus (SRP) using molybdenum blue. This procedure extracts loosely bound phosphorus and the portion dissolved in the interstitial water of the sediment

(b) The residual sediment was re-suspended in 0.1M sodium hydroxide, shaken for 15 hours, centrifuged and the supernatant filtered and stored. The extraction was repeated by shaking for two hours only and the extracts combined and analysed for SRP as in section (a). The phosphorus released by sodium hydroxide is the oxide bound fraction and is assumed to correspond to that portion bound to iron and aluminium hydroxides.

(c) A weighed subsample was dried at 105 ⊕C and digested with nitric acid, hydrogen peroxide and hydrofluoric acid to estimate total phosphorus. The total phosphorus will include the loosely bound and oxide fractions determined in stages (a) and (b) and that phosphorus which is bound to apatite and within the mineral matrix of the sediment.

RESULTS and DISCUSSION

The phosphorus speciation results are given in Table 1 and comparison data for remobilisable phosphorus concentrations in five Lake District lakes are given in Table 2. The following conclusions can be reached:

1. Sediment sampled from the inlet and outlet differ from that taken in the middle of the lake. The dry weight composition of the sediments indicate that those taken from the middle of Pennington Flash are different from those from the inlet and outlet and comparable to those from a number of Lake District water bodies, which generally consist 5-20 % dry weight. Samples taken from the middle of the lake are in a region where fine grained sediments are likely to be accumulating and therefore represent average conditions within the water body.

2. Phosphorus analyses of the sediments taken from the middle of Pennington Flash indicate a degree of nutrient enrichment which would place it towards the more eutrophic (nutrient rich) end of a series of Lake District lakes. With regard to loose and oxide bound phosphorus, the middle sediments are most like those from Grasmere (see Table 2); they both have oxide P contents of 2000 μg P/g. Previous work at IFE Windermere (Cranwell et al. 1995) has shown that the trophic status is reflected by the concentration of loose and oxide bound phosphorus fractions. The lake series indicated by the trend in this fraction found during the previous study is similar to that found by Jones (1972), with the state of eutrophication being: Derwentwater < Coniston Water < Bassenthwaite Lake < Grasmere < Esthwaite Water. Using this series for the basis of comparison it is apparent that Pennington Flash, being similar to Grasmere, would be expected to be enriched with nutrients when compared to an

oligotrophic lake such as Derwentwater. This is consistent with the fact that Pennington Flash receives sewage effluents that would be expected to contain high concentrations of phosphorus (T. Bruce, pers. commun.).

3. On the basis of these three samples it would appear that Pennington Flash is accumulating phosphorus. Levels of total and remobilisable phosphorus for the middle sediments are between about 3 and 6 times greater than those found for the inlet and outlet sediments.

4. The concentration of potentially remobilisable phosphorus is likely to be significant. Loose P and oxide P are considered to be potentially remobilisable and therefore a source of nutrient to the water body. Phosphorus not accounted for in these two fractions is taken to be resistant to remobilisation, present within the mineral matrices or as apatite. Up to one quarter of the phosphorus contained within the Pennington Flash sediments may be remobilisable (released as soluble phosphorus during redox recycling) and therefore a potential source of nutrient to the lake. This pool of phosphorus has important implications for any remedial work which may be undertaken to improve water quality; in the short term any reduction in phosphorus input to the lake is likely to be offset by recycling from surficial sediments.

Previous work has shown a seasonal variation in both the levels of total phosphorus and the proportion of that phosphorus which is remobilisable. Present observations are a snapshot of conditions within the lake based on the speciation of phosphorus within its sediments and therefore can only reflect that which prevails at that time.

REFERENCES

Cranwell P.A., Reynolds C.S., Lawlor A.J. and Tipping E. (1995) Sediment Analysis of Sensitive Cumbrian Lakes. Report to National Rivers Authority, North West Region, 23 pp.

Jones J.G. (1972) Studies on freshwater micro-organisms: phosphatase activity in lakes of differing degrees of eutrophication. J. Ecol., 60, 777-791.

Table 1. Phosphorus contents of Pennington Flash sediments. Results are given in μg P/g dry sediment. Key: "loose" is P extractable with NH_4Cl and "oxide" is P extractable with NaOH (see Methods section). The two remobilisable (loose + oxide) fractions are also expressed as a percentage of the total P.

site	% dry weight	total	loose	oxide	% remobilisable
inlet	63.9	1720	0.163	333	19.3
middle	18.1	7650	2.62	2000	26.1
outlet	49.9	2410	1.53	383	15.9

Table 2. Comparison values of phosphorus concentrations in recent sediments of Lake District lakes (Cranwell et al., 1995). The results are given in μg P/g dry sediment for April 1995.

lake	total	loose	oxide	% remobilisable
Derwentwater	4100	13	550	13.7
Coniston Water	4400	11	640	14.8
Bassenthwaite Lake	2700	25	1200	45.4
Grasmere	2900	22	2000	69.7
Esthwaite Water	4200	84	3400	82.9

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