Arb. Lab. Weyregg 5: 119 - 125

NOTE ON BIOAVAILABLE PHOSPHOROUS FROM SURFICIAL SEDIMENTS OF MONDSEE

A. GUNATILAKA

Abstract:

Surficial sediments of Mondsee contain high total phosphorous (T-P), total nitrogen (T-N), and organic carbon content. The bioavailable phosphorous extracted with 0.01 M NaNTA ranged from 23 - 49 % of T-P. In a laboratory experimant, when sediment cores were subjected to mineralization at 4°C for four months, resulted in nearly a three fold increase of bioavailable phosphorous values, suggesting a strong regeneration capacity of latent sediment phosphorous.

Introduction:

In many oligotrphic lakes, sediments play a dominent role as a sink for excess phosphorous (Hutchinson 1957, Wetzel 1975) but now there is accumulated evidence to show that in eutrophic lakes the reverse processes could take place; i. e. the sediments act as an active phosphorous source in the internal phosphorous cycling (Di Giano & Snow 1976, Lorenzen et al. 1976, Lung et al. 1976, Ahlgren 1976). Havon to play an important role in biological production processes, phosphorous in lake sediments thus become a dynamic component in chemical limnology.

Although extensive records have been kept for water chemistry, for many lakes; sediment nutrient analysis are rare. This could be considered as a serious omission. A knowledge of sediment phcsphorous levels and forms could provide substantial information on sediment water interactions, which in turn could be made use to model P-dynamics in lakes. This is an important step in assesing production capacity of lakes which is a prerequisite for lake management. Development of management stratagies to reduce production problems with the view of lake sanitation have become a major question for state as well as local governments.

However, investigations carried out in the recent past by various workers (Fitzgerald 197o, Golterman et al. 1969, 1977, Williams et al. 198o) show that all the phosphate that incorperated in lake sediments are not always available for algal growth. Only part of the phosphates in the sediments could be made use by algae like Scenedesmus (Golterman 1969, 1977). In the sense biologically available (or bioavailable) phosphorous fraction ist, that fraction, that could be extracted and used in growth by algae.

Golterman (1969, 1977) devises a method to determine bioavailable sediment phosphorous by directly meassuring P-uptake by algae (Scenedesmus, Chlorella) from sediment substrates against various chemical extractants (EDTA, DPTA & NTA) and found that 0.01 M NaNTA at PH 7.00, extracted a fraction similar to that removed by algae. High P- concentrations were recorded in Mondsee sediments (Gunatilaka 198o). A preliminary investigation was carried out to determine the bioavailable or the potentially recyclable phosphorous fraction in the sediments using above technique.

Results and discussion:

In autumn 198o ten sediment cores were taken from Mondsee at 65 m (max. depth), 63 m, 62 m, and also at the vicinity of See Ache (48 m & 46 m) using a Kajak corer. The sample description is similar to Gunatilaka (198o) but a new development was the proliferation of sewage fungi on survical layers in the cores removed at 65, 63 & 62 meters.

Surface sediments (o - 1 am & 1 - 2 am) were homogenized, dried at 7o^{o}C for constant weight and analysed for total phosphorous (T-P) and total nitrogen (T-N) (Raveh et al. 1979). Bioavailable phosphorous (Golterman - 1977) was determined using 1 g wet sediments. Carbon was determined as weight loss at 45o^{o}C. In a further experiment, another set of cores from the same depths were incubated at 4 $\pm$ 1^{o}C for four months and on termination, bioavailable -P was determined in the superficial layers in the same manner as above. The analaytical data is presented in table-1.

In the surficial sediments T-P values recorded (table-1) at 65 and 62 m were slightly higher than in 1979. Incidently the same samples had higher T-N and C content which may give a clue about its organic origin (sedimenting algae + sewage,). However, the core from 63 m show a low T-P content but the T-N did not indicate a parallel drop. Cores from 48 m and 46 m registered comparatively lower values for T-P but had similarities to the deepest region in T-N content.

In 6o % of the cores, the highest biovailable phosphorous fraction in the sediments were found between 2 - 3 cm. layer (sub-survace). Thus it is probable that, the part that has got mineralized from surface sediments, had already entered circulation. In the upper most layer, the vioavailable - P ranged between 25 - 42 % of T-P; the layer underneath had slightly higher level 23 - 49 % (Table-1). An exceptionally high bioavailable - P content was observed in one sample (63m).

The samples allowed to mineralize (incubation at 4^{o}C) had very high potential for biologically available phosphorous; with only one exception, in most cases a three fold increase in the concentrations were observed. At the inception of the experiment, there was almost no S^{2-} in the overlying water but on termination an accumulation up to 0.2 mM was seen. Irrespective of the fact that the metabolism was lowered at 4^{o}C the anaerobic conditions settled in, would have accelelerated the chemical dissolution of P, hence these values could be partly exaggerated. Also there was no physical mixing in the cores except for weak bioturbation errect produced particularly by Oligochaetes. Although the experimental conditions are far from the real lake situation, this experiment gives an indication of the magnitude of the potential for dissolution of sediment phosphorous.

Phosphate in the sediments could be either adsorbed on to clay or associated with sedimenting organic matter (autochthonus + allochthonus). Man-made sources could be distinguished from the natural sources as the former being usually associated with excess of nitrogen. The appearence of sewage fungus in Mondsee sediments is an indicator of possible sewage contamination.

Agricultural run off and also the phosphorous entering the lake water with river silt and clay could be considerable. Depending on pH and phosphate concentration, chemical bonds could be formed according to the following equilibria:

$$R.OH_2{+}Cl^- \quad + H_2PO_4^- \qquad R.OH_2 + H_2PO_4^- + Cl^-$$
$$\text{or } 2\ R.OH_2.OH \quad + H\ PO_4^- \qquad (R.OH_2^+)_2HPO_4^- + 2OH^-$$

The phosphate ions which get substituted for lattice-ions become extreamly immobile and resistant to 0.01M NaNTA extraction but phosphate freshly absorbed on to clay is available for algal growth. Iron bound phosphate ist entirely available, while the availability of apatite depends on the crystal size. However, the phosphate trapped in this way is not forever withdrawn from the phosphorous cycle (Golterman 1973). Whether this potential availability can indeed be used in the real lake situation depends strongly on the hydrodynamics of the system.

In imperical P-loading models such as that of Dillon & Rigler (1974) and Vollenweider (1976 a), no attention has been given to regeneration of phosphorous from sediments to lake waters. This is due to lack of carefull and detail con-

Sampling Location	Depth	Ignition wt. loss as % C	T-P /ug/g	T-N mg/g	Bioavailable-P (NTA-P) /ug/g	Bioavailable-P as a % of T-P	Bioavailable-P after 4 months incubation at 4± 1°C /ug/g	as a % of T-P
65 m	Surface	12.72	1117	14.35	274	25	634	57
	2 cm	9.25	994	9.6o	233	23	538	54
63 m	Surface	9.56	663	11.6o	28o	42	594	9o
	2 cm	9.1o	476	9.3o	234	49	42o	8o
62 m	Surface	1o.o4	1452	1o.6o	344	24	1o85	75
	2 cm	8.62	95o	9.35	3o8	32	841	89
48 m	Surface	9.71	8o8	1o.35	276	34	754	93
	2 cm	8.62	895	8.25	268	3o	732	82
46 m	Surface	9.71	633	11.35	176	28	616	97
	2 cm	8.87	527	11.o5	186	36	48o	92

Table 1: Total phosphorous (T-P), Total nitrogen (T-N), Carbon and biological available phosphorous in surficial sediments of Mondsee, collected on 21.1o.198o. Bioavailable phosphorous was determined from wet sediments using 0.1M NTA. For the other determinations, sediments dried at 7o°C was used; concentrations expressed for 1o5°C dried sediments.

sideration given to P-budget calculations (Vollenweider 1976 b). However, it is an important aspect which cannot be neglected, as public acceptance of water quality improvement will be related to visible reduction in the intensity of summer algal booms. Culturally eutrophicated lakes such as Lake Washington (Edmonson 1972) have recovered when addition of nutrients from urban and domestic sources have been reduced. Thus assesment of sediment nutrient regeration capacity is of importance in developing management strategies for lakes.

References:

ALHGREN, I. (1976): Role of sediments in the precess of a eutrophied lake.-p. 372-377. In H.L.Golterman (ed.) Interactions between sediments and freshwater (Proc. S.I.L.UNESCO Conf.) Junk and Pudoc, The Hague, The Netherlands.

DILLON, P.J. & F.H. RIGLER, (1974): A test of a simple nutrient budget model predicting the phosphorous concentration in lake water.- J. Fish. Res. Board 31: 1771 - 1778.

DIGIANO, F.A. & SNOW (1976): Consideration of phosphorous release from sediments in a lake model.- p. 318 - 323. In H.L. Golterman (ed) Interactions between sediments and freshwater (Proc. S.I.L.-UNESCO Conf.) Junk and Pudoc, The Hague, The Netherlands.

EDMONDSON, W.T. (1972): The present condition of lake Washington.- Verh. Int. Ver. Theor. Angew. Limnol. 18: 284 - 291.

FITZGERALD, G.P. (197o): Aerobic lake muds for the removal of phosphorous from lake water.- Lim. Oceanogr. 15: 55o - 555.

GOLTERMAN, H.L. (1977): Sediments as a sourse of phosphorous for algae growth. p. 286 - 293.- In H.L. Golterman (ed)

Interactions between sediments and freshwater (Proc. S.I.L.-UNESCO Conf.). Junk and Pudoc, The Hague, The Netherlands.

GOLTERMAN, H.L., C.C.BAKELS & J.JACOBS-MÖGLIN, (1969): Availability of mud phosphates for the growth of algae.- Verh. Int. Ver. Theor. Angew. Limnol., 17: 467 - 479.

GOLTERMAN, H.L. (1973): Natural phosphate sources in relation to phosphate budget: a contribution to the understanding of eutrophication.- Water Research 7: 3 - 18.

GUNATILAKA, A. (198o): Some observations on phosphorous in Attersee, Mondsee and Fuschlsee sediments.- Arb. Lab. Weyregg 4: 213 - 234.

HUTCHINSON, G.E. (1957): A treatise on Limnology, Vol. 1 John Wiley & Sons, NY. 1115p.

LORENZEN, M.W., D.J. SMITH & L.V. SIMMEL (1976): A long term phosphorous model for lakes: application to Lake Washington.- Mod. the Biochemical Processes in Aquatic Systems (Ed. Canale R.P.) pp. 75 - 91, Ann Arbor Sci., Michigan.

LUNG, W.S., R.P. CANALE & P.L. FREEDMAN (1976): Phosphorous models for eutrophic lakes.- Water Res. 1o, 11o1 - 1114.

RAVEH, A. & Y. AUNIMELECH (1979): The total nitrogen analysis in water, soil and plant material with pursulphate oxidation.- Water research 13: 911 - 912.

VOLLENWEIDER, R.A. (1976): Advances in defining critical loading levels for phosphorous in lake eutrophication.- Mem Ist. Ital. Idrobiol. 33: 53 - 83.

VOLLENWEIDER, R.A. (1976b): Rotsee, a sourse, not a sink for phosphorous? A comment and a plea for nutrient balance studies.- Hydrobiologia 38: 29 - 34.

WETZEL, R.G. (1975): Limnology.- W.B. Saunders & Co., N.Y. 743p.

WILLIAMS, J.D.H., H. SHEAR & R.L. THOMAS (198o): Availability to Scenedesmus quadricanda of different forms of phospho rous in sedimentery materials from the great lakes.- Limnol. Oceanogr., 25: 1 - 11.