

# Impact of alum treatment on Phosphorus sediment fractionation and short term release in polymictic shallow lake: Influence of pH Conditions

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**Abstract:** Phosphorus (P) release from sediment in 96 hours Batch pH stat experiments were carried out in different pH values (from 5 to 10) on fresh lake sediment samples treated *in situ* (TAI) or not (To) with alum. According to phosphorus fractionation, Fe-bound-P, Al-bound-P and Organic-bound-P represent the largest phosphorus pool (80 % of Total Phosphorus). At pH 10, phosphorus was mainly release from the Fe-P, Al-P and organic fractions. These represent 35 % of the total phosphorus content. At circumneutral pH, in oxic conditions, a much lower quantity of P was released (roughly 4 % of total P sediment content) than at pH 10. The addition of alum was shown to reduce the release of soluble reactive phosphorus (SRP) at circumneutral pH, in contrast, no influence had been noticed at alkaline pH.

**Key words:** aluminium, eutrophication; sediment; phosphorus, shallow lake

## INTRODUCTION

Internal loading is a frequent phenomenon in shallow polymictic eutrophic lakes throughout the world, and may prevent lake water quality from recovering even after external loads are reduced (SONDERGARD ET AL., 1992). Phosphorus (P) release from the sediments can occur via two different mechanisms: (i) release at the sediment–water interface during periods of anoxia or hypoxia, and the subsequent diffusion of dissolved phosphate into the water column; and (ii) wind-induced resuspension and bioturbation at the sediment surface, whereby either the sediment pore water P can be released into the water column or the P adsorbed to sediment particles can desorb into the water column (SELIG, 2003).

Mineral associations play an important role in the release of P during anoxic or anaerobic conditions. Phosphorus associated with iron minerals can become soluble in the absence of oxygen. Phosphorus release rates have been found to be closely correlated to the iron-bound fraction in sediment (PETTICREW and AROCENA, 2001). Chemical applications are intended to bind the P, and usually include aluminum sulphate (alum), lime, or iron (COOKE ET AL. 1993). Alum is particularly effective for P removal. An alum application can sorb P and inhibit diffusive flux from sediments especially in anaerobic conditions.

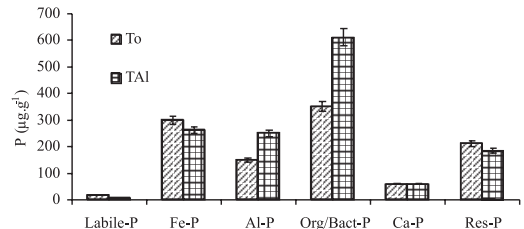
This work aimed at the determination of the impact of alum addition on phosphorus fractionation and its impact on P mobility dur-

ing sediment lab-scale resuspension at different pH conditions. The P release from one fresh lake sediment sample treated *in situ* with alum obtained with trap sediment devices was compared with a trap sediment sample used as control.

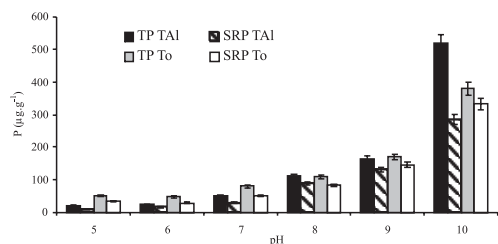
## RESULTS AND DISCUSSION

The phosphorus fractionation scheme designed by RYDIN AND WELCH (1998) was used to determine the distribution of P between several fractions. A large quantity of P in the form of Fe-P, Al-P and Org/Bact-P pools was measured (Figure 1). The impact of various pH conditions under oxic conditions, upon short term phosphorus release during resuspension was monitored as shown Figure 2. The sample To, which was not treated with alum, presented greater amounts of soluble reactive phosphorus (SRP) and total phosphorus (TP) released than the samples treated with alum at circumneutral pH. Figure 1 shows that Al-P fraction was lower for the sample To ( $150 \mu\text{g}\cdot\text{g}^{-1}$  DW) compared to TAI samples ( $250 \mu\text{g}\cdot\text{g}^{-1}$  DW), which is likely due to the absence of alum treatment on To in Spring 2000. Alum application could therefore greatly influence phosphorus fractionation and its potential mobility. However, the total P level in the leachate was not only detected as SRP, a part of the released P was dissolved organic P-compounds, which represented an average 35 % for TAI and 40 % for To of the total phosphorus released (results not shown). Figures 3 show that, after 96h resuspension of TAI and To lake sediment samples, the Organic-P (50 % of total Org/Bact-P), Al-P (42 % of Al-P) and Fe-P (31 % of total Fe-P) pools contribute strongly to the P released at pH 10.

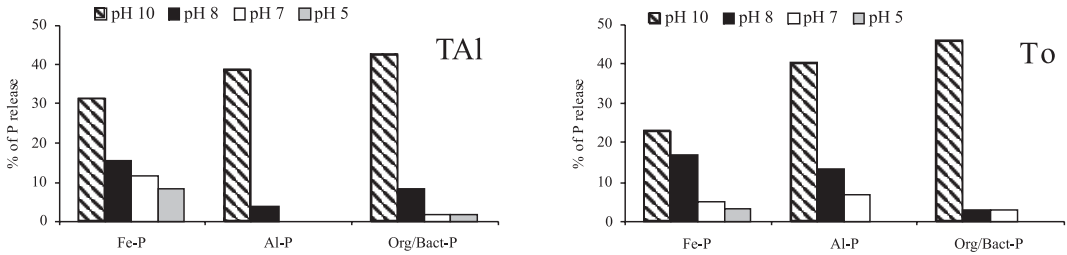
The phosphate chemistry in lake sediments is believed to be dominated by interaction with aluminium and iron species. At high pH, the intensified P release has been interpreted as an increase in negative charges on hydroxide surfaces and as competition between  $\text{OH}^-$  and  $\text{H}_2\text{PO}_4^-$  for sorption sites (LIJKLEMA, 1980). This sorption is strongly influenced by pH: the higher the pH, the lower the sorption (BOISVERT ET ALL., 1997). Moreover, alkaline conditions have been demonstrated as favouring organic matter dissolution through hydrolysis processes (You et al., 1999), which explains the major release of P from organic-P pool. RYDIN (2000) showed that about 60 % of the extractable Org/Bact-P pool was mobile. The observed results could therefore be explained by the release of polyphosphate from bacterial cells as suggested by GÄCHTER and MEYER (1993).



**Figure 1.** Phosphorus fractionation for the samples To and TAI (mean values, standard deviation,  $n=3$ ).



**Figure 2.** Short term Soluble Reactive Phosphorus (SRP) and Total Phosphorus (TP) release after 96 hours contact for samples (TAI and To) in oxic conditions for various pH conditions (mean value, standard deviation,  $n=3$ ).



**Figure 3.** Percentage of phosphorus release from the three main P-fractions (Fe-P and Org/Bact-P) after 96 h resuspension at pH 5, 7, 8 and 10 for samples TAI and To.

## CONCLUSIONS

Phosphorus mobility was monitored by 96 hours batch pH stat experiments. The results demonstrated that a high pH (common characteristic in eutrophic lakes during summer), when linked with intensive re-suspension, markedly increase the risk of internal P loading. Phosphorus release was from the Fe-P bound, the Al-P bound fraction and the organic fraction, it represents on average 37 % of total phosphorus released. Therefore, alum treatment does not allow to prevent P release from lake sediment particles resuspended in

alkaline pH conditions. On the other hand, the sediment treated with alum don't greatly contribute to the internal P loading which confirm that Alum can be efficient to limit the short term P mobility at circumneutral pH.

## Acknowledgements

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