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STUDY ON INFLUENTIAL FACTORS OF PHOSPHORUS RELEASE FROM WEST LAKE SEDIMENTS

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Abstract

The paper investigates the release of phosphorus release of West Lake sediments at various alkaline levels and disturbances during a laboratory simulation. The distribution of phosphate forms in the sediments and the content of phosphorus in interstitial water were also determined.

Key words: Lake sediment, Phosphorus release, Alkalinity, Disturbance

Introduction

Phosphorus is one of the limiting factors affecting lake eutrophication. Phosphorus release in sediments is influenced by various factors, on which Han (1993) performed laboratory simulations. Their results showed a positive dependence of phophorus release on temperature under anaerobic conditions, and the relationship between phosphorus release and pH was parabolic. The research obtained valuable results, but other factors affecting phosphorus release still need to be considered. For example phosphate forms in sediments, lake alkalinity and various disturbances to sediments caused by windinduced waves or travelling boats. This paper investigates these factors further in order to better understand the essence of phosphorus release from sediments.

MATERIALS AND METHODS

Sediments and overlying water were sampled on July 7th, 1996. Interstitial water was taken by centrifuging sediment samples at a rate of 7,000 rpm.

Phosphorus release in sediments with different alkalinities: 60g of wet-sediment was weighed out and divided equally into 12 groups. Two groups were oven-dried in aluminium boxes to guage water content. The remaining 10 groups were divided into 5 series, each containing duplicate samples. 100 ml of $1x10^{-4}$, $1x10^{-3}$, $1x10^{-2}$, $1x10^{-1}$ mol L^{-1} $NaCO_3$-$NaHCO_3$ buffer solutions, and distilled water were added respectively. The solutions were run down the container walls to avoid stirring of sediments. After 6 hours of still deposition at 25°C, the supernatants were then extracted, mixed, centrifuged at 7,000 rpm, and filtered through a 0.45 μm film. Realeased phosphorus was measured by the Molybdate blue procedure (Golterman & Clymo, 1969).

Phosphorus release under different disturbances: 60 g of wet-sediment was weighed, fully mixed and then divided equally into 12 groups. Two groups were used to measure the water content. The remaining 10 groups were stored in 100 mL plastic beakers. 6 groups were divided into 3 series of duplicate samples. 50 ml of 0.01 mol L^{-1} $NaHCO_3$ were added respectively. The remaining 4 groups were divided equally into 2 series, and distilled water (pH 6.5) were added respectively. Phosphorus release was studied under various conditions of stillness, with respective overlying water stirring and sediments strring with a magnetic bar. After 4 hours, the supernatant was extracted using a pipe for the first two conditions. For the third treatment, the supernatant was extracted after centrifugation. After filtration through 0.45 μm films, the phosphorus released was measured by the Molybdate blue procedure.

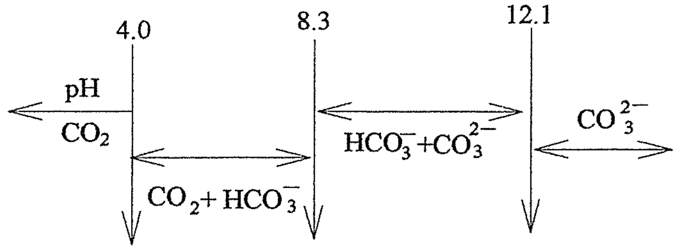
Soluble P content in interstitial water: Fresh sediment was centrifuged. The supernatant was extracted as described above and the Molybdate blue procedure was employed to measure the phosphorus contents. The sediment samples were stored for two weeks in refrigerator (4°C) to preserve their characteristics.

Phosphate forms in sediments: Analysis of various phosphate forms was conducted as described in ‘The method of soil analysis’ (1993). Other analyses were conducted as described in ‘The method of lake eutrophication’ (1987).

RESULTS AND DISCUSSIONS

Phosphorus release in different alkalinities: There was a great discrepancy in HCO_3^- and CO_3^{2-} contents as well as pH of West Lake water between winter and summer, as shown in Table 1. Phosphorus release at different alkalinities differed. At low alkalinity (10^{-2}~10^{-4} mol L^{-1}), the phosphorus released ranged from 8.0 ~ 9.0 μg/g, while this figure scaled up to 19.62 g/g when the alkalinity reaches 10^{-1} mol L^{-1}. This was due to disolved Fe-P and Al-P.

West Lake is well eutrophicated and thus has a flourishing upgrowth of algae from late spring to autumn. Therefore the former carbonic acid balance of low mineralized West Lake water (which is of HCO_3^--Ca(II) type) was impacted. HCO_3^- converted to CO_3^{2-} (Fig. 1), resulting in an increase in alkalinity,



with pH value of around 9.

Figure.1. The relationship between pH and CO_2

Table 1 The content of CO_3^{2} anmd HCO_3 in the West Lake

Location		Lake centre	L.Yue	L.Xiaonan	Inner Santan	pH
Summer	CO_3^{2}	0.258	0.304	0.203	0.02	8.299.80
	HCO_3	0.077	0.577	1.011	1.072	
Winter	CO_3^{2}	0	0	0	0	7.788.63
	HCO_3	1.367	1.367	0.959	1.392	

Influence of sediment disturbance on phosphorus release of.

The amounts of phosphorus released from sediments under various disturbances are shown in Table 2. The results show that if still deposited the release of phosphorus was very limited. If the sediments experienced disturbance, however, phosphorus in the interstitial water was released into the overlying water. The exchange between these two pases promotes the pH value of the interstitial water, further enhancing phosphorus to convert from its solid state into the interstitial water. From Table 2, we can see that the amount of phosphorus released under different conditions follows the sequence: sediment stirring > overlying water stirring > stillness after 4 hours, irrespective of being immersed by distilled water or $NaHCO_3$. The phosphorus extracted by distilled water when still deposited was below detectable levels. Obviously, the re-suspension of sediment particles caused by stirring contribute to phosphorus release. The results showed a strong dependence on alkalinity the effect being equal to that of sediment disturbance for the distilled water immersed sample.

Table 2. Influence of sediment disturbance on P release

	Sediment stirring	Overlying water stirring		No stirring	
	$NaHCO_3$ 0.01ml/L	H_2O	$NaHCO_3$ 0.01mol/L	$NaHCO_3$ 0.01 mol/L	H_2O
P release(μ g/g)	15.6	11.0	13.0	10.6	<detection limit

Phosphorus contents in interstitial water

The soluble phosphorus contents found sediments, interstitial and overlying in waters are listed in Table 3. This table shows that the TDP (Total Dissolved Phosphorus) in interstitial water was 103 times that in the overlying water. In the static state, the penetration of water into sediments is low (rate of water penetration is almost zero), thus making it difficult for water to exchange between interstitial and overlying waters. If alkali is added or sediments are stirred, phosphorus in interstitial water can be quickly released, thus leading to a leap of phosphorus in the overlying water.

Table 3. P contents of sediment, interstitial water and overlying water

	pH	Eh (mv)	TP (mg/L)	TDP(mg/L)
Overlying water	8.93	245	0.11	0.01
Interstitial water	7.1			1.03
Sediment	7.03	121	1.39g/kg	

Forms of phosphorus in sediments

When phosphate enters the lake, it soon reacts with other components in sediments, or is absorbed and fixed by them. When the condition is suitable for release, the fixed phosphorus returns to the water. The balance of phosphorus deposition and release is closely related to its form and the surrounding conditions. Phosphate forms in West Lake sediments were analysed, and the results are shown in Figure 2. Although the total amount of P varied greatly (0.8~2.1 mg/g), the percentage of each existing form were relatively constant. The results show that organic phosphorus comprised 20~50% of the total amount (with variations in different lake regions), while inorganic phosphorus, mainly in the form of Ca-P, comprised 23~63% (also varying in different lake regions). Phosphorus released from Fe-P and Al-P in sediments combine with Ca in the overlying water, resedimentation in the form of Ca-P. This concurs with corresponding results obtained for Taihu lake sediments by Wang Xiaorong (1996). Therefore, the recycling of phosphorus in West Lake water may occur via the following sequence: soluble P, Fe-P and Al-P in sediments dissolve into the water as pH increases. The phosphorus in the overlying water then subsides in the form of Ca-P, or is absorbed by particles, thus remaining suspended in the water. Thus the soluble phosphorus content remains low in West Lake water, while the total phosphorus content is high.

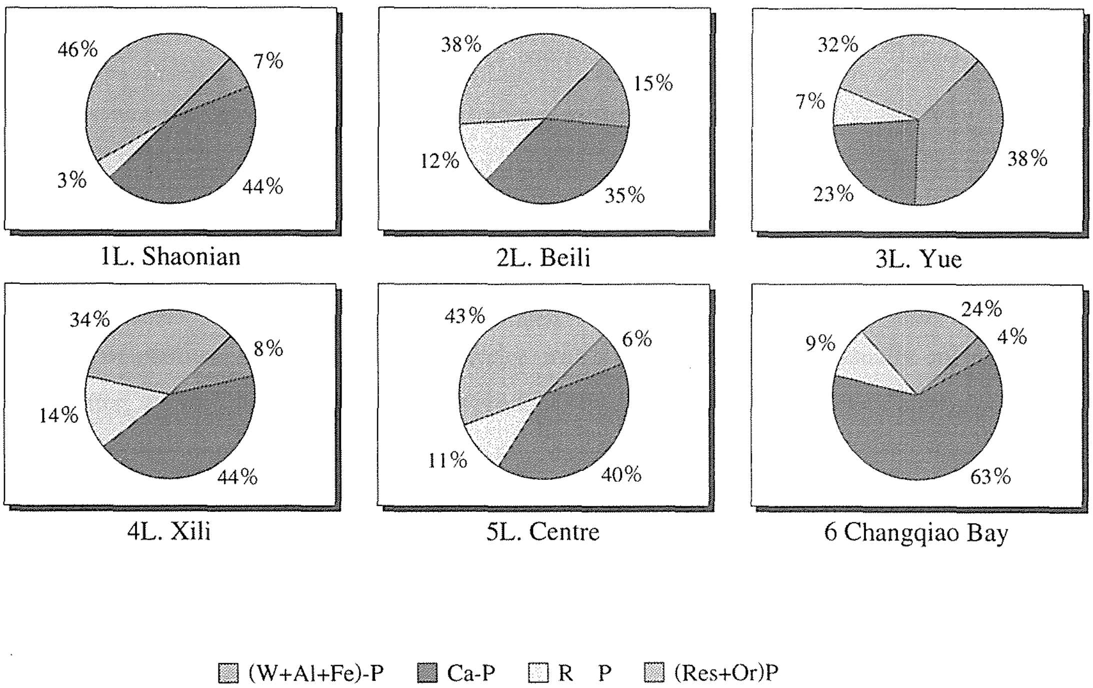


Figure 2. Distribution of Forms of P in West Lake Sediments

CONCLUSION

Phosphorus release from West Lake sediments is influenced by alkalinity, and sediment stirring contributes to a fast release. The great discrepancy of phosphorus contents in overlying water and interstitial water makes this possible. In neutral and still conditions, however, release does not occur. If the pH value increases due to the flourishing algae growth, P will be released from the sediments into the water. Stirring would accelerate this procedure. The phosphorus released is subsequently absorbed by suspended particles which then subside into sediments.

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