

Kinetic model of the fixation of phosphates on particles of sediments

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Abstract

The adsorption of phosphates on sediments was studied by distinguishing between the mineral and bacterial biomass compartments. Enrichment with Ca^{2+} , Fe^{3+} and Al^{3+} validates a multilinear model.

Introduction

Understanding the process of the fixation of phosphorus on sediments is important for water-quality control (Overman and Chu, 1977; Boström et al., 1982). For this reason, a number of studies have been carried out on the variation of phosphorus fixed by or released from sediments with time. The kinetic equation obtained can be said to be of the first order (Fried et al., 1957; Larsen et al., 1965; Probert and Larsen, 1972) or of the second order (Kuo and Loste, 1974).

The study of the fixation of phosphates by sediments is made difficult because of the complex and diversified structure of a sediment (a mixture of living and inert matter). As a first approximation, we can consider that the sediments can be divided into two groups: one group made up of a biomass (X) and the other, a non-living group (Mi). According to this subdivision, a model can be proposed (Fig. 1):

- The biomass fixed to the sediment transfers an electrostatic potential that can, before bacterial assimilation, induce biosorption of phosphates. After biosorption, assimilation will reach a state of equilibrium, accompanied most probably by a redistribution of phosphates among the various groups.
- Other than the biomass, the abiotic groups (Fe^{3+} , Ca^{2+} , Al^{3+}) can also constitute sites of phosphate fixation. Nevertheless, metals are generally held as precipitated salts (carbonates...) or in fairly stable organic complexes. If the cation forms soluble salts or compounds which are not very stable, the phosphates will be able to interact strongly, probably through precipitation.

The goal of our tests was to verify the frequency with which sediments contain metals and to explain the role played by the biomass present in the kinetics of phosphate fixation and release.

Material and methods

This study of the kinetics of incorporation was carried out on sediments of freshwater lakes (Gouet, Côtes d'Armor, France). Various cations in the sediments were determined by atomic absorption. The methods used to collect and prepare the samples and conduct the analyses have been described previously (Bonzongo et al., 1989). The sediments studied present the physico-chemical characteristics as summed up in Table 1.

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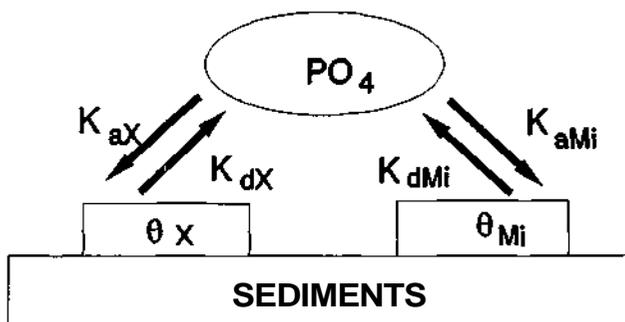


Figure 1
Model of the incorporation of phosphates in sediments

Enrichment of sediments

Multiplication of the biomass

To study the role of the microbial biomass of sediments in the fixation of phosphates, various glucose masses (0, 10, 20, 100 and 500 mg) were added to the equivalent of 5 g of dry sediments. The mixture was left to incubate at room temperature ($20 \pm 2^\circ\text{C}$). After bacterial growth had taken place, the following measurements were carried out: adenosine triphosphate (ATP), (Jones and Simon, 1977); the residual glucose (Dubois et al., 1965); and the phosphorus content in the different fractions according to the AFNOR T-90-023 standard, after fractionation as performed by Bonzongo et al. (1989). The equivalent of 5 g of dry sediments was then used for the kinetic incorporation.

Addition of calcium, iron and aluminium salts

Calcium, iron and aluminium were added to the sediments in the form of: CaCO_3 , $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ and $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$ respectively. As in the case of glucose, the addition was accomplished by enriching the sediments separately with 0, 10, 20 and 30 mg of Ca^{2+} , Fe^{3+} and AP^+ for 5 g of dry sediment. The sediment thus treated was used for incorporating phosphates.

Kinetic incorporation of phosphates

Sediments and the phosphate solution, prepared from KH_2PO_4 , were placed in a 100 ml flask (Fig. 2) in a ratio of 1 g of dry sediment per 100 ml of solution. The mixture was brought up to $\text{pH}=7$ using a Tris buffer and regulated by the addition of either