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The effect of extracellular polysaccharides on the goethite-surface promoted hydrolysis of organophosphates.

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Organophosphate monoesters comprise a significant fraction of phosphate in soils. In order to access phosphorus needed for growth, plants and microorganisms often require the hydrolysis of large organophosphate molecules. This hydrolysis can be enzymatic or a reaction promoted by contact with an environmental surface. Because phosphorus strongly adsorbs to environmental particles, the fate and transport of phosphorus in the biosphere can be significantly impacted by reactions at the surfaces of these particles. Soil minerals, including the common Fe(III) mineral goethite, have been shown to increase the rate of hydrolysis of organophosphates by acting as catalysts.

Many enzyme-secreting microbes and plants can also release extracellular polysaccharides (EPS) into their local environments. EPS is known to adsorb to environmental particles, including goethite. The adsorption of EPS may alter the physico-chemistry of the mineral-phosphate-enzyme system by impacting either the adsorption or enzymatic hydrolysis of organophosphate. Currently, there is little information available regarding the ability of EPS to enhance or inhibit the availability of essential nutrients, such as phosphate, in the environment.

In this study we have investigated the hydrolysis of the phosphate monoesters, glucose phosphate (GP) and p-nitrophenyl phosphate (pNPP). To investigate the hydrolysis mechanisms and extent of hydrolysis of phosphate monoesters we studied three systems: 1) abiotic hydrolysis, where monoesters are adsorbed on goethite surfaces; 2) enzymatic hydrolysis where the monoesters are adsorbed to goethite then exposed to an enzyme; and 3) testing whether the presence of alginate, which is used as a model for EPS, can inhibit or enhance the abiotic or enzymatic hydrolysis. To investigate this we used infrared spectroscopy and the ATR sampling technique. Abiotic hydrolysis was examined using goethite as the environmental surface. Adsorption of each monoester to the goethite was found to be rapid, and the subsequent hydrolysis was found to be dependent upon pH and the properties of the mineral-water interface. When enzyme was added to the goethite-monoester system, at the optimum conditions for the acid phosphatase enzyme, the rate of hydrolysis reached nearly the same rate as the enzymatic hydrolysis of the monoester in a goethite-free system. Thus, the enzyme can change the system from one with no hydrolysis to one with significant hydrolysis. The presence of alginate in the goethite-monoester-enzyme system changes the properties of the interface, thereby changing the hydrolysis of these phosphate monoesters.