2.6.24

Can one set of modeling parameters predict the extent of proton and Cd binding to bacterial surfaces in most environments?

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Biofilms and the bacteria within them can bind large quantities of metals. A major obstacle in the development of models that predict the extent of bacteria-metal adsorption is the sheer number of bacterial species present. If each bacterial speceis exhibits different adsorptive behavior it would be necessary, yet nearly impossible, to characterize the adsorptive behavior of each species separately. It has recently been hypothesized that the adsorptive capacities of all bacterial species are roughly similar, which if true, might allow for a single set of modeling parameters to describe bacteria-metal adsorption in many different environments.

We test this hypothesis by conducting acid-base titrations and Cd adsorption experiments using consortia of bacteria isolated from industrial wastes and contaminated soils and groundwater. The sampling environments were designed to compliment previous experiments utilizing bacterial consortia grown from uncontaminated soils and surface waters. The diversity of the consortia were quantified using denaturing gradient gel electrophoresis (DGGE). The data were modeled using a surface complexation approach to solve for proton and Cd binding constants and binding site densities.

DGGE results reveal that the consortia were diverse, averaging more than four species of bacteria from each sample. The calculated proton-binding constants were generally similar for all the consortia and the total binding site densities varied over a modest range of 2.7 to 4.1 (x 10^{-5} moles/l/wet gram bacteria). Cd adsorption data fell roughly into two goupings. The group exhibiting the higher affinity for Cd adsorption is characterized by bacterial consortia isolated from environments contaminated with gasoline-range hydrocarbons. Total binding site densitites for this group are the highest among all the consortia tested, while Cd binding constants remain roughly similar for all the consortia.

Comparison of the results from this study to previous studies reveals a modest (but real) range of binding site densities among bacterial consortia cultured from many different environments. Natural, uncontaminated consortia exhibit the lowest site densities over this range, while bacterial consortia from contaminated environments, particularly environments contaminated with hydrocarbons, occupy the high end. Proton and Cd binding constants among all the consortia are roughly similar, suggesting that site densities, not binding affinities control the extent of bacteria-metal adsorption in these settings.

2.6.25

Thermophilic biofilms and silica laminates: A causative relationship?

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The presence of microbial remnants in silica laminates from hot spring deposits has led many to the interpretation that biofilms are necessary for their formation [1]. Others have concluded that these are formed by abiotic processes such as intermittent wetting and capillary rise [2]. The requirement that biofilms be present for the formation of laminates has profound implications for the evidence of early life on Earth and to the interpretation of similar deposits that may be found on extraterrestrial bodies.

Field experiments have shown the growth of silica laminates over a short time period [3]. These also show the presence of biofilms, however, the relationship between the biofilms and laminations remains inconclusive. The difficulty in conducting biotic and abiotic experiments in a natural setting requires that a laboratory approach, under controlled conditions, be used.

The thermophilic bacterium *B. Flavothermus* (*BF*) was grown on glass microscope slides. These were then placed in a tray enclosed in an incubator at 60°C. A solution containing 570 ppm SiO_2 was passed over the immersed slides for several hours. Periodic sampling showed that *BF* cells were rapidly encrusted with granular silica. The glass slides also became encrusted and no difference in texture or thickness was apparent between bacteria and slide. To simulate a subaerial setting, a second experiment using slides that protruded above the water surface, was performed. Subaqueous *BF* biofilms became coated with a discontinuous aggregate of amorphous silica. At the air-water interface, thin laminae of silica were formed. These had smooth upper surfaces and granular undersides that held isolated bacilli. The lack of a biofilm suggests that the silica laminae formed abiotically by evaporation along the meniscus at the air-water interface. Abiotic experiments are underway to confirm that the growth of silica laminates can occur in the absence of thermophilic biofilms.

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