Microbe Wars: The Corrosion Phantom Menace

Randall E. Hicks
Professor, Department of Biology, University of Minnesota-Duluth

Corrosion of steel structures in the Duluth-Superior Harbor (DSH) is a severe problem for the maritime transportation industry. About 20 kilometers of steel sheet piling used to construct docks appear to be affected, which may cost more than $200 million to replace. Initially, several hypotheses were proposed to explain this severe corrosion. Our research has focused on two of these hypotheses, water quality and the influence of microbes. Water chemistry alone does not appear to be the direct cause of this corrosion. Corroding steel surfaces in the DSH are covered by complex microbial biofilms and tubercles contain distinct assemblages of bacteria, some of which are responsible for corrosion of steel in other environments. Bacterial activity, either directly or indirectly, appears responsible for accelerating this corrosion process. More recently, we have investigated the effects of several antifouling coatings on corrosion and to manipulate attached bacterial communities. Quorum quenching enzymes or surfactin in coatings altered bacterial community composition on steel coupons and reduced corrosion by 50%-60% in both lab and field experiments, even after the coatings were scratched. The relative abundance of DNA sequences from bacterial orders containing sulfate-reducing bacteria were initially very low compared with bacterial orders containing iron oxidizers. After 8 months in the field, members of the *Burkholderiales* (15%), *Nitrospirales* (15%), *Gallionellales* (11%) and *Nitrosomonadales* (10%) were the dominant bacterial orders found on all coupons. Members of the *Burkholderiales* decreased in relative abundance but increased or decreased in richness in the lab and field, respectively. Members of the *Rhodocyclales* and *Nitrosomonadales* increased in relative abundance in lab and field experiments. The relative abundance of several orders of iron-oxidizing bacteria and sulfate-reducing bacteria were correlated with the number of tubercles found on coupons. Concurrent reductions in tubercle formation and changes in bacterial community composition on treated coupons indicates that bacterial communities may accelerate the corrosion of steel infrastructure and that this corrosion can be altered by modifying attached bacterial communities.