AN ECOLOGICAL STUDY OF THE SULFUR-OXIDIZING BACTERIA FROM THE LITTORAL ZONE OF A MICHIGAN LAKE AND A SULFUR SPRING IN FLORIDA*

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SUMMARY

The sulfur-oxidizing communities of decomposing plants in a Michigan Lake and of a sub-tropical sulfur spring were studied using an in situ gradient enrichment method, electron microscopy, light microscopy and plating techniques. Oxygen tolerant and aerobic sulfur-oxidizing bacteria were found attached to plant surfaces either by a holdfast or by mucilage which encased microcolonies. Thiothrix and Thiocystis were commonly observed by microscopy on decomposing plant material. In situ thiosulfate gradient enrichments with plant material as inocula selected fluorescent pseudomonads rather than Thiobacilli and resulted in a three-fold increase in growth-rate as the thiosulfate concentration increased from 55 μg/1 to 1 g/l sodium thiosulfate. Isolate TBT-H, a fluorescent pseudomonad, and Pseudomonas aeruginosa were found to produce sulfide-binding 'exudates' which yielded globules of elemental sulfur. The active 'exudate' was only produced by organisms with fluorescent pigments and only in media containing S$_2$O$_3^{2-}$, which also stimulated fluorescent pigment production.

INTRODUCTION

Sulfide, a product of bacterial decomposition of organic matter, is slowly oxidized by O$_2$ to S$^0$, S$_2$O$_3^{2-}$, or SO$_4^{2-}$ depending on the reaction conditions. Chen and Morris identified a pH dependent induction period of 0.2 to 6.0 h before chemical O$_2$ uptake
for HS⁻ oxidation starts. Thus HS⁻ and O₂ can apparently exist simultaneously. In the littoral zone, HS⁻ and O₂ may be supplied together by decomposition processes and by wave action, respectively. Reduced sulfur compounds can thus be available for aerobic bacterial and chemical oxidation at the same time.

There are several groups of bacteria which might be involved in HS⁻ oxidation. These include the Chromatiaceae, Chlorobiaceae, colorless sulfur bacteria, and heterotrophic sulfur-oxidizing bacteria. Our knowledge of the role of these bacteria in the transformation of inorganic sulfur compounds in nature is based primarily upon selective enrichment as described by van Niel 10 and also upon the subsequent study of pure cultures. However, the elegance and convenience of this approach have sometimes overshadowed the fact that minor environmental variations between the enrichment (elective) culture and the natural habitat result in a completely different bacterial flora. As stated by van Niel: 'It is therefore clear that we cannot draw sound conclusions concerning the natural role of microbes from the experience gained with elective cultures unless we restrict our inferences to apply only to rigorously comparable conditions'. For this reason, an in situ gradient enrichment method 45 was used to investigate sulfur transformations which occur in the littoral zone of the lake described here. This procedure ensured that the conditions of enrichment were comparable to natural conditions. Direct observations of decomposing plants also served to confirm the conclusion that the organisms studied using gradients were actually members of the natural community of sulfur-oxidizing bacteria.

In the case of anaerobic hypolimnia, sulfur oxidation is carried out by relatively homogeneous communities of bacterioplankton 6 while in this study of littoral habitats a single heterogeneous community of aerobic and anaerobic populations of bacterial epiphytes was found. The concept of the micro-environment 12 is thus essential in understanding the littoral environment as opposed to the hypolimnion. Thin sections of natural samples were used to determine the physical arrangement of bacterial cells and colonies within the micro-environment. Bacterial communities observed in the littoral zone are compared to similar communities found in the anaerobic hypolimnion and in a sub-tropical sulfur spring. The results support the suggestion of Vishniac 20 that heterotrophic