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Bioaccumulation of manganese oxides in industrial heat exchangers

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Biofouling accumulated on the lamelli of large industrial heat exchangers using Baltic Sea water for cooling, causing loss of heat transfer and corrosion. The deposits could only partially be removed by high pressure (140 to 160 bars) washing. The material that persisted washing was high in inorganic matter, 30% of the dry weight. was Mn and 4% Fe. The concentration of Mn in the wet deposit was 1000 000 fold higher than that in the Baltic Sea water used for the cooling cycle. SEM-EDX (Electron Microscopy Energy Dispersive) and FESEM (Field Emission Scanning Electron Microscopy) imaging revealed on the lamelle surfaces wasp-nest shaped Mn rich nodules, diameter of 10 μm and with an entry hole of 1 μm in diameter. Organic matter content of the nodule mass was 20% of dry wt and contained DNA (10 to 50 μg 100 mg^{-1}) and culturable bacteria (10^6 to 10^7 cfu mg^{-1}). Among the viable bacteria, microaerophiles dominated tenfold over the aerobes. The culturable heterotrophic bacteria were identified by sequencing the 16S rRNA gene, and species of *Shewanella* species were found dominating, along with *Pseudomonas*, *Flavobacterium* and *Aeromonas*. Culture-independent analysis of the bacteria present in the deposits was carried out by cloning the 16S rRNA genes from the extracted DNA, using universal primers targeted for the domain bacteria and target-oriented primers for the bacterial phyla Proteobacteria, Firmicutes, Bacteroidetes, Deinococcus-Thermus and Planctomycetes. A total of 265 clones were obtained and sequenced. Ca 250 unique sequences were found, that belonged to 8 different phyla, but none of the identified taxa represented any known manganese oxidizing or depositing bacteria. We interprete these preliminary data to indicate that the pressure-wash persistant deposits on

the surfaces of lamellar heat exchangers had evolved by activity of microorganisms, mainly bacteria, that executed oxidation and accumulation of the low concentrations of dissolved Mn^{2+} (< 50 μg L^{-1}) present in the Baltic Sea water into an insoluble form (MnO_2).

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