32−11 Maintainability of Denitrifying Granular Sludge in Soft to Marginaly Hard Waters in an Upflow Sludge-Blanlet Reactor

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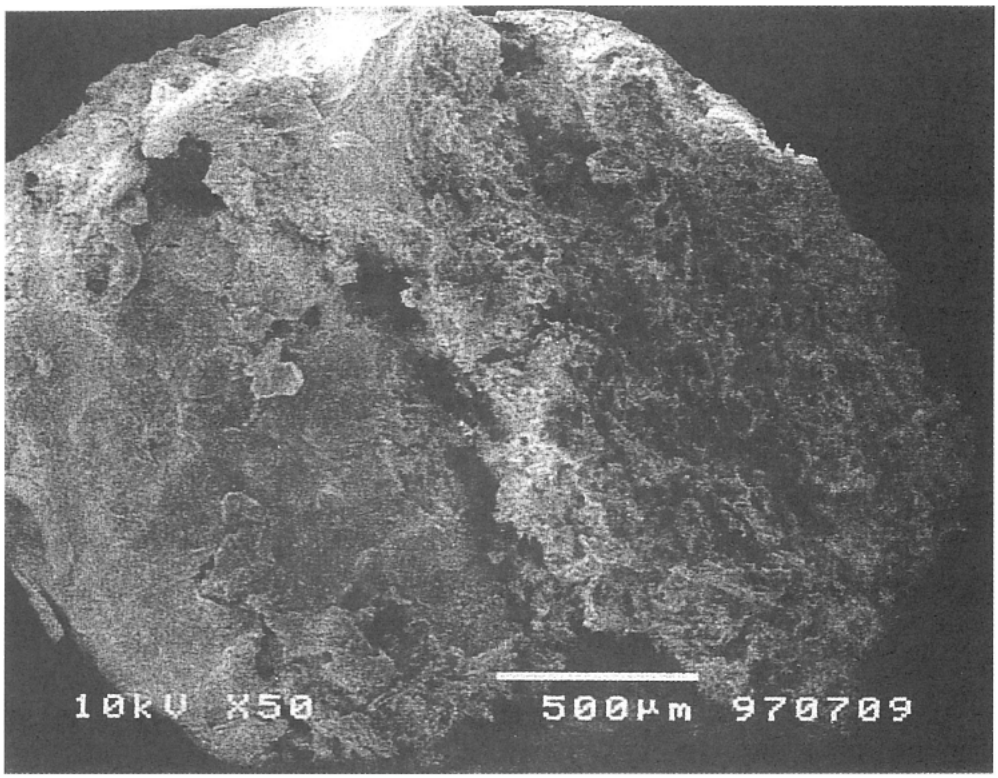
The maintainability of denitrifying granular sludge in a bench scale reactor treating soft groundwater with low nitrate (21mg N L^{-1}) was investigated. Others have shown that USB reactors fed with waters having hardness levels ranging from about 200 to 250mg $CaCO_3$ L^{-1} encountered difficulties due to floating sludge and sludge wash-out. However, with natural and simulated hard waters (hardnesses ranging from 260 to 400mg $CaCO_3$ L^{-1}) greatly improved performances were realized due to development of denser granules in conjunction with enhanced mineral precipitation. In this work, further elucidation of the factors involved in denitrifying granule maintenance was investigated with a focus on minimizing chemical additions to soft water intended for potable use. The objective of this research was to evaluate the significance of key factors (pH, alkalinity, calcium, nitrate, and loading rates) on granular sludge performance (e.g., nitrate removal and sludge retention).

Variations in precipitation potential were made by adjustments in pH and colcium addition. Variations in loading rates were made by adjustments in flow rate. Sludge bed volume (ca. 1.1L) was thus about 2/3 of the hydraulic volume (1.7L). Biomass yield was estimated to be about 0.77g VSS per g N removed. Alkalinity production in the reactor, resulting from denitrification activity, was 64 (SD=9.0, n=18) mg $CaCO_3$ L^{-1} which is in reasonable agreement with stoiciometric value for a depletion of 21mg NL^{-1}. ORP values fluctuated greatly, with good system performance (near complete reduction of oxidized nitrogen) occurring within a range of−233 to+191mV, (average−103mV, median−163mV).

With influent alkalinity at 180mg $CaCO_3$ L^{-1}, a calcium addition to a relatively low total hardness of 120mg $CaCO_3$ L^{-1} and an influent pH of 8.5, generation of mineral precipitation needed for production of a heavy granular sludge with good settling characteristics was achieved. Precipitation potential was demonstrated to be an effective tool for manipulating sludge characteristics. An increase in sludge density resulted in improved retention of biomass. With reduced mineral precipitation at a lower influent pH of 7.9, an increase in volumetric loading rate was also shown to be effective in cultivating biomass in a manageable granular sludge. Extended steady-state operation (with respect to granule mineral content and sludge concentration) was not demonstrated here (subject of further research); notwithstanding, via manipulative measures, at a hydraulic retention time of about 30 minutes consistent removal of low nitrate levels using a granular sludge with good retention characteristics was shown to be feasible without the high hardness levels hereto considered necessary.

(A)



(B)

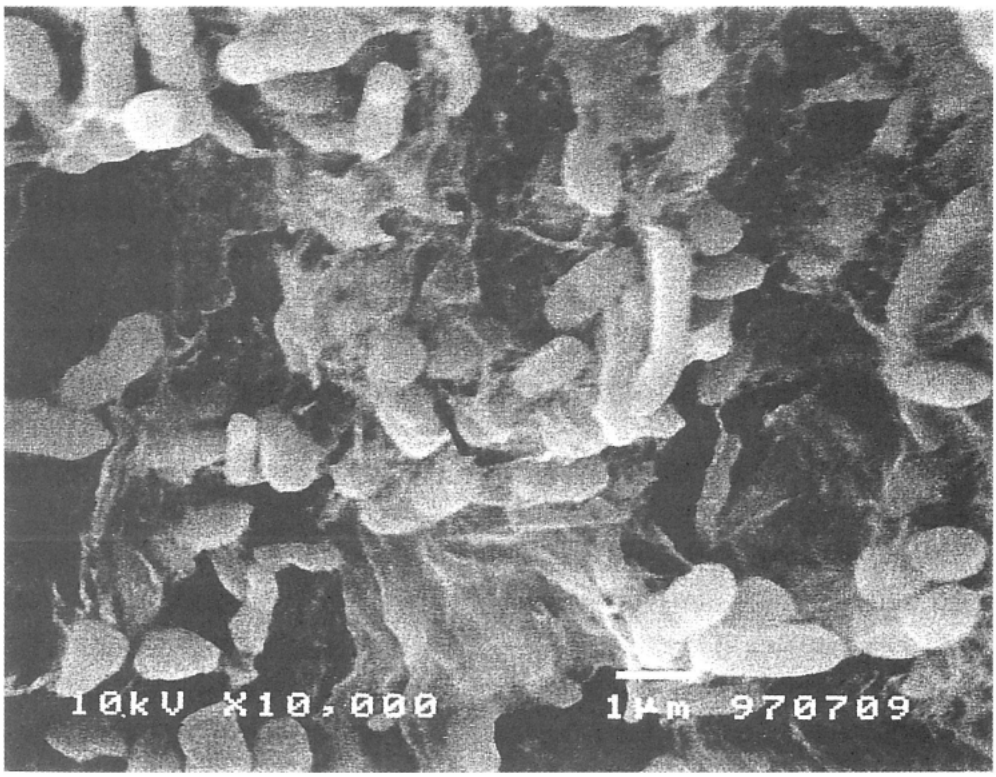


Figure. SEM micrographs of a 2 ㎜ diameter sludge granule : (A) 50X, (B) 10,000X.