Effect of phosphorus on biofilm growth in a completely mixed biofilm reactor

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More and more studies show that bacterial growth in drinking waters is not always regulated by carbon but rather by phosphorus concentration. However the role of phosphorus on biofilm formation in distribution networks is not completely understood. In the present study the effect of microbiologically available phosphorus (MAP) on biofilm growth in drinking water was investigated at the full-scale experiments during three years. Completely mixed biofilm reactor Propella® were supplied with drinking water taken from five locations with different MAP concentration ranging from 0.23 and 10.22 μg P L^{-1}. Inlet water contained no active chlorine and assimilable organic carbon (AOC) concentration varied from 114 to 273 μg L^{-1}.

Reactors were supplied with drinking water for about one month (to reach semi-steady state) at controlled conditions (temperature 15^{o}C, flow rate 0.25 m/s, dilution rate 0.084 h^{-1}) before PVC coupons were removed and examined. MAP concentration in the effluent from reactors were always lower than in the influent indicating that phosphorus was limiting bacterial growth in the reactors. Total bacteria counts in biofilm ranged from 5.1E+06 to 2.8E+07 cells/cm^2. MAP correlated positively with total amount of cells and heterotrophic plate counts in biofilm. The correlation slope was similar to that obtained in other studies where the plug flow reactors were used (Lehtola *et al.*, 2004), although the absolute values of bacteria in biofilm at the similar level of MAP were significantly higher in this study. This phenomenon should be investigated further. Specific biofilm growth rate (assuming no bacterial growth in bulk water) was in range of 0.005 to 0.02 day^{-1}. These values are lower than those determined for carbon limiting drinking waters (Block *et al*., 1993 and Boe-Hansen *et al*., 2002). We observed that the biofilm growth rate decreased with the increase of MAP concentration in water, which implies that biofilm growth in phosphorus limiting water does not always obey Monod kinetics. This observation should be taken into account in development of biofilm formation models.

In summary, this study showed that phosphorus may be limiting bacterial growth in drinking water biofilm; with increase of phosphorus in water the biofilm formation rate decreases whereas bacterial number in biofilm increases. Removal of phosphorus below 1 μg/l did not cease biofilm formation in completely mixed reactors.

Bibliography

Lehtola, M.J , Juhna, T., Miettinen I.T., Vartiainen T. and Martikainen P.J. (2004). Formation of biofilms in drinking water distribution networks, a case study in two cities in Finland and Latvia. *J. Ind. Microbiol. Biotechnol.*, **31**, 489-494.

Block, J.C., Haudidier, K., Paquin, J.L., Miaza, J. and Levi, Y. (1993). Biofilm accumulation in drinking water distribution systems. *Biofouling,* **6**, 333-343

Boe-Hansen, R., Albrechtsen, H.-J., Arvin, E. and Jorgensen, C. (2002). Bulk water phases and biofilm growth in drinking water at low nutrient conditions. *Water Research,* **36** (16), 4477-4486

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