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Biomass loss mechanisms in a pore clogging model

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It is widely recognised that microbial populations are a major determinant of the fate and transport of contaminants in soils and groundwater, with sessile microbial populations adhered to solid surfaces typically dominating planktonic forms. Much more poorly understood are the microbial dynamics that lead to the spatio-temporal distribution of biomass. The biomass distribution in turn affects contaminant transport at the pore scale through (a) the pore scale mass transfer resistances within and between the biomass, mobile and immobile fluid, and solid phases, and (b) flow field effects due to constriction of flow paths (pore clogging). Pore clogging is generally disregarded in oligotrophic conditions, but can be of significance in settings with greater biomass loading such as contaminant plumes and biobarriers. It can also be relevant to physiological and industrial contexts.

We propose a simple model of pore clogging by adhered biomass growth within an idealised pore space in order to explore the connection between microbial net growth, nutrient supply, and fluid flow. Within a single pore, flow resistance due to biomass growth exerts a nonlocal effect on nutrient supply. Mechanisms of growth limitation include flow restriction, intra-biomass transport, intrinsic biomass decay, erosion and sloughing, and predation. We show that a partially-clogged steady state in a single pore only exists under certain conditions on the functional forms of biomass loss terms.

For pores connected in parallel we investigate the conditions under which symmetric and asymmetric steady states and oscillatory solutions exist, providing the basis for application in a pore network model.