**On the relation between substrate inhibition and bioavailability limitations inside hetergenous environments**

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While many substrates at low concentration levels have a nutritive value to the microorganisms metabolizing them, the majority of microorganisms are known to be kinetically inhibited by high concentrations of substrate. Substrate inhibition is generally considered as a limiting factor for the bacterial growth and the biodegradation processes, which is of fundamental importance for the metabolic activities in natural and man-made environments (Haldane, 1930; Andrews, 1968). Another limiting mechanism highly relevant for the metabolic activity of microorganisms is the mass-transfer limitations controlling bacterial access to the substrate and typically known as bioavailability limitations (Best, 1959 ; Bosma et al., 1997). Unlike substrate inhibition, bioavailability limitations are mechanical, promoted by physical properties of the pore space and controlled by transport processes like advection and diffusion. Up to now, theoretical descriptions (i.e. mathematical rate formulations) of substrate inhibition and bioavailability limitations have been considered separately and there is no link between these two limiting mechanisms in cases both limitations are simultaneously present. In the absence of substrate inhibitory effects, bioavailability limitations were always considered detrimental for the success of bioremediation. As a result, it has been believed that better in-situ bioremediation is obtained in more homogeneous systems where the even distribution of substrate and bacteria would facilitate the access of a larger portion of bacterial community to a higher amount of substrate. The above hypothesis is challenged in situations where the full availability of an inhibitive substrate at high concentration levels would hinder the metabolic activity of the microorganisms.

To analyze the balance between nutritive and toxic levels of substrate in presence of bioavailability limitations in porous environments, we first analytically formulated the cumulative effects of substrate inhibition and bioavailability limitations together (Gharasoo et al., 2015). We then examined these effects in the presence of pore-scale heterogeneities using a well-established pore network model. While previous studies showed that the bacterial activity is restrained by bioavailability, the results from this study, however, revealed that bioavailability limitations as well as pore-scale heterogeneities can be beneficial for the degradation of an inhibitive substrate. It was found that at concentrations higher than a threshold, bioavailability limitations can diminish inhibition effects by reducing the bacterial exposure to the lethal concentrations of substrate, and thus to increase the overall efficiency of in-situ bioremediation. On the other hand, at concentrations below this threshold, bioavailability limitations further decrease the rates and act as an additional rate limiting factor along with substrate inhibition.