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A numerical model for reactive transport coupled with microbial growth on Darcy scale

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The injection of substrates, e.g. hydrogen with the purpose of energy storage, into subsurface structures could stimulate the growth of all present microbial species which are able to use this substrate for their metabolism. The linkage between transport, the growth of microorganisms, substrate availability and biodegradation results in a strongly coupled dynamic system. The difficulty in the development of a general model is the inclusion of processes which appear on different length and time scales. In this work, a flexible numerical model was developed which uses effective representations of the processes on Darcy scale. The mass exchange between two phases (gas and water) is treated instantaneously by using an equilibrium law. Multiple metabolic reactions can be included kinetically by defining the stoichiometry and kinetic coefficients. Different mathematical models can be selected to describe the substrate-limited microbial growth. Microorganisms can be considered as an immobile biofilm or as partially mobile within the water phase. The jump-like appearance of usual growth models and the strong coupling to the reactive transport equations results in a very stiff equation system. The numerical instability was overcome by a proper adaptive time step selection and a check for the physical possibility of each solution before it is continued to the next one. Example simulations are shown for a near wellbore and a field scale study of an underground hydrogen storage.

References

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