Bacteria in flow: surface colonization and biofilm formation

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The vast majority of microorganisms are exposed to fluid flow, whether in natural environments, the human body, or artificial systems. However, despite the pervasive occurrence and implications of a fluid dynamic environment, its influence on the transport and attachment of bacteria to surfaces and on the following biofilms formation remains poorly investigated and understood, especially in complex geometries that best describe real systems. The aim of this work is giving an overview of the influence of local hydrodynamic conditions on bacterial transport, surface attachment and biofilm formation.
We investigated the effect of laminar flow on motile bacterial suspension around a single pillar in a microfluidics channel [1]. With a systematic experimental and numerical study, we show that the combined effect of flow past pillars of different dimensions and bacterial motility can redirect attachment to preferential locations and increase the capture efficiency at imposed flow velocity comparable to bacterial swimming speed. The preferential attachment location depends on the local hydrodynamic conditions and, as revealed by a mathematical model benchmarked on the observations, on cell morphology and swimming traits.
On longer time scale, flow of the same diluted bacterial suspension triggers the formation of suspended filamentous biofilm structures known as streamers, maily constituted by extracellular DNA (eDNA) [2,3]. We have developed a microfluidic setup that allows real time visualization of the formation of biofilm streamers and the investigation of their biochemical composition by means of lectins staining. Using the experimental toolbox from biophysics to characterize the biofilm matrix, we could elucidate the relation between chemical composition and microstructure, use our understanding to control streamers formation and gain an insight on this biological system that could make an impact in the medical sector.

[1] E. Secchi *et al*., *Nat. Commu*. (2020)
[2] E. Secchi *et al*., paper in preparation.
[3] G. Savorana *et al*., paper in preparation.