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Modelling Pattern Formations of Bacteria: Influence of Gravity

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In microcontainers, growing bacterial colonies of various species, such as *Escherichia coli* and *Bacillus subtilis*, self-organise and form patterns. One of the phenomena that can be observed in patterns during physical experiments is the formation of plumes: vertical structures descending from the larger aggregate of bacteria near the top of the microcontainer. The mechanism of plume formation is still poorly understood. The use of mathematical modelling can help fill the gaps in knowledge.

Studies of mathematical models for bacterial pattern formation have intensified since the introduction of Keller–Segel partial differential equations model for chemotaxis in 1971 [1]. When modelling *Escherichia coli*, experiments have shown that the dynamics of oxygen have to be taken into account [2]. Hillesdon et al. [3] have shown that by coupling the Keller–Segel model with the fluid flow equation, plume formation can be modelled in colonies of *Bacillus subtilis*.

By coupling Keller–Segel model involving oxygen dynamics with Navier–Stokes incompressible fluid flow equations, we investigate the effects of gravity on the modelled *Escherichia coli* plume formation. The model consists of partial differential equations describing the dynamics of bacteria density, self-excreted chemoattractant concentration, oxygen concentration, and fluid dynamics. We also investigate the influence of these dimensionless model parameters: Schmidt number, Rayleigh number, and oxygen cut-off threshold. The numerical simulation was carried out using the finite difference technique.

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