Effects of hydrodynamics on the behavior of free-living amoeba in freshwater biofilms
A Perrin, P Herbelin, Frédéric Jorand, Salaheddine Skali-Lami, Laurence Mathieu

To cite this version:
A Perrin, P Herbelin, Frédéric Jorand, Salaheddine Skali-Lami, Laurence Mathieu. Effects of hydrodynamics on the behavior of free-living amoeba in freshwater biofilms. BIOFILM 7, 2016, Porto, Portugal. hal-03749795

HAL Id: hal-03749795
https://hal.univ-lorraine.fr/hal-03749795
Submitted on 11 Aug 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Effects of hydrodynamics on the behavior of free-living amoeba in freshwater biofilms

A. Perrin1,2,4, P. Herbelin1, F. Jorand2,4, S. Skali-Lam3,4 and L. Mathieu2,4,5

1 EDF Recherche et Développement, Laboratoire National d’Hydraulique et Environnement, Chatou, Cedex, France
2 Université de Lorraine, LRBE, UMR 7364 CRDUS – UL, Vandœuvre-lès-Nancy, France
3 Sattout, 54140 Vandœuvre-lès-Nancy, France
4 CRhIS, LCPME, UMR 7054 CRDUS – UL, Vandœuvre-lès-Nancy, France
5 Author correspondence : EDF R&D, 5-7 quai Watkin 75411 CHATOU Cedex, +33130670540, aline.perrin@edf.fr

Natural presence in water supplied to cooling circuits, free-living amoebae (FLA) can encounter conditions favourable to their multiplication as the water warms up. The temporary presence of the pathogenic Naegleria fowleri in industrial cooling circuits represents a potential public health risk in case of dispersion in the water. To better manage the amoeba problem, it is essential to identify the areas of the cooling system that are especially to their development.

Factors necessary but not sufficient to explain the growth of amoeba N. fowleri in biofilms (Figure 1). Biofilms are evolving structures that form as a result of a dynamic equilibrium, which is influenced by the hydrodynamic conditions.

What are the hydrodynamic conditions in cooling circuits?

OBJECTIVES

1. Develop a specific pilot-scale device capable of reproducing a wide range of hydrodynamic conditions found in cooling circuits.
2. Quantify and qualify the establishment, growth and survival of biofilms and of FLA in freshwater biofilms.

HYDRODYNAMICS CONDITIONS IN THE COLLING CIRCUITS, TRANSFERT OF AMOEBAE TO THE WALL?

In most of the filled pipes of cooling circuits, the flow is always turbulent, characterized by Reynolds number (Re), which is the ratio of inertial forces to viscous forces in the fluid. The viscous sublayer (next to the wall, biofilms) is of very small thickness and characterized by large velocity gradients. Flow in this viscous sublayer is considered to be essentially laminar, with a characterized shear rate (γ).

Diffusion transfer would be impossible given the size of amoeba (> 20 µm) : Convection.

In laminar flow conditions, the lift forces tend to elevate amoeba away from the wall.

Other mechanisms such as turbulence, sedimentation, locomotion and surface properties, may explain why FLA may be found in environmental biofilms (Bijela et al., 2012; EDF researches).

REACTOR DESIGN

Rotating disk biofilm reactor (Figure 3) (optimized and adapted to Abe et al., 2012; Mathieu et al., 2014; Pelleïeux et al., 2012)
- Biofilm that moves relative to the water
  → Rotating disk with removable stainless steel or concrete coupons (7.07 cm²)
- Sedimentation
  → Disc at the bottom of the reactor tank
- Shear rate is a function of the rotational speed of the disk and the radial distance from the axis of rotation (Navier-Stokes equations)

γ = 0.792 \( \frac{W}{r\cdot\nu} \)

(Schlichting, 1979).

4 radius positions on the disk: 4 different hydrodynamic conditions for each assay

ENSSTABLISHMENT OF AMOEBAE

Assay with rotating disc reactor
- 350 rpm
- Stainless steel
- 3 hydrodynamics : 17,727 (RII), 25,483 (RIII) et 33,238 s⁻¹ (RIV)
- Continuously fed with Loire freshwater at a rate of 1.38 L.h⁻¹
  → Hartmannella spp. were detected at densities 10³ amoeba.L⁻¹ at 30°C and 2x10² at 43°C
  → 8x10¹ bacteria.L⁻¹ and 10⁴ copies of genomes L⁻¹ (cell counting and qPCR)
- Freshwater biofilms generated were analyzed quantitatively and chronologically for presence of FLA and bacteria using microbiological culture and molecular biology methods (Figure 4).

Further assays will follow to enable validate the inter-assay reproducibility and to study the effects of different hydrodynamic conditions on Naegleria fowleri behavior in biofilms, as well as the impact of the type of materials (stainless steel or concrete).

The experimental process and technical feasibility have been validated, notably, that FLA colonization of freshwater biofilms is possible at shear rate up to 33,238 s⁻¹.

These results confirm that mechanisms other than convection, have allowed the establishment of FLA in biofilms (turbulence, locomotion or surface properties).

Further assays will follow to enable validate the inter-assay reproducibility and to study the effects of different hydrodynamic conditions on Naegleria fowleri behavior in biofilms, as well as the impact of the type of materials (stainless steel or concrete).