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Biofilms: A Comprehension of Microbial Chemical Ecology

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Abstract

Biofilms present a beautiful example of Microbial Ecology Evidences from the past glorious history of Microbiology has established it in the field of science. Many aspects of biofilms include the chemical ecological characters, including the hydrodynamics of the surface- microbial interaction. Apart from this, many other important community characters exist in biofilms.

Abbreviations: ESP: Extracellular Polymeric Substance; SEM: Scanning Electron Microscopy; TEM Transmission Electron Microscopy

Short Communication

With the discovery of the first microbial life form, credited to van Leeuwenhoek, who studied and concluded the existence of surface attached microorganisms on the tooth slime layer, it was in the later phase of microbiological advances that this slime layer, which was an altogether distinct phenotypic character, was coined the term, biofilms. Future research by Heukelekian and Heller [1], along with Zobell [2], established the phenomenon of surface kinetics in the exponential growth of the microbial life forms. Observations clearly reflected the substantially positive effect on the growth rate of the bacteria. The biofilms were not only tough in their composition, but also resistant to disinfectants and surfactants, as observed by Characklis [3], in his study on the microbial slimes as a result of waste water and industrial effluents. Initial studies on the ecological aspects of biofilms, started when Costerton and his team [4] propounded a theory of adherence of the microorganisms to various living and non-living surfaces and the benefits which the obtained from this micro - niche. From that time to the current scenario, last four decades have seen revolutionary changes in the various aspects of biofilm studies. The sophisticated Scanning Electron Microscopy (SEM) technique, Transmission Electron Microscopy (TEM), technique and microbiological and serological have elevated the level of characterization studies.

Biofilms: Population Dynamics

Scientifically a biofilm can be considered as an assemblage of microbial cells which is covered by a mucilaginous protective matrix which is composed of polysaccharide material. Apart from this, this matrix has an irreversible adhesion with the surface, i.e. it is not easy to remove by gentle physical removal methods. The nature of bio film depends a lot on its place of origin. As such, those originating in an aqueous system are known to be much complex than those produced on a solitary medical aperture, device or catheter. Complexity not only lies in the cellularity but also in the Extracellular Polymeric Substance (EPS) or polysaccharide matrix composition as well as other colony characters.

Surface characterization studies have always been a prime concern with respect to biofilms. Characklis and his team [5], concluded that microbial colonization gets aggravated with an increase in roughness as comparison to even surfaces. This attributes to increase in the surface area and decrease in the shear forces. The rate of film formation also gets affected by the surface physico-chemical properties. The extent and time period for initiation of the biofilm in an aqueous medium interacting with the surface substrate, depends upon the conditioning of the polymers of the medium to the substrate surface. Reports on the conditioned biofilm formation were proposed by Loeb and Neihof [6]. Another factor which affects the hydrodynamics of the chemical interaction between the microbial cells and the substrate surface is surface energy of the suspending medium [7]. Theoretically, hydrodynamic boundary exists, when any liquid flows on a substrate. The liquid which is in immediate contact with the substrate or the interface has a negligible flow velocity. This interface is termed as Hydrodynamic boundary layer. Above this layer, the region of turbulence exists, thus,

affecting the cell- surface interactions. The cells behave as particles, the rate of settlement of which depends greatly on the velocity characteristics of the suspended medium [8]. Apart from, the rate of flow of the suspension also marks the nutrient uptake and polymerization required for biofilm formation [9].

Architectural studies on the nature and structure of biofilms proves it to be a misnomer that, it is a homogenous polymer coated or conditioned colony of single type of cells. Rather, its heterogeneous nature, is gets more established evidences in form of micro channels present in between two or more micro colonies in an EPS matrix [10]. Moreover, the thickness of the EPS matrix is dependent upon the number of component microorganisms, such as separate in vitro biofilms of Klebsiella pneumoniae and Pseudomonas aeruginosa were thinner than the combined form [11].

The Community Characteristics of Biofilm Ecology

The biofilm micro colonies ideally fit into the ecological phenomenon of community with its own set of community characters or community dynamics. This system is an abode with ideal environment supporting transfer of genes and characters, creating a nutrient gradient, and setup of cellular interaction machinery known as quorum sensing [8]. Extra chromosomal gene transfer through conjugation is a common phenomenon in biofilms and occurs with much efficiency and a fast pace [12]. Apart from this, evidences have been given in favour of quorum sensing mediated transformation [13], which is also much quicker as compared to planktonic cells. Other important community characteristics include interaction with other microorganisms, dispersive nature, much more adapted to the environment, leading to stability in their structure.

Conclusion

The biofilms have been of great concern with respect to clinical perspectives. They have to found in direct association with diseases like Cystic fibrosis, native valve endocarditis, otitis media, periodontitis, etc., where biofilm- associated microbes have been reported. Further, broad ranges of indwelling medical devices have proved to provide a suitable environment for bio film formation.

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