作者	陈益山
中文题名	细颗粒泥沙生物膜生长及对吸附与解吸影响的实验研究
英文题名	Experiment on Biofilm Growth of Cohesive Sediment and Effect on Adsorption or Desorption
中文关键词	泥沙,生物膜,生长模型,多样性,吸附解吸
英文关键词	Sediment, Biofilm,Growth model, Community diversity, Adsorption and desorption
中文文摘	微生物是水生态系统的重要组成部分，广泛分布在各种天然水体中。泥沙在水生态系统中为微生物聚集提供了良好的基底条件。微生物代谢产物分泌胞外聚合物，在泥沙表面形成生物膜。生物膜的形成一方面改变了原有泥沙的物理性质及其力学运动规律，另一方面也改变了水体中污染、营养等物质的吸附降解特征。已有工作对长膜泥沙的研究主要集中在泥沙表面生长生物膜后对泥沙颗粒原有的形貌特征（絮体密度、粒径级配）、运动特性（沉降速度、流变特性）、输移特性（起动流速）以及床面形态（输沙率、粗糙度）等的影响，对长膜泥沙的生长及其吸附解吸化学特性和环境效应研究相对较少，对长膜泥沙自身生长的定量描述也相对缺乏，这些也是泥沙与水生态环境领域所关注的重要内容。 论文研究泥沙表面生物膜生长动力学模型、长膜泥沙群落多样性和吸附解吸特性等三个方面。 对生物膜生长动力学模型的研究，以天然泥沙颗粒为基底进行生物膜培养实验，着重研究泥沙表面生物膜的生长过程。模型采用生物烧失量作为变量，考虑了不同水流速度和泥沙粒径对生物膜形成和生长的影响，并从经典的生物膜生长理论出发，建立了长膜泥沙生物量随时间变化的数学模型。研究表明泥沙表面生物膜的生长速度和生物量变化与泥沙基底的粒径和水流速度有密切关系，泥沙粒径越细，水流速度越小，生物量越多，建立的生物膜生长动力学模型中能够很好的反映和模拟这些规律。 对长膜泥沙群落多样性的研究，通过最新的 16S rDNA 高通量测序技术来得到长膜泥沙的细菌群落关系。群落多样性分析包括基础多样性分析（多样性指数、分类学分析等）和高级多样性分析（Veen 图、样本聚类树、PCA 分析等）。群落多样性分析结果能很好的反映不同条件下的生物膜中的细菌丰度和多样性，并揭示泥沙粒径和水流速度对多样性的影响，为生物膜的环境影响打下基础。 对泥沙生物膜生长后吸附特性的改变研究，以硝酸铜、磷酸二氢钾溶液为吸附剂，进行不同生物膜生长阶段的室内静态吸附实验。吸附实验结果表明，生物膜生长后长膜泥沙对磷的吸附有极大的促进作用，而由于干净沙本身对铜的吸附能力非常强，生物膜的生长对泥沙颗粒吸附铜起了少量的促进作用。
外文文摘	Microorganisms are the important components of aquatic ecosystems and widely distributed in aqueous environment. Sediment, a special realm in aquatic ecosystems, provides excellent substratum for microorganism colonization. The secretion of metabolic products by microorganisms causes the formation and growth of biofilm on the sediment surfaces. Biofilm growth could influence the original physical properties of sediment and their transport processes, on the other hand, influence the adsorption and degradation properties of pollutants and nutrients in waterbody. The previous research usually focused on the impact on biofilm growth of sediment morphology features (floc density, size gradation), sediment movement process (settling velocity, rheological properties), sediment transport processes (incipient velocity) and bed surface morphology (sediment transport rate, roughness), but little is about the influence on the chemical properties (adsorption and desorption etc.) and environmental effects. And there is also little research about the quantitative analysis of the biofilm growth, which is the important aspect of sediment and aquatic ecological environment. In this paper, the research mainly includes three aspects: the dynamic model of the biofilm growth on the sediment surface, the community diversity of the bio-sediment, as well as the adsorption and desorption properties of the sediment. The research on the model of biofilm growth is directed through the culture experiment o

	f biofilm vegetating using sediment as the substratum, and focuses on the growing process of the biofilm. We use the loss on ignition(LOI) measured by muffle furnace as the variable in this model, consider the influence of the different flow velocity and sediment particle size on the biofilm formation and growth, and base on the classical theory of biofilm growth. Therefore a model of biomass that changed with time is proposed. Research shows that the biofilm growth rate and biomass was closely related with the sediment particle size and flow velocity. The smaller the sediment particle size and flow velocity, the larger the biomass. The above research could be well calibrated by the following model. The research on the community diversity of biofilm is based on the sequencing technology. The relations of the bacteria community are reflected using the sequencing technology called 16sRDNA. The analysis community diversity included basic diversity analysis (diversity index, taxonomic analysis, etc.) and senior diversity analysis (Veen figure, Hclust_bar, PCA analysis, etc.). The results of community diversity analysis can well reflect the abundance and diversity of bacteria under different conditions, and reveal the influence of sediment partical size and flow velocity on the diversity, as well as lay a good foundation for the research of the environmental effect of biofilm. The research on the changes of the adsorption properties when growing biofilm on sediment surface is based on the model of adsorption isotherm. The study performed some laboratory experiments using Cu(NO3)2 solution and KH2PO4 solution as the adsorbent at different biofilm growth stage. The results of the adsorption experiment show that the growth of biofilm on the sediment surface has a more promoting effect on adsorption of KH2PO4 solutions but a less promoting effect on adsorption of Cu(NO3)2 solution, for the sediment has a strong adsorption ability of the Cu(NO3)2 solution.
答辩日期	2017.12.21