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中文题名	泥沙颗粒沉降和起动速度受生物膜生长的影响研究
英文题名	Impact on Settling Velocity and Incipient Velocity of Sediment after Biofilm Colonization
中文关键词	泥沙颗粒;沉降;起动
英文关键词	sediment particles;settling velocity;incipient velocity
中文文摘	近年来随着社会经济的快速发展，污染物质的排放带来严重的水环境污染问题，导致水质恶化，水体物理、化学和生物特性发生改变，对水体中物质的迁移转化、泥沙底质运动特性和絮体形成等过程产生重要影响。在营养富集的水环境中，泥沙颗粒表面吸附的大量营养物质为微生物在其表面吸附成膜提供了有利条件，生物膜对泥沙颗粒物理特性的影响，特别是对泥沙颗粒运动特性影响的重要性已逐步得到认识。但目前的研究主要集中在海洋区域，以实地测量为主，而对淡水中泥沙颗粒运动特性的影响研究较少。论文主要研究淡水环境泥沙颗粒生长生物膜后沉降和起动特性的规律和变化情况。该研究建立在水沙界面上培养生物膜后进行的沉降和起动实验的基础上，通过对实验现象的观察和实验数据的采集，对生物膜生长后泥沙颗粒的沉降和起动规律进行分析和研究。对于生物膜生长后泥沙颗粒的粒径分布和沉降运动，主要运用图像采集和图像分析技术进行研究。在颗粒沉降运动的过程中采集序列图片，采用图像处理技术进行粒径统计分析，并通过 PIV(Particle Image Velocimetry)和 PTV(Particle Tracking Velocimetry)颗粒测速技术计算长膜颗粒的沉降速度。研究表明，生物膜的生长显著改变了泥沙颗粒的粒径分布，形成粒径范围很宽的颗粒级配，长膜泥沙粒径最大可达到原状沙的 1~2 个量级。利用长膜沙的沉降数据，拟合得到雷诺数 1~200 范围内的长膜沙颗粒的沉降绕流阻力系数公式，对长膜泥沙的沉速计算进行了探讨。生物膜的生长改变了泥沙颗粒的刚性表面特性，增大了颗粒的下沉阻力，长膜泥沙的沉速约为等密度等粒径光滑球体沉速的 50%~60%，同时由于密度的减小，长膜颗粒的沉速与等粒径泥沙相比就更小。关于生物膜对泥沙起动条件影响的研究，主要通过水槽实验来对比有无生物膜生长的两种沙样的起动过程，观察两种泥沙起动现象的区别，分析两者起动流速的差异和随培养时间的变化规律等。结果表明富营养水体中生物膜生长繁茂，对泥沙起动特性有着显著的影响，能够增强床面泥沙的抗冲性，床面泥沙的起动流速随培养时间的增长呈现出先升后降然后趋稳的钟形变化趋势，并根据实测数据推导了生物膜生长后床面泥沙的起动流速公式。
外文文摘	In the last few decades, human activates discharge industrial, agricultural and domestic waste into water systems, which generally contaminate water and causes eutrophication. Eventually, the pollution phenomena lead to a series of changes in sediment properties, such as the transformation of substances, floc formation, particle settling movement and bed stability. These phenomena prompted the interdisciplinary research of sediment science and water ecology as a trend. The presence of biofilm growth significantly affects the physical properties of sediments. In eutrophic aquatic areas, the adsorption of nutrients on sediments provides favorable conditions for microbial activities, and the effects of biofilm on sediment properties particularly on sediment motion characteristics have attracted increasing attention. However, most studies were carried out in field of marine areas, few laboratory experiments have been taken in freshwater area systematically.This dissertation mainly focuses on the changes of size distribution and the dynamic characteristics of sediment after biofilm colonization. The research built on the experimental studies of settling movement and incipient motion after the biofilm cultivation on sediment, and on the basis of experimental observation and data collection, the settling and incipient motion pattern were compared and analyzed deeply.The grading curves and settling velocity were presented by particle image acquisition and image analysis techniques. During the process of particle settling, digital images were captured continuously; image processing technology was used to analyze the statistics, and two matching algorithms of PIV (Particle Image Velocimetry) and PTV (Particle Tracking Velocimetry) were utilized to calculate the settling velocity. Experimental results indicate that the range of bio-particle sizes is 1-2 orders of magnitude wider than that of primary particles. A drag coefficient formula of bio-particles was proposed as a function of particle Reynolds number between 1~200. The drag force exerted on a bio-particle is larger, and settling velocities of bio-particles are approximately 50-60% of an equivalent smooth sphere. A fitting formula for the drag coefficient with biofilm

	was proposed and settling velocity calculation in different position was discussed. The experimental data show significant changes of particle distribution after biofilm colonization, on the other hand, the resistance force exerted on a bio-coated particle is larger than that for a primary particle through changing the surface characteristics.The study on the biofilm effects on incipient motion conditions was performed by a series of flume experiments. Two kinds of sediment samples, one kind were with biofilm colonization, the other without biofilm, were observed to compare the different entrainment process and analyze the variation trend of incipient velocity over time. It was found that the incipient motion phenomena were quite distinct between them. Biofilm grew prosperously and sediment with biofilm had a higher stability, and the incipient velocity increased up to a threshold level with time and then declined, indicating a bell-shaped trend. Incipient velocity formulas for sediments after biofilm colonization were derived according to the data gained from the experiments.
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