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中文题名	泥沙颗粒吸附磷的规律及微观形貌变化的研究
英文题名	The Phosphorus Adsorption Rule and Surface Micro-topography Change of Sediment Particle
中文关键词	泥沙颗粒;微观形貌;泥沙吸附;孔分布;磷
英文关键词	sediment particle;micro-topography;adsorption on sediment;pore distribution;phosphorus
中文文摘	社会经济的快速发展，同时带来突出的水环境污染问题。天然水体中存在泥沙运动，特别是我国大江大河的泥沙输沙量较大，泥沙在污染物的迁移和转化过程中担任着非常重要的角色。泥沙对氮、磷等污染物的吸附改变了水体中污染物的浓度，又使泥沙自身形貌和输移特性发生变化，研究泥沙与污染物之间的相互作用是解决这些问题的科学基础。 本文从微观角度出发，对泥沙吸附磷的规律及其形貌变化进行了探讨，采用的研究手段和主要结论包括以下几个方面。 通过先进的扫描电镜对泥沙颗粒的微观形貌观测发现：天然状态下的泥沙颗粒表面形貌十分复杂，常附着大量污染物质，与清洗干净的泥沙差异较大。为比较干净泥沙与被污染泥沙的差别，研究以 KH_2PO_4 溶液为吸附剂，完成了在不同吸附剂浓度和泥沙浓度条件下的室内静态吸附实验，并采用气体吸附法观测吸附后泥沙颗粒表面的孔隙特征，发现颗粒表面 1-10nm 的孔隙在受污染前后体积变化最明显。随着污染程度的加重，泥沙比表面积减小，孔体积减小，平均孔径增大，在污染过程中孔径较小的孔隙逐渐被填充。进一步又采用能量弥散 X 射线能谱仪（EDS）对吸附后泥沙的表面元素进行分析，统计结果显示，泥沙颗粒表面的磷元素分布与颗粒表面的微结构有较好的相关关系。 分析泥沙颗粒吸附磷的规律可见：吸附包括了物理吸附和化学吸附两个方面，其中物理吸附速度很快，是个可逆过程；而化学吸附比较缓慢，属于不可逆过程。在水流剪切力的不断作用下，能够稳定吸附在颗粒表面的磷酸根离子大多应是与颗粒表面通过化学作用结合的离子，因此吸附平衡时污染物应大多集中在水流剪切力较小的孔隙之中，导致这部分孔隙被大量填充。 在电镜实验观测的基础上，论文用数学方法描述了清洗泥沙颗粒的形状和表面结构，并用概率统计的方法构建了数学泥沙的研究平台。该平台可以表征泥沙颗粒的三维形貌，同时也能反映出泥沙颗粒表面上每个微区的磷吸附规律。用该平台结合吸附动力学方程可以用来完善已有的水沙和水质数学模型，完善后的模型已经应用到北运河流域和岩滩水库的污染物迁移及泥沙输移计算之中，并取得了满意的计算效果，表明该模型具有较好地应用前景。
外文文摘	One of the consequences of rapid economic development in China over the past twenty years has been a significant increase in aquatic pollution. There is a large amount of sediment transported in natural aquatic systems, especially in China’s big rivers. Sediment particles, therefore, play an important role in the migration and transformation of pollutants. The adsorption of nitrogen, phosphorous and other pollutants on sediment particles changes not only the concentration of pollutants in the water but also the surface micro-topography and transportation characteristics of the sediment particles themselves. More and better research into the interaction between sediments and pollutants is the key to solving these pollution problems. This dissertation discusses on a microscopic level the adsorption law of phosphorus and the changes that phosphorus produces on sediment particle surfaces. The methods and results are as follows. The study used an advanced scanning electron microscope (SEM) to observe the surface micro-topography of sediment particles. From the investigation, it was discovered that the surfaces of natural particles are very complex. Often they are heavily coated with pollutants. These polluted surfaces show notable differences compared to clean particles. In order to compare the surfaces of clean particles to polluted particles, the study performed some laboratory experiments using KH_2PO_4 solution as the adsorbent. Then a series of adsorption experiments were conducted on sediments with various degrees of initial phosphorus. The sediment particle surface pores which have adsorbed phosphorous iron were measured using the gas adsorption method. Based on our experiments, the study discovered that pores ranging in size from 1 to 10nm show significant changes after the particles are polluted. As the pollution levels increase, the specific particle surface area and pore volume decrease

	and the average pore size inversely increases. Small sized pores, it was found, gradually filled as the sediments were polluted. We used an energy dispersion spectrometer (EDS) to analyze the chemical elements on the particle surface. The statistical results of our analysis indicate a close causal relationship between the phosphorus distribution on the particle surface and its micro-topography. There are two complementary processes at work in the adsorption of phosphorous iron on particle surfaces—physical adsorption and chemical adsorption. Physical adsorption is a reversible process which occurs rapidly, whereas chemical adsorption is an irreversible process which occurs slowly. As an effect of constant flow shear stress, the phosphorous iron that is stably adsorbed on the particle surface combined with the particle surface through a chemical reaction. Where the flow shear stress is lower, pollutants, therefore, gather in pores as the reaction reached equilibrium. This gathering action causes the pores to fill. Based on our SEM observations, we used mathematical methods to describe the form and texture of the clean surface particles. From these mathematically derived results, we built a research platform. This platform calculated not only the three dimensional topography of sediment particles but also the interaction processes between the particle surface micro-area and the phosphorous iron. Combining this platform and the adsorption kinetics equations, we were able to refine an existent one dimensional numerical model for water, sediment and water quality by adding modules to it to make it more powerful and to improve its predictive accuracy. The study applied the model to simulate pollutant migration and sediment transportation respectively in the Beiyun River and the Yantan Reservoir. We were able to obtain verifiable results using this model and methodology. This model demonstrated strong potential for describing the pollution processes which contaminate clean sediments in China’s river systems.
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