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中文题名	水沙输移对水体富营养化的影响研究
英文题名	Research on the Effects of Flow and Sediment Transport on Eutrophication
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中文文摘	水体富营养化是目前我国大部分河湖和水库面临的问题。水体中营养盐富集，浮游植物生长旺盛，导致溶氧减少，给水质恶化带来了不可忽视的影响。本文主要通过理论分析和数值模拟等方法，研究了水沙输移对水体中营养盐和浮游植物生长等过程的影响，并基于此改进现有的富营养化模型。 通过理论推导的方式分析了水沙运动对于水沙界面处营养盐释放通量的影响。构建了不同模式下底泥营养盐通量的统一表达式，并将其引入描述营养盐输移和交换的偏微分方程组，求解得到解析表达式，进而可以计算上覆水和底泥中的营养盐浓度以及底泥通量的时空变化规律。在此基础上进一步分析了沙波参数、水深和泥沙粒径对于底泥通量的影响，确定了控制底泥通量大小的关键参数。 引入垂向掺混系数、水龄等水动力学指标，分析了富营养化发生的规律和潜在的工程措施。基于环境流体动力学（EFDC）模型，模拟了三峡坝前香溪河支流和长江干流水动力、营养盐、叶绿素 a 浓度的时空变化，并对比了干支流垂向掺混系数差异、水龄分布特征，统计分析这两个指标与叶绿素 a 浓度的关系，从而量化水动力对浮游植物生长的影响。结果表明，香溪河在垂向上的掺混能力相对较弱，纵向上水体输运能力和交换能力较差，水龄值较大，因此有利于浮游植物的富集；而长江干流中水体基本不存在分层现象，在水流较大的输运速率下浮游植物细胞被迅速向下游输移，因此不利于浮游植物的富集，叶绿素 a 浓度要远远小于支流。同时论文给出了利用水温和水龄估算香溪河库湾水体表层叶绿素 a 浓度的经验公式，分析了可能应对香溪河富营养化的调控措施。 提出了泥沙输移影响富营养化过程的途径，并据此改进富营养化模型。泥沙颗粒的存在会对水体形成遮光效应，直接影响光照强度沿水深的垂向分布，从而影响水中浮游植物的光合作用；同时，泥沙颗粒对营养盐尤其是磷酸盐具有较强的吸附作用，被吸附的营养盐会随着泥沙沉降而沉降，也会随着泥沙的起悬再次释放到水体中，从而影响水体中营养盐的浓度分布。论文以太湖为研究对象，采用数值模拟的方法，计算了不同风场条件下的水动力特征和悬沙浓度分布。在对模型率定验证的基础上，通过不同情景的模拟，对比分析了有无泥沙吸附、有无遮光效应以及有无底泥释放条件下的磷酸盐浓度分布、叶绿素 a 浓度分布等，定量研究了水沙输移对水体富营养化的影响规律。
外文文摘	Eutrophication has become a problem facing most of the rivers, lakes and reservoirs in our country. An overabundance of nutrients and vigorous growth of phytoplankton along with the decrease of dissolved oxygen can have a significant influence on water degradation. In this paper, theoretical analysis and numerical modelling were applied to investigate the effects of water flow and sediment transport on the nutrient and phytoplankton dynamics in natural water bodies, and to improve the existing eutrophication model based on the results. The impact of flow and sediment movement on sediment-water nutrient fluxes was investigated by means of theoretical derivation. By constructing a unified expression for sediment-water nutrient fluxes under different controlling modes, introducing it into a system of partial differential equations describing nutrient transport, and then analytically solving this system, we have obtained the distribution of nutrient concentration in the overlying water and sediment, along with the spatiotemporal variation of nutrient fluxes. The effects of bedform parameters, water depth and sediment grain size on sediment-water nutrient fluxes were further analyzed, and the key factors that influence nutrient fluxes were identified. Hydrodynamic indexes including vertical mixing coefficients and water age were introduced to analyze the occurrence of eutrophication and its potential en

	gineering countermeasures.The three-dimensional hydrodynamics along with the spatiotemporal distribution of nutrients and chlorophyll a in the Yangtze River and Xiangxi Bay were simulated using the Environmental Fluid Dynamics Code (EFDC) model. The differences of vertical mixing coefficients and water age in the Yangtze River and Xiangxi Bay were compared, and the correlations between chlorophyll a concentration and these two indexes were statistically analyzed to quantify the effects of hydrodynamics on phytoplankton. The results show that in Xiangxi Bay the vertical mixing intensity is relatively weak, and water age is large implying that the transport rates and exchange capacity of water flow in the longitudinal direction are also relatively poor, which favors the accumulation of algal biomass. While in the Yangtze River there exists no stratification, algal cells will be transported to the downstream region quickly by the water flow with high transport rates and low water age, which prohibits the accumulation of algal biomass, therefore the chlorophyll a concentration is much lower than that in the tributary. Furthermore, two empirical formulas that relate chlorophyll a concentration to water temperature and water age have been established in this paper, and they could be used to estimate the surface chlorophyll a concentration in Xiangxi Bay. The possible countermeasure for the eutrophication in this area was also analyzed. The ways that sediment transport affects eutrophication were proposed to improve the eutrophication model. The existence of sediment can cause shading effects in the water, which directly affects the vertical distribution of light intensity and algal photosynthesis. Meanwhile, sediment particles have a strong adsorption capacity for various nutrients especially for phosphorus. Adsorbed nutrients may accumulate at the riverbed due to sediment deposition, and could be released to the overlying water with sediment resuspension, which then influences the nutrient distributions in water. In this paper, numerical modelling was used to simulate the velocity field and suspended sediment distribution under various wind conditions in Lake Taihu. On the basis of model calibration, different scenarios were simulated to compare the distributions of phosphate and chlorophyll a under the influences of surface adsorption, shading effects and sediment flux, and to quantitatively investigate the effects of water flow and sediment transport on eutrophication.
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