From eutrophication to black disaster: physicochemical characteristics and formation mechanism of black bloom in Lake Taihu, China

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Water column hypoxia is one of the most serious threats from eutrophication to large water bodies. The outbreak of black bloom in some hyper eutrophic shallow freshwater lakes is a dire consequence of severe water column hypoxia and exacerbates the eutrophication greatly in the long term. In the past several years, black bloom phenomenon has become a serious ecosystem disaster in some important severe eutrophic lakes in China, which caused not only environment degradation but also drinking water crisis. Black color and offensive odour of the water column are two notorious sensory features of the so called black bloom. Field investigation showed that the dissolved oxygen (DO) levels were very low (nearly to 0 mg/L) as well as the oxidation-reduction potential(ORP). The nutrients concentrations such as ammonia nitrogen, soluble reactive phosphorous (SRP) were significantly higher in the black bloom water than in the normal lake water. High Fe^{2+} and ΣH_2S ($\Sigma S^{2-}=S^{2-}+HS^{-}+H_2S$) were typical characteristics of the black bloom water. Volatile organic sulfur compounds (VOSCs), including dimethyl sulfide, dimethyl disulfide, and dimethyl trisulfide were very rich in the black bloom water column, which were considered as the main odour-causing compounds. Analysis of the black substances of the black bloom water using X-ray photoelectron spectroscopy indicated that abundant FeS were included in these particles. Therefore, the black color of the black bloom water could be attributed to the formation of FeS in the anoxic/anaerobic water column.
Field investigation and laboratory incubation experiment indicated that the formation of black bloom was closely related to the surface sediment. The Fe^{2+} concentration in surface sediment pore water was high and showed a release tendency from the sediment water interface to the overlying water in the black bloom system, while the ΣH_2S production at sediment water micro-interface was obviously high compared to the normal system. Thus, the surface sediment was the important material source to the black causing compound of the black bloom. Analysis of microbioal community diversity demonstrated that sulfate reducing bacteria (SRB) were abundant in the surface sediment of black bloom, which strongly influenced the production and accumulation of ΣH_2S and drove the formation of black bloom finally.