Review on the Causes of Eutrophication in Water

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Abstract. In recent years, eutrophication in river water bodies has become one of the main water environment problems. However, the factors that contribute to eutrophication of river water bodies are complex. Eutrophication assessment methods are diverse, and contaminated water bodies have many sources of pollutants. Eutrophication reduces the self-purification capacity of water bodies and destroys the biodiversity of river ecosystems. There are many ways to evaluate eutrophication, and scholars in China and abroad have conducted a lot of research on river eutrophication in different regions, and established a sound mathematical model, evaluation criteria and method selection. Choosing a method suitable for assessing the degree of eutrophication of river water bodies is a priority at present. This paper aims to summarize the causes of eutrophication of a series of water bodies through the method of literature analysis, list the commonly used ways to evaluate eutrophication of water bodies and analyze the characteristics of each method, summarize the existing results, and use them as a reference for dealing with the phenomenon of river eutrophication. The paper finds that according to the U.S. Environmental Protection Agency (EPA), river bottom pollution is one of the main causes of water eutrophication, which is fundamentally due to irrational human activities, especially the increase of agricultural practices. Besides, agricultural pollution is the first major pollution of surface water pollution in rivers, lakes and other land surfaces, contributing 2/3 of the total pollution load.

Keywords: eutrophication · non-point source pollution · river pollution · nitrogen and phosphorus pollution · environmental assessment

1 Introduction

With the development of science and technology and social progress, China's urbanization process is gradually accelerating, and at the same time, it has triggered a series of river ecological problems. Eutrophication of water bodies is a phenomenon of water pollution in which humans discharge pollutants into rivers, resulting in excessive nutrient content in rivers, rapid reproduction of algae and other plankton, decreased dissolved oxygen content of water bodies, and deterioration of water quality. Most scholars believe that the main reason for the eutrophication of water bodies is the increase in the content of nutrients such as nitrogen and phosphorus in water. Since the phosphorus in the water body cannot be fully recycled, the phosphorus element has become the main polluting

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factor of the phenomenon of eutrophication in the water body [1]. Compared with the previous research, this paper will evaluate the causes of eutrophication of water bodies through the method of literature analysis, and on this basis, different solutions are enumerated to provide a reference for the treatment of the water environment of rivers.

2 Causes of Eutrophication of Water Bodies

The study of Liu Hui et al. (2019) shows that in lakes or rivers with eutrophication, available phosphorus can be used as an indicator to evaluate the degree of eutrophication [2]. The causes of eutrophication of water bodies are mainly divided into the following categories: (1) non-point source pollution in the upper reaches of river water bodies; (2) bottom matter pollution of lake reservoirs; (3) emission and loss of phosphorus-containing pollutants; (4) excess nutrient salts accepted under natural factors.

2.1 Non-point Source Pollution in the Upper Reaches of River Water Bodies

Non-point source pollution is also known as non-point source pollution, that is, environmental pollution without a fixed sewage outlet. Its pollution sources mainly come from domestic garbage, sewage, fertilizers, industrial wastewater and so on. Pollutants contaminate water bodies through surface runoff, leading to eutrophication. Non-point source pollution involves a wide area, which is scattered and difficult to detect and treat [3].

Chinese scholars have conducted a relatively comprehensive study of source pollution. Gong Shifei et al. (2019) used factor analysis methods to analyze the non-point source pollution characteristics of some typical watersheds of Danjiangkou Reservoir [4]. The results showed that the main factors affecting the water quality of the water in the reservoir area were total nitrogen (TN), total phosphorus (TP) and chemical oxygen demand (COD). Among them, the human activities that affect TN and TP are agricultural production and aquaculture. Tang Xiaoyang et al. (2018) analyzed the non-point source pollution phenomenon in the agricultural areas of the Jianghan River Basin [5]. It was concluded that the use of fertilizers in farmland in the region was the biggest contributor to the increase in TN levels, while the reason for the increase in TP levels was mainly due to the surrounding livestock farming. Cai Jinzhou et al. (2011) used the comprehensive survey method and selected 4 reservoir areas as samples for investigation. Studies have shown that local TN and TP are the main polluting factors, while the main sources of pollutants are planting and aquaculture. Xiao Ma et al. (2011) used the outlet coefficient model (ECM) to evaluate the nitrogen and phosphorus loads of non-point sources in the Three Gorges Reservoir area [6]. The team believes that potential nitrogen and phosphorus loads are related to rural domestic waste, animal husbandry, land use, atmospheric sedimentation and runoff.

International research on source pollution dates back to the late 20th century. As early as 1998, Shortle et al. pointed out that farmers' cultivation behavior is a major human activity that leads to non-point source pollution of water bodies, because the use of organic fertilizers can exacerbate the entry of nutrient factors into water bodies [7]. Novotny (1999) argues that the increase in street garbage and the use of pesticides and

fertilizers will cause greater pollution to the water environment, resulting in eutrophication [8]. According to Horan (2001), overexploitation of rural land has increased emissions of agricultural non-point source pollutants, which is due to the rapid growth of the world's population [9].

2.2 River Bottom Pollution

River substrate is a natural erosion product of minerals, rocks and soil in river water bodies. Substrate pollution is a phenomenon in which a large amount of physical, chemical and biological substances enter a water body, causing changes in the physical properties of sedimentation and affecting the structure, biomass or quality of benthic communities. Ye Zhou's (2018) study pointed out that in the human activity area between urban and rural areas, the pollution of river water bodies is seriously affected by anthropogenic disturbances, ecological problems are prominent, and there is bioabsorption and abiotic absorption of sediment phosphorus in the substrate [10]. Li Ruzhong et al. (2016) have studied the abiotic and bioorbital absorption of phosphorus elements in the bottom of rivers on the outskirts of cities [11], pointing out that soil erosion and siltation caused by human activities are the main reasons for the increase in phosphorus content in river substrates. Shuangshuang Zhang (2014) analyzed the spatio-temporal distribution of pollutants in the sediment of Nansi Lake, and used four monitoring data of lake sediment and water quality to evaluate the pollution factor content [12]. The team concluded that the sediment of the lake has a significant enrichment effect on organic matter, TN, and TP, which is not affected by natural sedimentation. It is mainly caused by anthropogenic pollution. Among them, the upgrading of sewage treatment plants near lakes is the reason for the increase in the content of pollution factors in the sediment.

Foreign scholar Kane T et al. (2010) pointed out that land-use change can alter the affinity of biological and abiotic processes on phosphorus in the river substrate, which will have an impact on the nutrient content of Hanoi and the ecosystem downstream [13]. D. Von Schiller et al. (2008) argue that land-use changes at larger spatial scales (i.e., watersheds) can affect physical, chemical, and biological properties at lower spatial scales, ultimately altering the structure and function of rivers [14].

Another major source of nitrogen and phosphorus in the substrate is industrial wastewater. Some water bodies are affected by the mining of nearby phosphate, the discharge of chemical enterprises, and the imperfect urban sewage pipe network system. Besides, the wastewater discharged by some chemical enterprises near the upper reaches of the river directly enters the river and is deposited in the substrate. Moreover, the wastewater discharged by factories in agriculture, processing industry, animal husbandry and other industries contains more nitrogen, while the wastewater discharged by chemical industry factories contains more phosphorus [15].

2.3 Emission and Loss of Nitrogen and Phosphorus Pollutants

Pollution of water bodies by phosphorus-containing compounds can lead to a decline in water quality and eutrophication. Tian Chang et al. (2020) of the College of Resources and Environment of Hunan Agricultural University conducted a two-year field team experiment and found that the TN and TP concentrations in the rice field water body

reached a peak after fertilizer application [15]. Research by Li Weiran (2020) points out that in China's rice irrigation areas, due to the application of fertilizer, a large amount of nitrogen and phosphorus elements enter the river channel through the runoff of the drainage ditch. The content of total nitrogen and total phosphorus in the river channel peaks at different growth stages of rice, leading to eutrophication of water bodies and river pollution [16]. Gao Weiwei (2019) proposed that in the upper reaches of the Yangtze River, phosphorus in the basin has become a major pollutant in recent years, of which the disorderly development of phosphorus-related industries is the root cause of the loss of phosphorus pollutants in the basin [17]. Among them, the phosphate mine mining, phosphorus-containing chemical industry, agricultural activities and large-scale aquaculture industry in the upper reaches of the river basin are all the causes of pollutant emissions.

Daniel J C (2009) pointed out that crop production requires the provision of fertilizer, and the increase in TN and TP in farmland water bodies is related to surface runoff due to rainfall during crop fertilization period [18]. The loss of TN and TP in the basin is mostly the result of the combination of geology, climate, soil conditions and human activities, especially the runoff caused by human factors will cause the loss of nutrients in farmland and aggravate the eutrophication of water bodies.

2.4 Excess Nutrient Salts Accepted by Natural Factors

With the development and construction of some river basins, the hydrological conditions, runoff forms and nutrient transport and distribution of some rivers have changed greatly. Tang Xianqiang (2020) believes that excessive large-scale development and construction in recent years has led to a decline in the environmental quality of some waters, and the degree of eutrophication is common [19]. Wang Jinghan et al. (2018) pointed out that cyanobacteria are suitable for survival in water bodies with high temperatures and low CO_2 concentrations, and in Yangtze River area, the spring temperature difference is large and the temperature continues to rise, which also leads to the prolongation of the red tide bloom phenomenon [20]. Nutrient pollution from human and natural inputs is a key driver of water quality problems in lakes. Among them, the limiting factors that dominate the growth of algae depend on seasonality and location (Fig. 1).

3 Conclusion

In conclusion, it has four points to conclude. First, after years of sedimentation, there are accumulated nutrient salts in the substrate of lake water bodies. Under natural conditions such as wind and water flow, nutrients in the sediment are released under disturbance, providing an environment for algae to multiply. Therefore, river bottom pollution is one of the main causes of eutrophication of water bodies. The anthropogenic effects on river substrates are mainly recorded through structural indicators such as water chemistry, river channel changes and algal biomass. In agriculture-dominated watersheds, there was a significant increase in algal biomass (chlorophyll a).

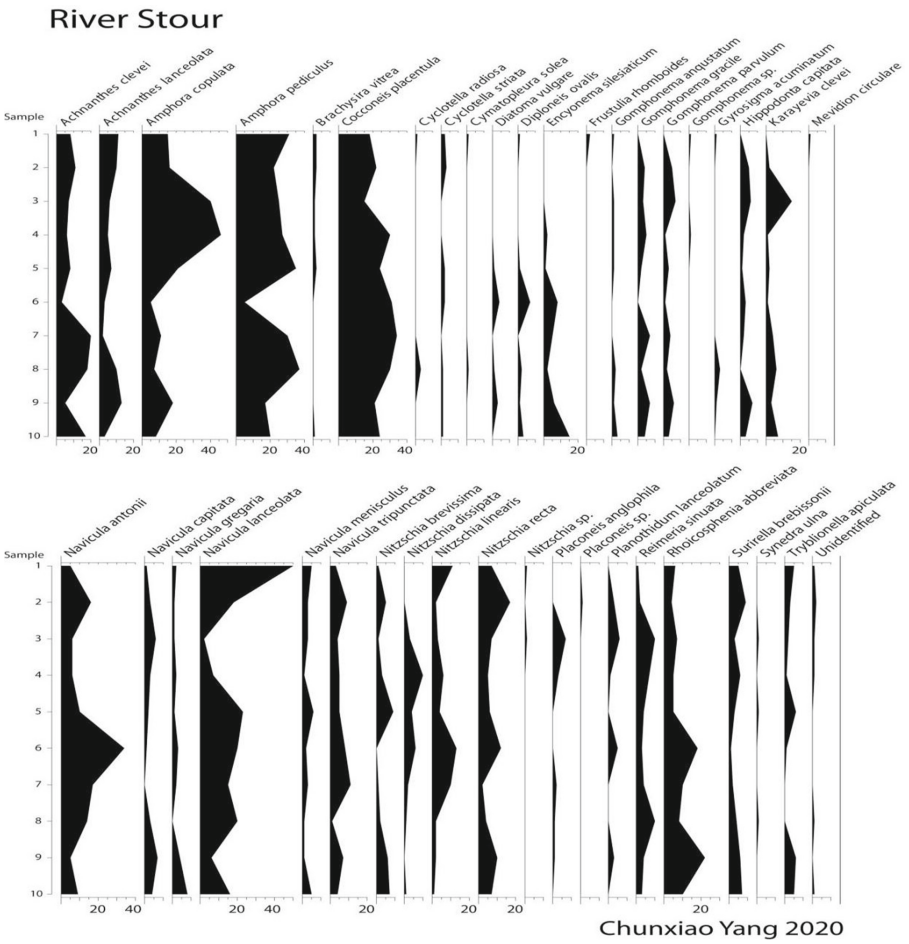

Fig. 1. Abundance distribution of diatoms in lower River Stour

Second, the root cause of non-point source pollution in the upper reaches of river water bodies is irrational human activities. Agriculture and animal husbandry in the upper reaches of rivers are the main factors leading to the eutrophication of water bodies. In the upper reaches of rivers where eutrophication occurs, there is also the discharge of domestic sewage. Humus in the soil of agricultural land in the upper reaches of rivers also increases the phosphorus content in the water body.

Third, the impact of increased agricultural behavior on the content of polluting factors is enormous. In some rural areas and small and medium-sized cities, due to the lack of effective means to purify domestic sewage, a large amount of untreated domestic sewage is discharged from upstream to the river, and the total phosphorus content in the river channel will rise. The use of excessive fertilizers, pesticides and phosphorus-containing detergents can lead to excess phosphorus entering the river. In addition, the artificial feed in the high-density aquaculture industry increases the content of nutrients in the water,

so that zooplankton, especially algae, multiply in large quantities, seriously endangering the local water environment.

Finally, the eutrophication of river water bodies has complex causes, and the treatment of eutrophication treatment should be comprehensively considered in combination with the local background environment and the actual situation of the river. It is necessary to comprehensively compare a variety of technologies and adopt a variety of treatment methods to achieve the optimal effect of solving the pollution problem. Besides, it is a good way to find a evaluation method through the investigation of the overall situation of the river water body in the research area.

There are some limitations of this paper. The research on water eutrophication is insufficient and there is no specific experimental data to support it. In addition, the research scope can be expanded in the future to analyze different basins. Future research can focus on these areas.

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