Research progress on release of endogenous pollutants and remediation technologies in water sediments

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Abstract. The problem of water pollution is becoming more and more serious, and the release of endogenous pollution in water sediments is an important aspect. The paper summarizes the chemical, environmental and hydrodynamic factors of common pollutants in sediments, and the effects of endogenous pollutants release, pollution control and treatment in the sediments, put forward some ideas about the development of research on endogenous pollutants in sediments. It is hoped to promote the in-depth development of prevention and treatment of endogenous pollutants in water sediments.

1. Introduction
Water resources are invaluable resources, not only the basic material resources needed for human production and life, but also strategic resources for national development. With the acceleration of urban development and industrialization, the use of domestic sewage and industrial wastewater is increasing, and the problem of water pollution is becoming more and more serious, leading to a decline in the quality of water environment in lakes and rivers and nearshore waters [1]. The water environment pollution comes from external input and endogenous release. Due to the increase of environmental awareness, the external input is controlled and the input quantity begins to decrease. Compared with the external input, the endogenous release is more difficult to control, so endogenous release becomes an important Question [2]. The problem of internal pollution of sediments is common in most lakes and sea areas in China. For example, the pollution of nitrogen and phosphorus in Taihu Lake is serious, the water body is eutrophic, and the endogenous pollution accounts for 40% of the external input [3]; the heavy metals in the Bohai Sea are enriched, Bohai Bay The heavy metals Cd and Hg in the sediments are seriously exceeded [4]; the degree of micro-plastic pollution in water sediments in China is relatively high, and the highest abundance of micro-plastics detected in China is 2-3 orders higher than that in foreign countries [5]. When the physical and chemical properties of the water-sediment interface change, the pollutants in the sediment can re-enter the overlying water body through molecular diffusion, sediment resuspension and other processes, resulting in secondary pollution of the overlying water body.
Based on the chemical properties, environmental factors and hydrodynamic factors of endogenous pollutants, this paper summarizes the effects of different factors on the release of endogenous pollutants in sediments, and combines the current methods for controlling and controlling endogenous pollutants in sediments. Several ideas for the direction of research in future work are presented.

2. Study on pollutants in water sediments
Water sediments are a common "sink" of various pollutants, and nutrient elements, heavy metal pollutants and organic pollutants constitute a complex mixture of coexistence. Among them, the ecological effect of pollutants in sediments is a long-term comprehensive effect formed by the interaction of various pollutants and environmental factors.

| Time  | Progress                                                                 |
|-------|---------------------------------------------------------------------------|
| 1950  | The eutrophication of water caused by nitrogen and phosphorus nutrients has attracted people's attention. |
| 1965  | Attention to the adsorption-desorption kinetics of nitrogen and phosphorus nutrients at the water-sediment interface |
| 1980  | Frequent heavy metal events began to study the exchange of heavy metals at the water-sediment interface |
| 1990  | Start to pay attention to the distribution of organic pollutants in sediments |
| 2004  | Thompson first proposed the term "microlastic" |
| 2010  | Start to pay attention to the distribution and interaction of composite pollutants |

2.1. Nutrient Contaminants
Eutrophication of water is a common environmental problem in the water environment. Excessive nitrogen, phosphorus and other nutrient elements enter the water body, causing abnormal reproduction of algae and aquatic organisms, resulting in eutrophication of water bodies and deterioration of water quality. China is a country with many lakes. In the past 30 years, the eutrophication of lakes and rivers in China has become more and more serious, and the proportion of eutrophic lakes has exceeded 30% [6]. The forms of nutrients in sediments are diverse, and different forms of nitrogen and phosphorus have different bioavailability and geochemical behavior in water [7]. For the study of nitrogen content and release law in sediments, generally in the form of chemical combination, there are three forms of total nitrogen, inorganic nitrogen and organic nitrogen. Phosphorus in sediments can be roughly divided into inorganic phosphorus and organic phosphorus, but only a part of phosphorus in sediments participates in circulation. Meybeck et al. [8] found that particulate phosphorus in water is the main form of phosphorus. The suspended particulate matter is released as a medium.

2.2. Heavy metal pollutants
Heavy metals are non-biodegradable and accumulating pollutants [9]. Heavy metals and suspended particles in water are concentrated in sediments by adsorption, complexation and sinking [10], and more than 99% of heavy metals entering water bodies Enriched in sediments in a variety of forms [11]. When the water environment conditions change, the originally enriched heavy metals will be re-released from the sediments, causing secondary pollution of the water bodies and aggravating the bioavailability of heavy metals in the water bodies. The environmental behavior and biological toxicity of heavy metals in sediments are not only related to the total amount of heavy metals, but also to the occurrence of heavy metals. The environmental behavior and biological toxicity of different forms of heavy metals are different. The occurrence of heavy metals in sediments determines their migration release, biological toxicity and potential environmental hazards. Heavy metals such as Hg, Pb and Cd cannot be eliminated by biodegradation and can be transmitted through the food chain to endanger human health. According to the research, with the change of external environment, the heavy metal extracted from the acid in the sediment is more easily released into the water body, which can be used as a short-term ecological risk index to evaluate the heavy metal pollution in the sediment environment [12].
2.3. Persistent organic pollutants

Persistent Organic Pollutants (POPs) are bioaccumulative, highly toxic, long-range and difficult to degrade, and are easily adsorbed on sediments, which is extremely harmful to the ecological environment and human health. The persistent organic pollutants currently studied are mainly Polycyclic Aromatic Hydrocarbons (PAHs), Polychlorinated Biphenyls (PCBs) and Organochloride Pesticides (OCPs). Most of the POPs are hydrophobic organic matter. The hydrophobic organic matter is easily adsorbed to fine particles with a large specific surface area and settles into the sediment environment. Therefore, the sediment is considered to be a “repository” of persistent organic matter [14].

2.4. Microplastic contaminants

As a new type of pollutant, microplastics has received extensive attention from scholars at home and abroad. Plastic particles <5 mm in diameter are called micro-plastics [15]. Micro-plastics have been detected in different degrees around the world, with distribution in all corners of the world, from rivers and lakes to oceans. In recent years, it has been found that both freshwater and marine environments face severe micro-plastic pollution problems, and micro-plastics are also present in water bodies and sediments [16]. Compared with large plastics, microplastics have a higher residual level in the water environment and are more easily ingested by organisms, posing a potential threat to the health of the organism [17]. Microplastics are not only toxic pollutants themselves, but also important carriers of pollutants in water environments. Microplastics can absorb heavy metals, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). These pollutants are rich in living organisms. The collection, which is transmitted along with the food chain, may have a detrimental effect on human health [18]. Unlike other contaminants, microplastics are insoluble in water, exist as particulate matter in water bodies, or settle in sediments. According to existing research, the main place where microplastics occur in water environments is sediments [19].

3. Environmental factors on the release of pollutants in sediments

3.1. Influence of overlying water temperature on pollutant release in sediments

Temperature has an important effect on the re-release of endogenous contaminants in the sediment. Temperature can affect the kinetic process of endogenous pollutant release, which in turn affects the physicochemical conversion rate of endogenous pollutants; temperature can also affect the activity of microorganisms in the water environment and promote the decomposition of pollutants in the water environment. For nutrient elemental pollutants such as nitrogen and phosphorus, when the water temperature rises, the growth rate of plankton and microorganisms increases, so the demand for nutrients such as nitrogen and phosphorus in the water environment increases, and the concentration of nitrogen and phosphorus in the water environment decreases. Small, promote the release of nitrogen and phosphorus in sediments [20]. Micro-plastics are microbial carriers. It has been found that the surface of micro-plastics is covered with a thick layer of biofilm [21], which increases the temperature and promotes microbial activity. Lobelle et al [22] found that surface biofilm can change the buoyancy and viscosity of floating microplastics in water environment, reduce the hydrophobicity of microplastics, and cause microplastics in water environment to settle into sediments; temperature promotes the release of heavy metals The effect, the temperature rise, on the one hand promotes the desorption of heavy metals, the heavy metals on the sediments will be released into the water environment; on the other hand, it affects the solubility of carbonate-bound heavy metals in the sediments, thereby increasing the heavy metals in the sediments into the water environment. Release [23]. For POPs, an increase in temperature also promotes its release. Morgan et al [24] found that the levels of polychlorinated biphenyls (PCBs) re-released from sediments to waters were higher in winter than in winter. Generally, when the temperature rises, the desorption capacity of the deposits to the pollutants increases, and the endogenous pollutants in the sediments are released through the pore water to the water.
3.2. Influence of overlying water salinity on pollutant release in sediments

In aquatic ecosystems such as oceans, bays, and estuaries, the salinity of water bodies is constantly changing and affects pollutants in sediments. Rysgaard et al. [25] found that when the salinity increased, the adsorption capacity of NH4+ decreased significantly. Salinity can affect microbial activity. As salinity increases, ammonia nitrogen and nitrite release will increase, and nitrate release will decrease [26]. Salinity affects the micro-plastic buoyancy and surface biofilm. As the salinity increases, the micro-plastics in the sediment will float up into the water body, increasing the amount of micro-plastics in the water environment. For heavy metals, the competition between alkali or alkaline earth metals and heavy metal ions adsorbed on the sediment increases with increasing salinity, thereby promoting the release of heavy metal ions into the water [27]. For persistent organic matter, an increase in salinity will cause agglomeration of organic matter in the sediment and reduce the desorption process of persistent organic pollutants [28]. Under normal circumstances, the increase of salinity will increase the concentration of nutrients, heavy metals and micro-plastics in water, and the persistent organic pollutants will decrease with the increase of salinity.

3.3. Effect of pH on pollutant release in sediments

The change in pH has an important influence on the release of endogenous pollutants in the sediment. Experimental studies at home and abroad have found that the release rate of nutrient salt changes with the change of pH value, and the release rate of nitrogen and phosphorus nutrients is the smallest under neutral conditions, but increases under acidic or alkaline conditions. [29]. At present, there are few studies on the effect of pH on micro-plastics in sediments, but studies have shown that high pH can promote the degradation of plastics. The increase of pH can increase the adsorption and precipitation of heavy metals, and the decrease of pH will weaken the adsorption of heavy metals. For persistent organic matter, the pH value will change the organic matter structure and solubility of the sediment, and it is beneficial to the adsorption of hydrophobic organic pollutants under low pH conditions [30]. Gao et al. [31] found that organic the amount of chlorinated pesticides adsorbed in the sediment decreases as the pH increases.

3.4. Effect of hydrodynamics on pollutant release in sediments

For aquatic environments such as oceans, rivers, and lakes, hydrodynamic forces cause resuspension of sediments, causing re-release of endogenous contaminants from the sediments into the overlying waters. The hydrodynamic action will increase the shear effect at the sediment-water interface. If the shear force is greater than the critical value, the surface sediment will be resuspended, and the pollutants adsorbed on the suspended particulate matter will enter the overlying water from the sediment. Caused serious "secondary pollution" [32]. Zhu Guangwei and other studies have found that frequent disturbances of heavy winds and waves are the main way to release phosphorus from the body of Taihu Lake, and have an important role in the supply of nutrients before the outbreak of Taihu Lake bloom [33]. As the disturbance intensity gradually increased, the release of nutrients increased sharply. It was found that the resuspension process can cause the concentration of nutrients in water to be as high as tens of times [34]. Studies by Kalneiais and others have shown that the amount of particulate heavy metals released during sediment resuspension is quite large and may be the most important source of heavy metals in water sediments [35]. Kalneiais et al. found that with the increase of hydrodynamic conditions, the particle size of suspended particles in water becomes smaller, and the small particle size has larger specific surface area and cation exchange capacity, and the adsorption capacity of heavy metals is enhanced, and the amount of bound heavy metals in water is increased. Achman et al. found that polychlorinated biphenyls (PCBs) released by resuspension of sediments in the Hudson estuary area of New York State were 2 to 100 times more than external sources such as sewage and atmospheric deposition [36]. The resuspension of sediments caused by hydrodynamic forces releases a large amount of pollutants into the water body, and the amount of pollutants released is far greater than that caused by other environmental factors.
4. Sediment pollution control and treatment measures

The control and treatment measures of endogenous pollution in water sediments are summarized as: prevention and prevention. First, reduce or cut off the input of external sources of pollution, control the external input of pollutants in water bodies, thereby improving the environmental quality of water sediments; second, implement the treatment of contaminated sediments to reduce the toxicity of pollutants in sediments.

4.1. Control of external input and natural purification

The pollution control cost of sediments is relatively high, and the treatment effect is not necessarily ideal. In the light and moderately polluted areas, the pollutants can be reduced to the natural purification process such as dilution, volatilization, adsorption, physical reaction, chemical reaction and biological action of the sediment-water system itself after effectively controlling the input of external pollution. Accepted concentration. For the natural purification ability of water bodies, measures can be taken to strengthen, such as diversion method of water diversion, introducing water from lower nutrients from the lake to reduce the concentration of nutrients in the lake, thereby achieving the purpose of repairing water bodies [37]; enhanced phytoremediation Methods, Zhang Chaolan et al. found a physiological and biochemical response to heavy metal Cd stress in wetland plants [38].

4.2. Physical Repair Technology

Physical restoration generally uses related engineering techniques to remove contaminants directly or indirectly, typically including in situ coverage and dredging [39]. The principle of in-situ coverage is to use the covering material to isolate the contaminated sediment from the overlying water, effectively preventing its resuspension or migration, and limiting the release of pollutants in the sediment [40]. Most of the covering materials required for in-situ coverage are clean deposits, sand or gravel, etc., and in recent years, activated carbon or newly developed materials containing activated carbon have been used as a cover layer. Compared with covering materials such as sandstone, activated carbon cannot only isolate pollutants, but also actively adsorb pollutants in sediments, and more effectively control the release of pollutants into water bodies or absorption by seabed habitats [41]. The use of in-situ cover to repair contaminated sediments, although simple to operate, can be applied on a large scale, but because this method not only reduces the water depth, but also is destructive to benthic activities, since the pollutants are still present in the water environment, This method is therefore not suitable for the repair process of all contaminated deposits.

Dredging repairs generally use mechanical methods to directly remove contaminated sediment. When measures such as the self-purification ability or the covering method of the water body cannot effectively control the release of the pollutants to the water body, the contaminated sediments must be dredged and repaired. Dredging is only used when the sediment is seriously polluted. The cost of dredging is very expensive, but the amount of pollutants can be quickly reduced by dredging.

4.3. Chemical repair technology

Chemical repair refers to the addition of chemical reagents to contaminated sediments. A series of oxidation, reduction and precipitation polymerization of chemical reagents and pollutants cause the pollutants in the sediment to be separated or combined into low toxicity or no toxic substances [42]. Chemical repair mainly includes leaching method, chemical passivation method, vitrification method and the like. The rinsing method generally involves injecting or injecting the eluent into the deposit to promote the release of the contaminant, and then extracting the solution containing the contaminant for subsequent treatment. The leaching method is mainly applied to the remediation of freshwater environment sediments such as rivers and lakes. It is easy to operate, has fast treatment effect and low cost, and can deal with various pollutants such as petroleum, heavy metals and persistent organic pollutants [43]. Chemical passivation is to reduce the environmental impact of contaminated deposits by adding chemical agents to the surface of contaminated sediments to convert contaminants in the sediments to make them harmless or solidified.
5. Conclusion
The release process of endogenous pollutants in sediments is a hot topic of research, and domestic and foreign scholars have carried out a lot of work. However, the release of sediment from endogenous pollution is a very complicated process, and there are still many problems to be solved. This paper reviews the work of predecessors on the types of pollutants in sediments, the factors affecting the release of pollutants, and related repair techniques. In view of the current shortcomings and future research directions, the following work can be carried out from the following aspects:

(1) Advance research on the release process of multi-pollutant complex pollutants. For the release process of pollutants in sediments, research on single pollutants is still ongoing. In practice, sediments contain a variety of pollutants (nutrient salts, heavy metals, micro-plastics, persistent organic pollutants, etc.), and the relationship between them is very complicated for the re-release of endogenous pollutants. There is a lack of coexisting release process research. Therefore, in future research work, it is necessary to strengthen the research on the release of pollutants and environmental effects by the complex effects of multiple coexisting pollutants.

(2) Strengthen the study of re-release of endogenous pollutants under the coupling of various environmental factors. The re-release of endogenous pollutants in sediments is caused by factors such as temperature, salinity, pH, hydrodynamics, etc., and the relationship between them is very complicated. At present, the main factors for environmental factors are still single element and qualitative evaluation. There are few studies on the coupling effect of multiple impact factors and the quantitative evaluation of pollutants. Therefore, in the future research work, it is necessary to strengthen the study of the coupling of multiple influence factors on the release of endogenous pollutants.

(3) Optimize the repair technique according to the release process. The study of sediment release from endogenous pollution is to better control the release of endogenous pollution and reduce the pollution caused to water bodies. According to the research results, it provides better scientific support for on-site pollution control and repair technology, improves the efficiency of pollutant treatment, reduces secondary pollution caused by the treatment process, and reduces the difficulty of sediment restoration.

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