

Study on the Water Ecology Protection and Water Environment Remediation Technology, focusing on the heavy metal removal

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Abstract. Water environmental pollution has become a growing problem with the increase in pollutants released because of the expansion of human activities. Since water is peculiarly susceptible to pollution, water pollution control has garnered copious attention among the most crucial environmental conundrums. Therefore, water environment remediation is not only of great significance for river ecology, but also of theoretical and practical importance for sustainable human development. China's central government passed the Yangtze River Protection Law in response to the need for changes in governance arrangements and cooperation. The purpose of this study is to explore the technology of heavy metal treatment in water environment remediation, to study and solve a series of problems such as water ecological maintenance methods, river desilting, and water body renewal. This paper will analyze the benefits of water environment remediation technologies and explore their potential for sustainable development, focusing on the removal of heavy metals from water body.

1 Introduction

The Yangtze River, as a large water ecosystem, is home to a diversity of biological species, thus providing a huge ecosystem for organisms. As China's longest river, the Yangtze River's ecosystem is rich in biodiversity and contributes to the continuation of human survival and sustainable development. The water environment is of great significance to human survival. With industrial development river ecosystem health indices are deteriorating, and an increasing number of the 4,300 species are at highly depleted or endangered levels, there's no shortage of endangered animals and plants among those 4,000 species. The biological resources of the Yangtze River, especially the number of fish species, still show imperfections, while the fishing trend in the Yangtze River Basin has not declined significantly. the recovery of the Yangtze River's fishery resources has so far been insufficient in terms of catch trends, dolphin population status and fish biotic integrity indices. In order to respond positively to the integrated monitoring data implemented while advancing the process of improving ecosystem health, it is necessary to enhance the effectiveness of coordinated governance. There is a need to integrate Yangtze River governance with water

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and environmental remediation techniques to manage the Yangtze River water environment and protect water resources and biodiversity.

In order to strengthen its efforts to protect the water ecology of the Yangtze River Basin, China has released a number of conservation policies. In 2018, a new policy document set phased goals: the initial phase focuses primarily on introducing a year-round fishing ban in parts of this region; while the long-term goal, set for 2035, aims to restore the river's ecology, ensure the effective protection of habitats, promote the growth of aquatic biodiversity, and restore the water body's ecological functions [1].

To improving the efficiency of river training, different river training methods should be used for different rivers, to avoid the inefficiency caused by the wrong methods. Aeration is one of the widely used techniques in physical technology because of its ability to increase the rate of degradation of organic pollutants in rivers and increase biological activity. Physical techniques are effective but costly and harmful to riverine water environment. Although chemical treatment can solve the problem in the short term, it should be improved because of its high cost and the risk of secondary pollution of the environment caused by chemical substances. Ecological engineering methodologies possess the merits of elevated economic, environmental, and ecological efficacy, coupled with straightforward sustainability and the absence of secondary contamination. There is some variability between the performance of artificial wetlands, microbial injections, eco-floating beds and biofilm technologies, but all are among the most widely used ecological technologies. Artificial wetlands have a good regulating effect when the water quality is less polluted and the hydraulic load is smaller [2].

Various water environment remediation technologies can well improve the water environment, improve the biodiversity and protect freshwater resources. The most suitable water environment remediation technology should be selected according to the specific analysis of different rivers in different situations. Among the many environmental problems, water pollution in rivers poses a very serious challenge, especially in developing countries and less economically developed regions. Rivers are not only the main source of drinking water for the population, but also support a wide range of needs, including domestic use, agricultural irrigation, commercial operations, industrial production and recreation. However, rivers in some countries have lost their use due to high levels of pollution. Worse still, this pollution contributes to the spread of numerous waterborne diseases in developing countries, releasing intolerable odors and further polluting air quality. Effective management of water quality relies on strict policy regulation of solid waste, wastewater discharges and stormwater runoff, as well as clear standards for the treatment of wastewater. Successfully addressing water pollution in rivers, however, requires both financial investment and time.

Heavy metals are very harmful to water bodies, not only to aquatic organisms but also to human health. Heavy metal pollutants can accumulate in water bodies and pose a threat to the growth, reproduction and survival of aquatic organisms. For example, heavy metals such as Cd and Pb can affect the reproductive and nervous systems of fish, leading to deformities and death. In addition, heavy metals are also enriched in living organisms through the food chain, which in turn can cause harm to higher-level organisms. Heavy metal pollutants will change the physical and chemical properties of water bodies, affecting their self-purification ability; at the same time, heavy metals will also accumulate in the soil, affecting the structure, fertility and microbial communities of the soil, which will in turn affect the growth and yield of crops. In the field of environmental pollution, several heavy metal elements and the metalloid arsenic are of great concern because they are difficult to degrade in the environment, are enriched, and may enter the human body through the food chain, posing a hazard to human health. Levels of heavy metals and other toxic substances in water are increasing as a result of increasing discharges from both natural and anthropogenic sources. Excessive intake of heavy metals by individuals can exacerbate cellular responses triggered by oxidative stress,

which can increase the probability of developing tumors, neurological disorders, diabetes mellitus, infertility, developmental delays, renal impairment and cardiovascular diseases [3].

The purpose of this treatise is to elucidate the contamination of aquatic milieu, while also presenting rectification methodologies predominantly aimed at heavy metals within the aquatic environment, and elucidating their pivotal function in the rehabilitation of river systems.

2 Principles of water environment remediation technology

There are various methods of treating polluted river water, and more than one method is usually used to treat river water [4]. This is because using only one of these methods often fails to address multiple causes of polluted river water or to effectively clean up heavily polluted river water. Therefore, the use of hybrid technologies, which incorporate several different approaches, can address a wider range of problems and show greater effectiveness in treating polluted river water. Given this context, it is advisable to advocate for the employment of amalgamated methodologies for the purification of fluvial waters. The primary technologies presently utilized for addressing high concentrations of heavy metals encompass microfiltration, chemical precipitation, coagulation, and flocculation [5]. The process of wastewater purification can be delineated into three phases: primary, secondary, and advanced treatment. During the primary phase, both physical and chemical modalities are applied to eliminate pollutants from the wastewater. The secondary phase consists of anaerobic or aerobic biodegradation. The advanced treatment encompasses methodologies such as chemical oxidation, electrochemical deposition, crystallization, distillation, and photocatalysis, along with adsorption, membrane separation techniques, and ion exchange processes.

When tertiary treatment is fully integrated with primary and secondary treatment, removal efficiencies of up to 99% can be achieved [6]. Heavy metal removal methods can be categorized as adsorption, chemical precipitation, coagulation-flocculation, ion exchange, and membrane technology. In adsorption, because of the porous nature of the organic or inorganic material in the adsorbent, it is capable of adsorbing large amounts of heavy metals. Adsorption is considered to be one of the best choices for the heavy metal removal [7].

2.1 Adsorption

Adsorbents that can be used as adsorbents are generally inorganic materials from nature or biomass, such as fly ash, treated tree sap, zeolites and microorganisms. Activated carbon, which is made from a variety of different materials capable of providing microbial carbon, is the most common adsorbent used by the general public today. Only biosorbents with high adsorption capacity and low preparation cost are considered for heavy metal removal. Nano adsorbent materials synthesized using minerals and organic matter can completely adsorb and remove heavy metal ions from wastewater [8].

2.1.1 Nanomaterials

Fig.1 shows the keywords of the literature related to nanomaterials and heavy metals in recent years, from which it can be seen that nanomaterials play a crucial role in this field, and they have a great contribution to sewage treatment, thus realizing the water environment remediation. This not only helps to reduce the heavy metal content of sewage, but also

provides new ideas and solutions for sustainable development and promotes the efficient recycling of resources.

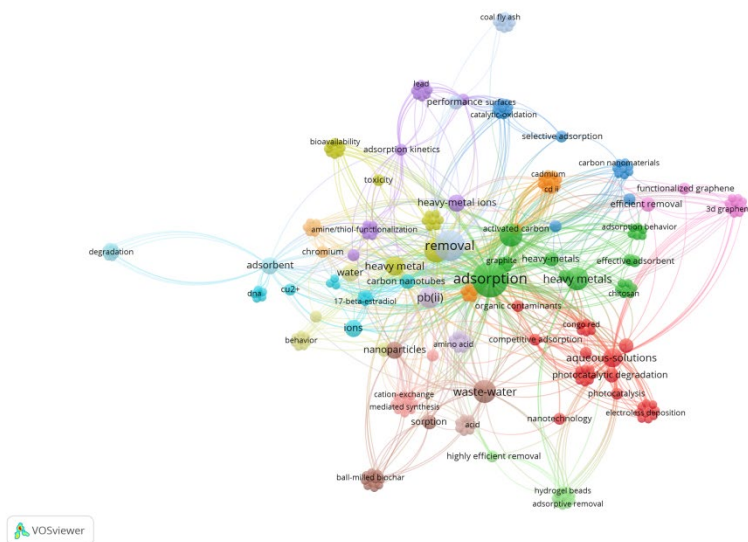


Fig. 1. Keyword map of nanomaterials synthesized with adsorbed heavy metal articles (Photo/Picture credit: Original)

2.1.2 The role of nanomaterials in adsorption

Because nanomaterials generally have a large total surface area per unit volume of material, they adsorb well. Nanoparticles, with their uniquely high specific surface area, have demonstrated a wide range of compelling and innovative applications in a variety of disciplines. The principle of adsorption of heavy metals in the aqueous environment by nanomaterials is to adsorb pollutants using different types of nanoparticles that compose themselves, such as bimetallic, metallic, carbonaceous, metal oxides and zeolites. Much effort has been invested in the use of nanomaterials to treat wastewater. Once the adsorbent has adsorbed the hazardous substances in the wastewater, the adsorbent can be reused after some treatment of the adsorbent, thus making the cost of water adsorption remediation lower and more sustainable. Tests have shown that after 8 rounds of reuse of the adsorbent, a removal rate of about 87% can be achieved[9]. The results of the study show that nanosorbents because of their high specific surface area and reusability, nanomaterials have a strong adsorption capacity for heavy metal ions. So far, a wide variety of nanomaterials such as nanorods, nanorings and nanotubes have been tested in the adsorption of heavy metal oxides [10]. Although nanomaterials are very good adsorbents, they have certain drawbacks, such as expensive material costs, limited reuse potential, and harm to human health.

2.2 Separation of heavy metals

Chemical precipitation (i.e., coagulation and sedimentation) is widely used in industry and is one of the most effective and proven methods. The principle is simply summarized as adding a precipitating agent to the wastewater, which is heavy metal ions precipitated and thus removed. The main methods are hydroxide precipitation, sulfide participation and carbonate precipitation. Among them, hydroxide precipitation is widely used because of its relative

cheapness and simplicity. Sulfide precipitation removes more heavy metal ions and is more efficient in remediating wastewater. It has been shown that sulfide precipitation can remove toxic heavy metal ions, but this method produces bad odor and toxic hydrogen sulfide gas, so sulfide precipitation is recommended to be carried out under neutral conditions [11].

3 Conclusion

Various methods for removing heavy metal ions from wastewater, and in this paper nanomaterial adsorption and chemical precipitation is analyzed. In adsorption, nanomaterials have been widely adopted as adsorption media for pollutants in water and wastewater treatment for their excellent surface area-to-volume ratios and efficient reuse properties. In addition, their strong adsorption efficacy for heavy metal ions further establishes their preferred status as promising technological solutions for sewage remediation. Although nanomaterials have many advantages, their disadvantages are also more obvious. One is that nanomaterials are less commercially available, making them less applicable and underutilized. The second is the sustainability of nanomaterials, more green synthesis methods of nanomaterials should be explored in the future to synthesize environmentally friendly and economically sustainable materials. As an emerging field, nanomaterials have a broad application prospect in wastewater treatment.

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