Treatment of Heavy Metal Pollution in Sediment and Its Resource Utilization in Building Ceramics

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Abstract With the rapid development of China's social economy and the acceleration of urbanization, a large quantity of production and domestic sewage is discharged into rivers and lakes, and the concentration of pollutants leads to serious excessive heavy metals in sediment, which affects the ecological environment. In this paper, the treatment technology of heavy metal pollution in sediment and its resource utilization in building ceramics in China are systematically analyzed and summarized, in order to provide a reference for the treatment of sediment in rivers and lakes and the sustainable development of building ceramics industry.

Key words Sediment, Building ceramics, Resource utilization, Research progress

1 Introduction

In recent years, with the rapid development of social economy and the acceleration of urbanization in China, a large quantity of polluted industrial wastewater and domestic sewage has been discharged into rivers and lakes, resulting in serious pollution of water environment, while a large number of pollutants in water gather in sediment, resulting in serious over-standard heavy metal content in sediment, and the polluted sediment will cause secondary pollution of water body due to the change in environmental conditions, thus destroying water ecological environment.

At present, with the continuous advancement of urbanization in China, the market demand for building ceramics is increasing day by day. With the continuous mining of existing kaolin, natural mud and other raw materials, regional environmental pollution is caused, especially the mining of kaolin tailings has caused environmental pollution and a large number of potential safety hazards[1]. Against this background, the resource utilization of sediment in building ceramics has attracted wide attention of scholars at home and abroad. The resource utilization of sediment in building ceramics can not only realize the treatment of heavy metal pollution in sediment and the protection of water ecological environment, but also effectively reduce the demand for natural resources in building ceramics industry and alleviate the environmental pollution problems caused by resource exploitation, which is of great significance to the protection of water ecological environment and the sustainable development of building ceramics industry[2].

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2 Research progress of heavy metal pollution in sediment and its treatment technology

2.1 Current situation of heavy metal pollution in sediment in China In recent years, many domestic scholars have studied and analyzed the current situation of heavy metal pollution in sediment of important reservoirs or rivers and lakes, and it is generally found that the heavy metal contents in sediment of reservoirs obviously exceed the standard, especially in reservoirs seriously affected by industrial sewage. The research of Fan Chengxin *et al.* found that Cd pollution in lake and reservoir sediments in China was the most serious, and it even reached moderate or severe pollution level[3]. In the sampling investigation of a reservoir in Guangdong, Linyi Reservoir and 132 large and medium-sized reservoirs in Ganjiang River Basin, it was found that there was a risk of heavy metal pollution in reservoir sediment, and Cd, Mn, Cu and so on exceed the standard, posing a certain threat to human life and the survival of animals and plants[4-6]. Therefore, it is extremely urgent to control the heavy metal pollution in sediment, and it is of great significance to realize the resource utilization of sediment.

2.2 Main technologies for treatment of heavy metal pollution in sediment According to the remediation theory of heavy metal pollution in sediment, the existing sediment treatment technologies can be roughly divided into two categories according to the remediation location: *in-situ* remediation and *ex-situ* remediation. *In-situ* remediation is a technology that directly adopts comprehensive means to treat sediment without moving it; *ex-situ* remediation is a technology of transporting polluted sediment from river channel and then treating it. In practice, *ex-situ* remediation has the characteristics of high input cost, so *in-situ* remediation is more widely used.

2.2.1 *In-situ* remediation technology. *In-situ* remediation technology refers to the treatment of sediment directly in contaminated sites to reduce the pollution of sediment to water, and it can be divided into *in-situ* physical remediation technology, *in-situ* chemical remediation technology and *in-situ* bioremediation technology.

(i) *In-situ* physical remediation technology. At present, the common *in-situ* physical remediation technologies mainly include capping remediation technology and electric remediation technology. Capping remediation technology uses covering materials to separate sediment from the water above, so as to inhibit the release of heavy metals from sediment to water[7], but it will reduce the water depth and water capacity of reservoirs, rivers and lakes. Electric remediation technology is a fast and efficient *in-situ* green remediation technology. By putting sediment pollutants into an electrolysis device with cathode and anode, a series of electrochemical reactions are carried out by using electric field, and then the electrodeposition or ion exchange extraction of heavy metal ions or compounds in the electrode area is realized, so as to achieve the effect of removing heavy metals from sediment, and it has a good application prospect[8]. (ii) *In-situ* chemical remediation technology. *In-situ* chemical remediation technology uses chemical reagents to react with the sediment at the bottom of the river to separate, fix pollutants in the sediment or transform them into non-toxic chemical forms, thus reducing the diffusion and migration ability and toxicity of heavy metals in the sediment[9]. At present, the reagents with good remediation effect used in this technology mainly include calcium polysulfide, ferrous sulfate, sodium dithionite, *etc.*[10], but the dosage of reagents should be carefully treated in practical application to avoid the potential harm of inappropriate reagents or dosage to regional water ecological environment, which makes the *in-situ* chemical remediation technology have certain limitations. (iii) *In-situ* bioremediation technology. *In-situ* bioremediation technology refers to the purification of heavy metal pollutants in sediment by microbial reagents or aquatic animals and plants under certain conditions. The *in-situ* bioremediation technology has the advantages of convenient operation, low price and little environmental interference. However, whether it is animal, plant or microorganism, as long as it exceeds the maximum tolerance of heavy metals, the effect of ecological restoration will be reduced, and even there will be counterproductive effect[11].

2.2.2 *Ex-situ* remediation technology. The *ex-situ* remediation technology refers to the removal of sediment pollutants from the original positions in rivers or lakes and reservoirs, and it can be divided into on-site remediation and off-site remediation. Compared with *in-situ* remediation technology, this technology has certain operability and controllability in engineering, and has certain advantages for small polluted areas, but it may cause secondary environmental pollution in the remediation process[10]. At present, *ex-situ* remediation technology has been applied in many engineering cases at home and abroad, which provides experience for the combination of *ex-situ* remediation technology and other technologies.

3 Progress in resource utilization of sediment in building ceramics

At present, the ceramic industry consumes an average of 2.8 billion t of raw materials and 48.7 million t of coal for production every year[12]. This large amount of energy consumption is obviously contrary to the concept of ecological civilization construction and sustainable development in China. The composition of sediment is the same as that of clay, and it can replace clay to produce ceramic, ceramsite and other materials, and its resource utilization can boost the sustainable development of the ceramic industry. For this reason, local governments in China have successively issued relevant policies to support the reform and development of this industry. For example, the 13th *Five-Year Development Plan of New Wall Materials in Zhejiang Province* issued in 2016 clearly pointed out that it is necessary to adhere to green development and actively carry out demonstration and promotion of silt resource utilization. Since the release of the plan, some enterprises in Zhejiang Province have successfully realized large-scale utilization of silt resource utilization[13]. At the same time, many scholars in China have also carried out research on the resource utilization of sediment in building ceramics and achieved rich results. For example, Mao Rui *et al.* found that a certain amount of dredged silt in combination with natural clay was used to prepare building ceramics, the proportion of dredged silt used was as high as 20%, which realized the reuse of resources and considerable economic benefits[14]. The research of Xiao Jibo *et al.* showed that high-efficiency phosphorus-removing sediment ceramsite could be obtained under certain conditions by mixing river sediment with pore-forming agent *Cyperus involucratus* Rottboll, coal granules, cement and water. The prepared sediment ceramsite not only had certain phosphorus removal ability, but also effectively reduced the required cost, so it was one of the suitable sediment resource utilization schemes[15].

4 Conclusion

(i) The internal components of sediment pollutants are complex, and may cause secondary pollution to the water ecological environment in the treatment process. Therefore, it is necessary to comprehensively utilize a number of technical means to reduce the potential risks of sediment pollution treatment. (ii) To build a beautiful and livable ecological environment and realize sustainable development, dredging and resource utilization of river and lake sediment is one of the important ways. To realize resource utilization of sediment, it is necessary to promote resource utilization of sediment in building ceramics on the basis of sediment pollution control, combined with sediment characteristics and siltation trend. (iii) The resource utilization of sediment in building ceramics needs the support of building ceramics enterprises, and the development of building ceramics enterprises can not be separated from local policy support. Local government departments need to strengthen their support to building ceramics enterprises, especially to increase the policy support to resource utilization of sediment in building ceramics.

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derivative forms such as domestic service, package + property service and child care service, which can provide more intimate, convenient and comfortable services and meet the diversified needs of the elderly[9].

(vii) Personnel training: The service personnel of the elderly care are the key factors of industrialization development. It is necessary to strengthen their training and education, improve their professional skills and service awareness, and establish a sound service standard and assessment system to ensure the quality of life and safety of the elderly. The government can formulate targeted training plans, and carry out training courses through trade associations, vocational skills training institutions, universities, *etc.*, so as to improve the professional quality of the elderly care service personnel. Enterprises can also attract and retain outstanding talents by career development planning, professional skills training and working environment improvement, so as to improve the overall quality of the elderly care service industry.

(viii) Capital investment: government and social capital can be invested in the elderly care industry in various ways, such as encouraging enterprises to invest in the construction of elderly care projects. The government can also guide social capital to invest in the elderly care industry, and establish financing tools such as elderly care industry investment funds and elderly care industry trusts to improve the rate of return on capital. At the same time, the government can increase financial subsidies to elderly care service enterprises, and encourage enterprises to increase investment and improve service level.

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