10.70711/eph.v2i3.5758

Innovative Technologies for Sustainable Water Treatment in Environmental Protection

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Abstract: Water treatment technology is faced with problems such as low efficiency, high energy consumption and incomplete pollutant removal of traditional methods, which need to be solved by innovative technology. New membrane technology and efficient adsorption materials provide an effective solution for sustainable water treatment. Membrane technology can remove a variety of pollutants, improve water treatment efficiency and reduce energy consumption. Efficient adsorption materials use physical and chemical adsorption to effectively remove harmful substances in the water and ensure the safety of water quality. Through multi-technology collaborative treatment and optimization under the concept of circular economy, the water treatment process can achieve higher resource utilization efficiency and lower environmental burden.

Keywords: Water treatment technology; Membrane technology; Adsorption materials; Multi-technology collaboration; Circular economy

Foreword; Introduction

The discharge of wastewater, agricultural non-point source pollution in the process of industrialization have increased the difficulty of water quality control. In order to ensure the sustainable utilization of water resources and environmental protection, it is urgent to explore new water treatment technologies. Innovative water treatment technologies, such as new membrane technologies and highly efficient adsorption materials, provide an effective way to solve these problems. In addition, the optimization strategy combined with the multi-technology collaborative treatment mode and the concept of circular economy can improve the effect of water treatment while reducing the treatment cost and environmental burden. To explore the application and effect of these innovative technologies in water treatment, to provide technical support for the sustainable utilization of water resources.

1. Status quo and existing problems of water treatment technology

Traditional physical and chemical water treatment methods, coagulation precipitation, activated carbon adsorption and conventional filtration, although can remove most of the pollutants in the water, but its treatment efficiency and adaptability is insufficient, it is difficult to deal with the complex water quality and multiple pollutants.[1] These methods are often accompanied by high energy consumption, chemical agent consumption and waste treatment problems in the treatment process, resulting in a large environmental burden. In addition, it has been difficult for existing technologies to efficiently remove trace harmful substances in water, such as drug residues, heavy metals and organic pollutants, especially in industrial wastewater and agricultural runoff, which is particularly unsatisfactory. The existing water treatment facilities have low scale and standardization, and the lack of customized solutions for different pollution sources and regional characteristics leads to the unstable water treatment effect.

2. Innovative specific application and solutions of water treatment technology

2.1 Application of the new membrane technology in water treatment

Membrane technology mainly includes reverse osmosis membrane, ultrafiltration membrane, nanofiltration membrane and microfiltration membrane, which are applied to different processing links according to the different pore size size and separation mechanism. Reverse osmosis membrane technology is the core method to remove soluble salts, heavy metal ions and other trace pollutants in water. In the process of reverse osmosis treatment, water molecules are driven through the semi-permeable membrane by applying high pressure, and the soluble solids and pollutants are blocked. The new reverse osmosis membrane is made of composite materials or nanomaterials, which has higher water permeability and pollution resistance, effectively reducing energy consumption and operation cost. Nanofiltration membrane is used to remove small molecular organic matter and bivalent and above ions, which is outstanding in the preparation of drinking water and wastewater reuse. The new nanofiltration membrane has added a multilayer polymer coating in the manufacturing process, which improves the selectivity and antioxidant properties, while enhancing the high temperature and acid and alkali resistance. Ultrafiltration membrane and microfiltration membrane are mainly used in the pretreatment stage, removing suspended matter, bacteria in the water and some viruses through physical interception. The modified ultrafiltration membrane adopts the gradient aperture structure, which reduces the risk of blockage and extends the service life of the membrane. The practical application of membrane technology requires the rational design and optimization of the system. It includes the installation of multistage membrane components to improve the treatment capacity and stability in series or parallel, and the online cleaning equipment and the combination of chemical cleaning and physical washing to reduce the risk of membrane contamination. In the fields of industrial wastewater treatment, reclaimed water reuse and seawater desalination, the new membrane technology has become an important tool to solve the problem of water treatment with its excellent removal efficiency and economy.

2.2 Water pollution treatment technology of highly efficient adsorption materials

As a traditional adsorption material, activated carbon has a large specific surface area and excellent adsorption capacity, but the removal effect of some trace pollutants and specific compounds is limited.[2] Nanoadsorption materials and functionalized adsorption materials have become a research hotspot, such as the use of nano iron oxide to treat heavy metal pollution, and the efficient removal by relying on its strong adsorption with metal ions. The preparation of adsorbed materials is a key step to improve the performance. By modifying the activated carbon, the number and type of the surface functional groups of the activated carbon are enhanced to make it more excellent in the removal of polycyclic aromatic hydrocarbons and halogenated organic compounds. Bio-based materials, such as chitosan and cellulose, can be used as an efficient adsorbent to treat dye and drug residues in water. Moreover, composite adsorbents achieve the synergistic removal of multiple pollutants by combining metal oxides and organic polymers. The specific application process of adsorption technology includes the addition and separation and recovery of adsorbent. In wastewater treatment facilities, the adsorbent has full contact with pollutants by operating through batch injection or fluidized bed reactor. To improve the adsorption efficiency, the residence time of the water flow and the specific surface area of the adsorbent are usually optimized. The saturated materials are recycled through pyrolysis, chemical regeneration and other ways. With the application of dynamic adsorption tower, continuous and automatic pollutant treatment can be realized, and the water treatment efficiency can be greatly improved.As shown in Figure 1:

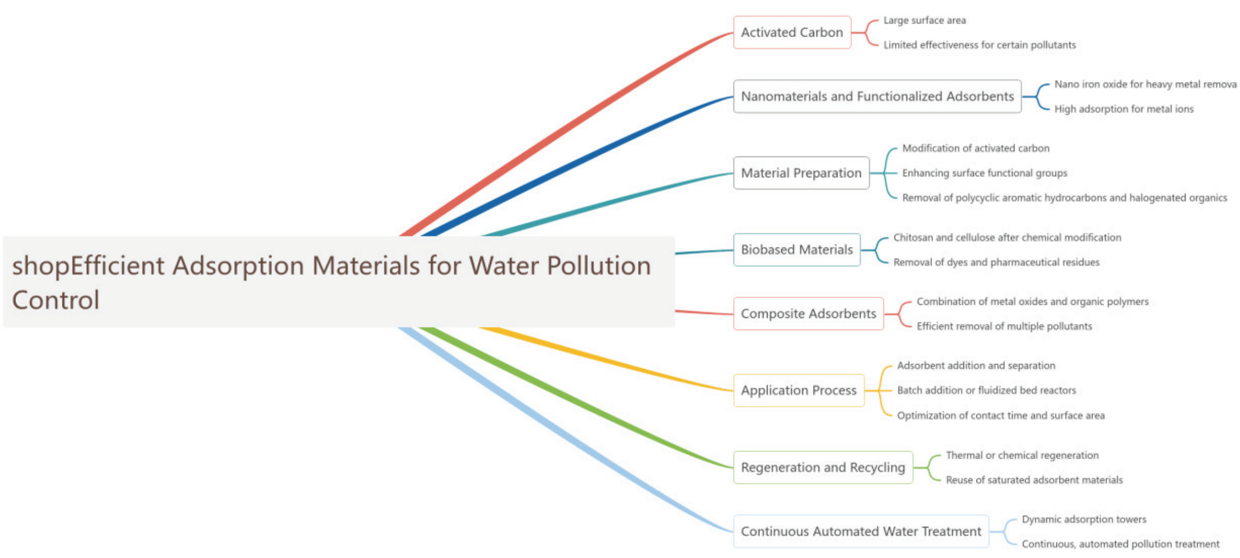

Figure 1. Efficient Adsorption Materials for Water Pollution Control

3. Integration and optimization of sustainable water treatment technology

3.1 Advantages of multi-technology collaborative processing mode

Through the combination of membrane filtration, adsorption, REDOX and other technologies, the multiple removal of various pollutants in the water can be realized. In wastewater treatment, large particles are first removed by physical or chemical precipitation, then membrane technology is used to remove fine particles and soluble substances, and finally adsorption or oxidation technology is used to remove organic pollutants and trace heavy metals in the water. This mode can flexibly adjust the combination of different technologies according to the water quality change to optimize the treatment effect.

3.2 Optimization of the water treatment system under the concept of circular economy

By implementing a closed-circuit circulation system, the treated water body is reintroduced into the production process, reducing the dependence on fresh water resources and reducing the wastewater discharge.[3] The key to system optimization is to improve the water quality of reuse water, and adopt multi-stage filtration, reverse osmosis and ultraviolet disinfection processes to ensure that the reuse water meets the water quality requirements of different applications. In addition, through the integration of waste heat recovery technology, the energy consumption in the water treatment process can be reduced, the energy utilization efficiency is improved, and the dual saving of water and energy is realized. This model not only improves the utilization rate of water resources, but also reduces the environmental burden in industrial production, providing a sustainable solution for the water treatment industry.

4. Epilogue; Peroration

The development of sustainable water treatment technology provides practical solutions for the efficient utilization of water resources and environmental protection. The application of new membrane technology and efficient adsorption materials has greatly improved the water treatment efficiency and pollutant removal ability, especially when showing obvious advantages in dealing with complex pollutants. Through multi-technology collaborative treatment and system optimization, the water treatment process is not only more efficient, but also can reduce energy consumption and resource consumption, and promote the recycling of water resources. The continuous progress and optimization of these technologies provide more possibilities for the future development of the water treatment field, helping to achieve the dual goals of environmental protection and sustainable utilization of resources.

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