Activated carbon used in the wastewater treatment industry

In the field of wastewater treatment, activated carbon is widely employed for water quality improvement and pollutant removal due to its superior adsorption properties. COD, serving as a critical indicator of water body pollution severity, directly influences water quality in terms of its value. Consequently, whether activated carbon can reduce COD levels, and under what specific conditions activated carbon should be utilized for COD treatment, has become a pivotal issue in wastewater management.

Wastewater treatment technologies can be classified into three categories based on their mechanism: physical, biological, and chemical methods.

Yunchneg

① Physical methods: These primarily utilize physical processes to separate non-dissolved substances from wastewater, without altering their chemical properties during the treatment process.

② Biological treatment: Utilizing the metabolic capabilities of microorganisms to decompose and oxidize dissolved or colloidal organic compounds in wastewater into stable inorganic substances, thereby purifying the wastewater.

③ Chemical treatment: This method utilizes chemical reactions to treat or recover dissolved or colloidal substances from wastewater; it is commonly applied to industrial wastewater.

Brief Introduction to Wastewater Treatment Technologies

Primary treatment: This stage primarily removes suspended solid pollutants from wastewater; most physical treatment methods can only fulfill the requirements of primary treatment. After undergoing primary treatment, the BOD of the wastewater typically decreases by approximately 30%, which still falls short of the discharge standards. Primary treatment serves as pre-treatment for secondary treatment.

Secondary treatment: Primarily removes colloidal and dissolved organic pollutants (BOD and COD) from wastewater, achieving a removal rate exceeding 90%, thereby ensuring that organic pollutants comply with discharge standards; the removal rate of suspended solids reaches 95%, resulting in high-quality effluent.

Yunchneg

Tertiary treatment: further treatment of recalcitrant organic compounds, as well as soluble inorganic substances—such as nitrogen and phosphorus—that can cause eutrophication of water bodies. Primary treatment methods include biological nitrogen and phosphorus removal, coagulation and sedimentation, sand filtration, activated carbon adsorption, ion exchange, and electrodialysis.

I. COD Removal Efficiency of Activated Carbon

Activated carbon is commonly used in wastewater treatment to reduce COD, particularly when treating recalcitrant organic compounds, where its effectiveness is especially pronounced.

Adsorption mechanism of activated carbon: The primary principle of contaminant removal by activated carbon is the adsorption of organic compounds from water via its abundant micropores and mesopores on its surface. Due to the strong interaction forces between the organic compounds and the activated carbon, these compounds are adsorbed onto the surface or within the pores of the activated carbon, thereby reducing the COD value of the water.

Yunchneg

Factors affecting COD removal efficiency: The COD removal efficiency of activated carbon is influenced by a variety of factors, primarily including:

1. Types of activated carbon: Activated carbon of different shapes (e.g., column-structured activated carbon, granular activated carbon, and powdered activated carbon) exhibits distinct pore size distributions and adsorption properties; consequently, their COD removal efficiencies also vary, with powdered activated carbon demonstrating the highest removal rate.

2. Adsorption time: The adsorption process of activated carbon is a dynamic one; typically, as the adsorption time increases, the removal

efficiency gradually rises, but after a certain duration, it tends to reach saturation, at which point it can no longer effectively remove COD.

3. pH value: The acidity or alkalinity of the water significantly influences the adsorption efficiency of activated carbon. Generally, activated carbon exhibits optimal adsorption performance in a weakly acidic to neutral environment.

4. Temperature: An increase in temperature typically enhances the adsorption rate of activated carbon; however, excessively high temperatures may disrupt the structure of the activated carbon, thereby reducing its adsorption capacity.

5. Activated carbon dosage: The dosage of activated carbon directly determines its COD removal efficiency. When the COD concentration is high, it is necessary to increase the activated carbon dosage to improve the removal rate.

Yunchneg

6. Mixing time: Stirring ensures that pollutants in the water have sufficient contact with the activated carbon, thereby enhancing adsorption efficiency.

II. Applicability of Activated Carbon Under Different COD Levels

Although activated carbon can effectively reduce COD, its applicability is not unlimited. In fact, the COD removal efficiency of activated carbon is closely related to the COD concentration in the

wastewater. When treating wastewater with high COD levels, relying solely on activated carbon may result in excessively high costs; therefore, the specific COD level must be carefully considered when selecting activated carbon for use.

When the COD value is relatively low (50–500 mg/L): For wastewater with low COD levels, activated carbon is a suitable treatment option. In such cases, the organic matter in the water is moderately difficult to degrade, yet this does not lead to excessively high activated carbon operating costs. Therefore, employing activated carbon under these conditions can effectively reduce COD while maintaining relatively economical treatment costs.

Yunchneg

When the COD value is high (>500 mg/L): If the COD concentration in the wastewater is high, relying solely on activated carbon for COD removal will significantly diminish its effectiveness. Under such conditions, the adsorption capacity of activated carbon will gradually approach saturation, and treatment costs will rise sharply. Therefore, for wastewater with a COD value exceeding 500 mg/L, it is generally necessary to combine activated carbon with other treatment methods (e.g., oxidation treatment, membrane filtration, biological treatment, etc.) to enhance overall treatment efficiency while reducing costs.

III. Optimal Operating Window for Activated Carbon in COD Removal

Given the degradation characteristics of organic compounds in water, activated carbon is commonly employed in the downstream stages of wastewater treatment—particularly in the final treatment phases—to further remove recalcitrant organic compounds from the water. Below are several key considerations regarding the application of activated carbon in wastewater treatment:

Pre-treatment stage: When the COD value is high, it is often necessary to first employ physicochemical methods (such as coagulation, sedimentation, or membrane filtration) for pre-treatment to reduce the COD concentration and alleviate the load on subsequent activated carbon treatment.

Yunchneg

Post-treatment stage: Once the readily degradable organic matter in the water has been biodegraded or removed by other means, activated carbon can be employed to further remove recalcitrant organic compounds, thereby optimizing water quality and reducing the COD value to an appropriate range.

Advanced treatment stage: In industries or regions where extremely stringent COD discharge standards must be met, activated carbon can be incorporated as part of the advanced treatment process to ensure that the

effluent quality complies with rigorous environmental protection requirements.

IV. Recommendations for the Application of Activated Carbon in COD Removal

The adsorption properties of activated carbon enable it to play a crucial role in wastewater treatment, particularly in the removal of recalcitrant organic compounds. However, the decision to employ activated carbon and the appropriate timing for its application should be based on a rational assessment of the COD concentration of the wastewater. For wastewater with a COD value ranging from 50–500 mg/L, activated carbon is an optimal choice as a final treatment step; however, when the COD value is extremely high, relying solely on activated carbon offers limited effectiveness, and it should be combined with other treatment methods.

Yunchneg