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Reclamation of textile dyeing wastewater for process use via a highly efficient integration system

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Abstract

In this study the secondary effluent after ODOBEZ system processing from a textile dyeing factory was recycled and reused in a dyeing bath. A pilot-scale combined system of a bio-activated carbon reactor (BAC) and membrane separation module (MS) was constructed and studied in detail. Through the efficacies of adsorption as well as biodegradation in BAC, the quality of secondary effluent can be improved further, and then it can be reclaimed and reused in a dyeing bath by using a membrane separation module to reduce the conductivity of the wastewater. This integrated system not only can decrease the frequencies of back washing and replacement of activated carbon via special bio-augmentation, but also alleviate the damage and fouling of membrane due to the further reductions in chemical oxygen demand (COD), suspended solids and color of influent after BAC; this lengthens the lifetime of membranes. In addition to the recycle and reuse fraction of the secondary wastewater in a dyeing bath, the final concentrated retentate after processing in this integrated system meets the stipulated regulations and can be discharged directly with no additional treatments. Once the COD of secondary inflow falls in the range of 100–200 mg/L, the COD of outflow after BAC can be reduced to the range of 50–80 mg/L with a hydraulic residence time of 4 h. In this situation the percentage of water reclamation can reach above 50%, and the final concentrated retentate can be discharged directly. The results of the dyeing tests by using recycling water showed that color deviation indexes, ΔE, were always less than 0.5, which was the criterion for laboratory-scale dyeing tests. After almost a year of operation, a detailed economics assessment was made, and it was found that a total cost 9.14 $NTD was enough to reclaim per cubic meter textile wastewater to a dyeing bath, which included costs in membrane replacement, activated carbon replacement, reagents for membrane washing and power consumption.

Keywords: Water reclamation; Bio-activated carbon (BAC); Membrane; Conductivity removal; COD

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1. Introduction

Water is one of the paramount elements for agricultural, recreational, potable, breeding and industrial purposes. Among these, water usage in industry is more than 15% of the total water consumption in Taiwan, and a majority of this becomes wastewater that is finally discharged to surrounding areas, which exerts a great impact on the environment and therefore the related ecology. In addition, Taiwan is currently suffering from serious droughts, and the water shortage has formed an intractable problem for those industries consuming large amounts of water, e.g., semiconductors, paper or pulp and textile dyeing. To overcome this difficulty, water saving and water reclamation have become a priority for government, researchers and manufacturers.

For the textile dyeing industry, since large amounts of different dyes and chemical reagents are used in the processes, the conductivity in wastewater is definitely high. Unfortunately, among all the contaminants in wastewater, i.e., turbidity, color, COD and conductivity, the last one is the most recalcitrant impurity to be removed, as it profoundly affects the quality of products after dyeing. Since the suitability of the recycling water for the dyeing process use is both product quality-oriented and economic-oriented, what needs to be developed is an economical system that can continuously produce high-quality recycling water.

To deal with the turbidity, color and COD in wastewater, the commonly used methods can be classified into two categories: physicochemical and biotreatment. In general, physicochemical methods and biotreatments are combined and used together to treat the wastewater. No matter which one is positioned first, once all the units perform well in their functions, the turbidity, color and COD in wastewater can be removed effectively. However, conductivity, which results from ion concentration in wastewater, usually cannot be eliminated completely by first or secondary treatment units, and additional equipment is always indispensable. For conductivity or hardness removal, commercialized approaches include: precipitation, ion exchange and membrane separation. Among these three methods, precipitation always accomplishes ion elimination but with large amounts of sludge production, which increase the environmental impact and end-piping treatment cost. Ion exchange suffers from high initial manufacturing costs, and extra equipment is needed to handle the final regenerated wastewater. In addition to the drawbacks mentioned above, the administrable concentrations for precipitation are usually limited to higher values, which is harmful for wastewater reclamation. During membrane operation, the inflow is forced to divide into retentate and filtrate. By selecting a suitable membrane (i.e., pore size, material, electric charge and module), ions can be eliminated to a certain extent, and filtrate can be recycled and reused in manufacturing processes with economical factors taken into account.

It is well acknowledged that a stable and high-quality inflow is required to mitigate the fouling and pore blocking of membrane. As a consequence, a pretreatment is always necessary for the membrane separation system. The pretreatments for membrane separation (MS) are always complex. Among these are sand filtration, microfiltration, ultrafiltration and advanced bioreactor (e.g., immobilized biofilm reactor and BAC as used in this study). BAC possesses several advantages to serve as a pretreatment for membrane separation over other pretreatment units. First, special bacteria, which have high degradation abilities, are inoculated in activated carbons and form biofilms in the surface and/or pores of activated carbons. They can adsorb suspended solids in wastewater and further degrade organic com-pounds of secondary effluent. BAC performs well, especially for wastewater with a lower organic loading. Second, it has a high cell density and a high handling