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RECENT ADVANCES IN THE USE AGRICULTURAL-BASED MATERIALS FOR WASTEWATER TREATMENT

Nazli TURKTEN, Yunus KARATAS*

Kirsehir Ahi Evran University, Faculty of Arts and Sciences, Department of Chemistry, 40100, Kirsehir, Turkiye

Corresponding author e-mail: nazli.turkten@yahoo.com

ABSTRACT

Nowadays, with the rapid growth of industrialization and agriculture, pollution of surface and ground water resources has become a global issue to address. Therefore, value-added and inexpensive materials using either agricultural or industrial wastes have become common and feasible alternatives in wastewater treatment. The application of adsorbents and biochar-based photocatalysts utilizing waste products of the agricultural sector, mostly sugarcane bagasse, rice husk, and coconut husk, has received considerable interest in eliminating recalcitrant pollutants from water. The preparation of biochar-based TiO_2 and ZnO photocatalysts from agricultural by-products not only promotes their higher degradation efficiency of organic compounds, but also promotes a high eco-efficiency. Moreover, these photocatalysts open a new path for further developments to overcome the limitations of TiO_2 and ZnO, which lower the application performance due to the reduction of the band energy gap and the recombination of electron/hole pairs.

Keywords: Agricultural-based materials, agricultural wastes, biochars, photocatalysis, water treatment.

INTRODUCTION

The rapid increase in agricultural waste, population, and industrialization has led to severe water pollution worldwide (Noor and Khan, 2023). Traditional methods mostly used for the removal of pollutants from aqueous phase are biological treatment, flocculation, membrane separation processes, chemical precipitation, adsorption, and ion exchange. Among these numerous wastewater treatment techniques, adsorption is considered to be an effective and cost-effective method for the elimanation of organic contaminants (Dai et al., 2018; Rosales et al., 2017). Recently, studies have focused on agricultural waste-based adsorbents because of their natural, renewable, environmentally friendly, and cost-effective properties (Yahya et al., 2018; Younas et al., 2023).

Vvarious organic waste peels of fruits and vegetables derived from agricultural or food industry may be promising as alternative biosorbents to commercial activated carbon due to their availability and efficiency (Akpomie and Conradie, 2020; Younas et al., 2023). To date, a wide variety of agricultural waste peels, such as grapefruit, ash gourd, banana, cucumber, and potato have been adopted as low-cost biosorbents for the treatment of pollutants (Saeed et al., 2010; Sreenivas et al., 2014; Stavrinou et al., 2018). Zou et al. have studied grapefruit peel as a biomass material on the adsoprtion of uranium(VI) from aqueous solution (Zou et al., 2012). Ash gourd peel as a vegetable-based waste has been used in biosorption of chromium (Sreenivas et al., 2014). The feasibility of using banana peel as an adsorbent in the removal of dyes (congo red) (Mondal and Kar, 2018), pesticides (atrazine and ametryne) (Silva et al., 2013), heavy metals (Pb(II), Cu, and Cd(II)) (Anwar et al., 2010; Vilardi et al., 2018), fluorides, (Mondal, 2017), phenolic compounds (Achak et al., 2009; Mishra et al., 2022), oil spill (Alaa El-Din et al., 2018) from water has been reported.

Nowadays, numerous researchers have investigated the production of agricultural waste material, which mainly consists of cellulose, hemicellulose, lignin, and extractables (Othmani et al., 2022; Zhou et al., 2015). Coconut husk (Foo and Hameed, 2012), coconut shell (Zhu and Kolar,

2016), pistachio nut shells (Foo and Hameed, 2011), rice husk (Shamsollahi and Partovinia, 2019), sugarcane bagasse (Garg et al., 2008a; Garg et al., 2008b) are attractive agricultural waste materials used in wastewater treatment as the potential removal of various pollutants. However, the utilization of these materials as adsorbents for the elimination of recalcitrant pollutants is still not efficient. Therefore, photocatalysis is an effective method to achieve complete degradation or mineralization potential (Sutar et al., 2022).

BIOCHAR-BASED PHOTOCATALYTS

In wastewater treatment, photocatalysis can be applied under light irradiation at appropriate wavelengths and with proper catalysts. In a typical photocatalytic mechanism, light absorption by metal oxide semiconductors such as TiO_2, ZnO, CeO_2, and WO_3 leads to the generation of electron-hole pairs. Photogenerated electron hole pairs produce hydroxyl and superoxide anion radicals (Kumar et al., 2020; Ramalingam et al., 2022).

Agricultural residues are significant potential source of bichar-based catalysts (Sutar et al., 2022). TiO_2-biochar composite has been prepared using coconut for the degradation of Reactive Brilliant Blue KN-R dye (Zhang and Lu, 2018). Lu et al. obtained biochar from pyrolysis of waste walnut shells to synthesize a series of TiO_2-biochar composites. In another application, a high photocatalytic performance was reported for the photocatalytic degradation of methyl orange (Lu et al., 2019). Moreover, numerous studies have demonstrated the potential usage of ZnO-biochar in water treatment (Sutar et al., 2022). Leichtweis et al. prepared biochar derived from pecan nutshell with ZnO composites for the removal of acid red 97 from aqueous solution (Leichtweis et al., 2020). ZnO-biochar composites were produced with three different biomass (*Salvinia molesta*, sugarcane bagasse, and exhausted black wattle bark) and high photocatalytic degradation efficiency was reported on the degradation of sulfamethoxazole antibiotic and methyl orange dye (Gonçalves et al., 2020).

BIOTEMPLATE PHOTOCATALYTS

In recent years, TiO_2 materials using biotemplates such as butterfly wings (Yu et al., 2016), cellulosic cotton (Li et al., 2021), leaves (Gesesse et al., 2019; Li et al., 2009; Yan et al., 2017), leaf extracts (Goutam et al., 2018), pollens (Bu and Zhuang, 2013; Dou et al., 2012; He et al., 2013), rice husk (de Cordoba et al., 2019; Hui et al., 2015; Turkten et al., 2023), *Staphylococcus aureus* (He et al., 2014), starch (Tang et al., 2008), tobacco stem silk (Li et al., 2023), yeast (Chen et al., 2010) have been synthesized to improve the photocatalytic activity of TiO_2. Thus, extraordinary morphologies and properties of these templates are often found in the designed materials. Additionally, the use of agricultural wastes such as rice husks can be an alternative route to reduce environmental pollution by producing a value-added product for water treatment (Turkten et al., 2023).

CONCLUSIONS

The use of adsorbents mainly derived from agricultural waste or the food industry, in wastewater treatment is a promising green, low-cost and renewable resource. However, photocatalysis is more effective in mineralizing persistent pollutants than conventional methods. The use of biochar-based and biotemplate photocatalysts has opened a highly eco-efficient way to solve the environmental pollution problem. In the future, more studies are needed to develop green photocatalysts, and biochar-based and biotemplate photocatalysts can be considered as new promising catalysts in wastewater treatment.

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