Utilization of Agro waste Bio Adsorbents in Textile Wastewater Treatment

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Abstract

The textile industry generates huge amounts of wastewater which must be treated effectively in a bid to prevent water scarcity through re-use. In this chapter, the use of bio adsorbents from agricultural waste which included corn stalks, baggase and saw dust were used as bio adsorption carriers for textile water. Bio adsorbents with particle size ranging from 200-1000µm and surface area of 500-1100 g/m^2 were used to determine the effect of bio adsorbent size on textile wastewater treatment focusing on the total suspended solids (TSS) and the chemical oxygen demand (COD). Furthermore, the effect of bio adsorbent's mass per unit volume with ranges between 1-5 g/L was also investigated on the impact from TSS and COD reduction. TSS and COD reduction by more than 70% were noted for increasing mass per unit volume in the textile water. However, an increase in the particle size of the bio adsorbent during textile treatment resulted in decreased efficiency of the TSS and COD reduction. Bio adsorbents present an attractive option which is easy to adapt for textile wastewater treatment.

Keywords: Agro waste, bio adsorbents, COD, textile wastewater, TSS

1. Introduction

The textile industry generates a lot of wastewater during processing and since water is a scarce commodity, there is need to preserve this water by adopting sustainable wastewater treatment technologies (Wyman et al., 2005; Attaher, 2014). Several wastewater treatment technologies that have been adapted to date include: bio filtration, ion exchange, sedimentation, solvent extraction, chemical oxidation, membrane processes, coagulation, oxidation, Fenton process, and electro coagulation (Bhatnagar and Minocha, 2006; Qian et al., 2013). The major disadvantage of the stated wastewater treatment methods is low efficiency as well as cost effectiveness (Ahmad et al., 2012; Zhang et al., 2012). This calls for the need to adopt technologies like bio adsorption in textile wastewater treatment.

Bio adsorption is an attractive wastewater treatment process due to its low cost and easy to use as well as its wider application in different types of wastewaters (Dang et al., 2009; Ansari and Mosayebzadeh, 2010; Rathinam et al., 2010). Agro waste has increasingly become popular as a bio adsorbents raw material source and has been successfully used in wastewater treatment (Bhatnagar Minocha., 2006).

Table 1. Sources of bio adsorbents from agro waste

Source of bio adsorbent	**Wastewater treated**	**Reference**
Rice husks	Nickel ions removal	(Bansal et al., 2009)
Sugar cane baggase	Nickel ions removal	(Garg et al., 2008)
Jackfruit peels	Rhodamine dye	(Jayarajan et al., 2011)
Groundnut husks	Textile water	(Chakrabarti et al., 2005)

Other types of agro waste that have been used include rice husk, sugarcane baggase, saw dust, soybean hull, cotton seed husks, rice husks, mango peels waste, coffee and tea waste, brewery waste (Khan et al., 2004). This study focused on investigating the effect the potential to use bio adsorbents on the textile wastewater using various agro based bio adsorbents. Three bio adsorbents namely corn stalk, baggase and saw dust were investigated in consideration that these are in abundant in Southern Africa. The effect of the bio adsorbent particle size and mass per unit volume were investigated on their potential to reduce COD and total suspended solids (TSS).

2. Materials and Methods

2.1 Raw wastewater physicochemical characteristics

Raw wastewater was obtained from a local textile industry and analysed for its physicochemical characteristics which included chemical oxygen demand (COD), total suspended solids (TSS) and pH. These were analysed according to the APHA (2005) analyses methodologies. All experiments were done in triplicate and an average used.

2.2 Bio adsorbents from agricultural waste

Corn stalk, baggase and saw dust agricultural waste bio adsorbents were used in this study. These were in the form of bio char with varying particle size from 250-1000 µm. The bio chars were loaded in the treatment reactors with varying mass per unit volume of 1-5 g/L. The bio chars were soaked in distilled water to allow for activation of the bio adsorbents properties for 10 minutes. The bio adsorbents were then oven-dried at 105 ^{o}C overnight before use in a packed column as treatment for the textile wastewater.

2.3 Effect of bio adsorbent mass per unit volume used

The effect of the bio absorbent mass per unit volume was tested by putting masses of 1-5 g/L of the bio adsorbent to 150 mL of distilled water. The mixed were stored at 250 rpm for 3 hours and allowed to settle for 20 minutes afterwards. The filtrate was tested for the TSS, COD and pH.

2.4 Effect of bio adsorbent particle size

The effect of the bio adsorbent particle size on the treatment process was studied by setting three sets of 150 mL conical flasks each with the different bio adsorbent with particle size between 200-1000 µm. The flasks were agitated for 3 hours at 250 rpm left to settle for 20 minutes and filtered out. The filtrate was analyzed for TSS, COD and pH. The percentage change in the physicochemical parameters was calculated in accordance to Equation 1.

$$\%\ \text{Change of parameter} = \frac{\text{Initial concentration} - \text{Final concentration}}{\text{Initial concentration}}\ \text{X}\ 100 \qquad (1)$$

3. Results and discussion

3.1 Raw textile wastewater characteristics

The raw textile wastewater had pH ranging from 5.5-11, COD ranged from 1000-3400 milligrams per litre (mg/L) and the TSS ranged between 1984-4200 mg/L.

3.2 Bio adsorbents characteristics

The bio adsorbents from corn stalks, baggase and saw dust had an average moisture content of 8-9%, ash content of 7-8%, pH of 6-7, surface are of 500-1100 m^2/g and bulk density of 2.2 g/cm^3.

3.3 Effect of bio adsorbent loading on textile wastewater

3.3.1 Effect on TSS

Increase in the bio adsorbents mass per unit volume resulted in decreased TSS with more than 50% for all bio adsorbents (Figure 1). Durairaj and Durairaj (2012) reported between 74-85% colour removals from textile when bio adsorbents were used for treating the wastewater and attributed this to the bio absorbent capability of the agricultural waste bio adsorbents. Khativha et al. (2016) indicated that bio adsorbents absorb organic and inorganic compounds from wastewater. These compounds include proteins, lipids and carbohydrates (Hausen and Cheong, 2007). As indicated by Figure 1, an increase in the bio adsorbent loading resulted in increased amounts of solids removed from the wastewater for all the type of bio adsorbents. This was attributed to the bio adsorbents acting as bio filters with solid particles attaching themselves on the bio adsorbents resulting in decreased TSS.

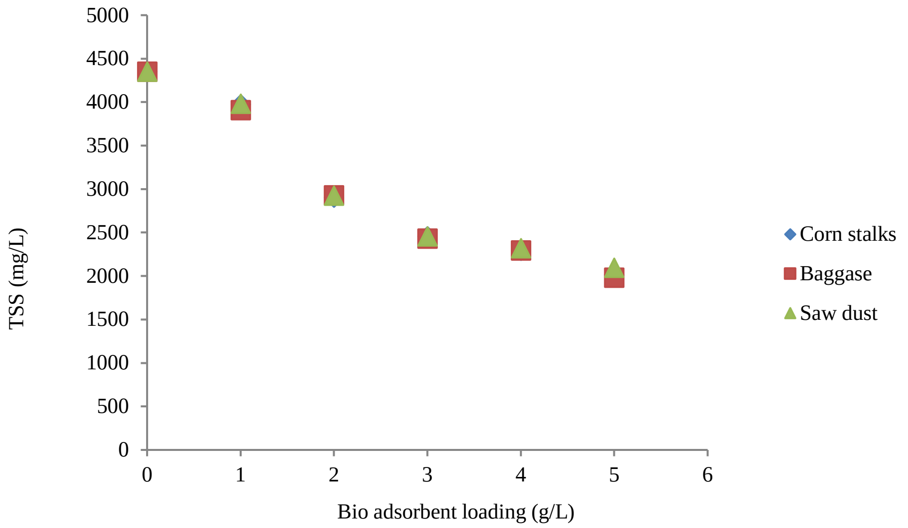

Figure 1. Effect of bio adsorbent loading on TSS

3.3.2 Effect on COD

An increase in the bio adsorbents loading resulted in decreased COD values for all the various bio adsorbents used as indicated in Figure 2. The COD values decreased by more than 60% with the greatest reduction at 5 g/L of bio adsorbents. This behaviour is attributed to the fact that agro waste bio adsorbents have the potential to leach out organic and in organic contaminants from the wastewater with them acting as a bio filter (Hausen and Cheong, 2007). The amount of COD removal was proportional to the amount of bio adsorbents used (Muthukumarau and Beulah, 2015).

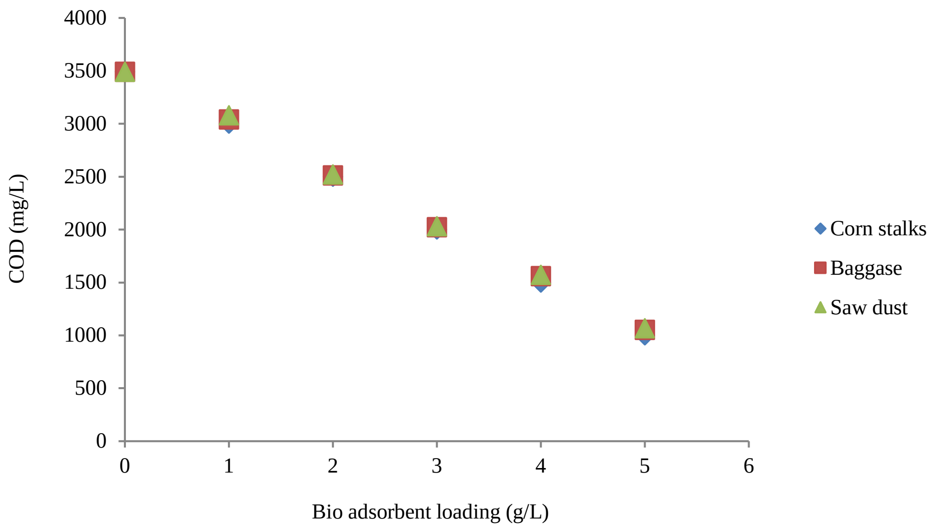

Figure 2. Effect of bio adsorbent loading on COD change of textile water with particle size of 200 µm

3.4 Effect of bio adsorbent particle size on textile water

3.4.1 Effect on TSS

Lower bio adsorbents particle size of 200 µm had greater TSS removal capacity as compared to larger particle sizes of greater 750 µm (Figure 3). From Figure 3, it is clear that the highest COD removal takes place when the particle size of the bio adsorbent is small with removal efficiencies as high as 20%. This behaviour is attributed to the increase in surface area available for bio adsorption enhancing the adsorption process.

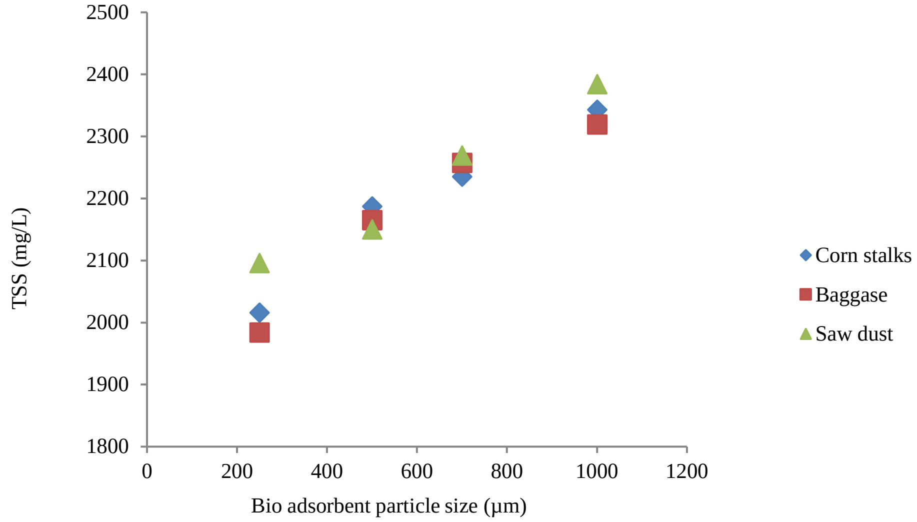

Figure 3. Effect of bio adsorbent particle size on TSS change of textile water with bio adsorbent loading of 5g/L

3.4.2 Effect on COD

The COD removal efficiency from the textile wastewater was greatest at 200 µm and decreased with increase in particle size to 1000 µm for various bio adsorbents with loading of 5 g/L (Figure 4). Bhatti et al. (2015) also reported a 79% reduction in COD when bio adsorbents from corncobs, sugarcane baggase, cotton sticks, sunflower and peanut husk were used for textile wastewater treatment. From Figure 4, it can be seed that the highest COD removal was for all the bio adsorbents with particle size of 200 µm. Lower bio adsorbents particle sizes have higher surface area which increases the adsorption properties hence increased COD removal (Dargo et al., 2014).

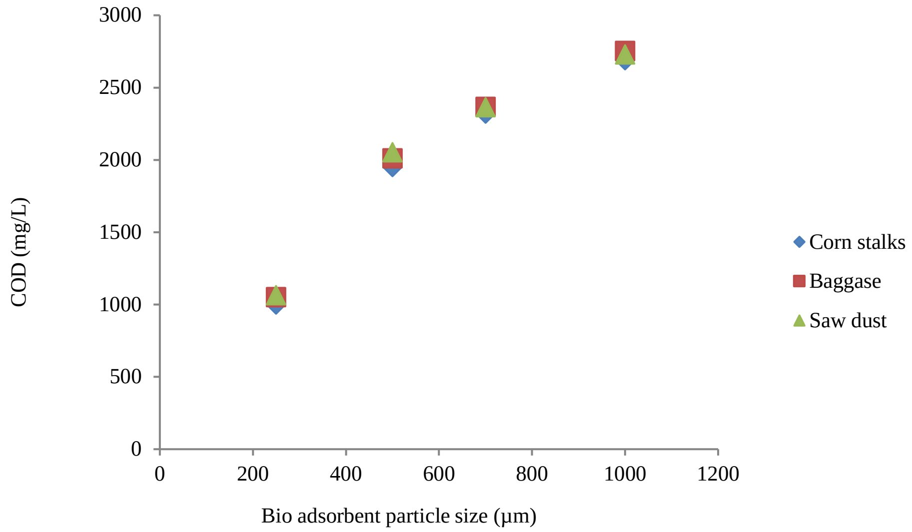

Figure 4. Effect of bio adsorbent particle size on COD of textile water with bio adsorbent loading of 5g/L

4. Conclusion

Application of agricultural waste bio adsorbents in textile wastewater treatment presents an alternative, cheap and easy technology. The application of corn stalks, baggase and saw dust bio adsorbents which can easily be obtained in abundance in Southern Africa results in effective COD and TSS reduction in textile water. Small bio adsorbent particle sizes of 200 µm and high mass per unit volume of 5 g/L are ideal, in textile water treatment. The performance of the bio adsorbent during textile water treatment is irrespective of the source of the agricultural waste.

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