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RESEARCH ARTICLE

SUGARCANE BAGASSE ADSORPTION EVALUATION AND APPLICATION ON BOD AND COD REMOVAL FROM TEXTILE WASTEWATER TREATMENT

Desalegn Abdissa*, Ketema Beyecha

School of Chemical Engineering, Jimma University / Jimma Technology Institute, Jimma City, Ethiopia
**** Corresponding Author Email: abdissa694@gmail.com; desalegn.abdissa@ju.edu.et***

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ABSTRACT

Without properly treated Wastewater released from textile industry contains organic and inorganic pollutants and causes environmental problems. Textile wastewater contains: BOD, COD, toxic heavy metals, organic and inorganic particle matter, colour and etc. The multi-component pollutions needs latest technology treatment. Butch adsorption process is one of the best selective unit operations for such treatment using organic waste material. Sugarcane bagasse was used for this experimental study in butch adsorption process. The variable affects the adsorption process are adsorbent dose changes 0.5 g to 2 g in 200mL sample, pH ranges 3 to 11 and retention time 3 to 7 days. The maximum BOD removed was 85% at 0.5 g, 3days and 8.32 dose, retention time and pH values respectively, and the maximum COD removed was 86% at 1 g, 3 days and 8.24 adsorbent dose, retention time and pH value respectively. Adsorbent dose, pH and retention time are significant factors on the competitive pollutant removal.

KEYWORDS

adsorbent dose, removal efficiency, maximum point, sugarcane bagasse.

1. INTRODUCTION

Wastewater generated by different production steps of a textile industries have a high pH, temperature, detergents, oil, suspended and dissolved solids, dispersants, levelling agents, toxic and non-biodegradable matter, colour ,BOD, COD, nitrogen as NH_4^+, sulphites $(SO_3)^{2-}$, sulphates $(SO_4)^{2-}$, phenols, lead(Pb^{2+}), cadimium, hexavalent chromium(Cr^{6+}), copper(Cu^{2+}), nickel(Ni^{2+}), zinc(Zn^{2+}), free residual chloride (Girish, 2019). Such contaminated waste water can causes environmental problems unless properly treated before its disposal.

Applying low cost, efficient and simple application technologies are necessary for textile waste water treatment (Paździor, Bilińska, & Ledakowicz, 2019). Sugarcane bagasse is one of the primary agro-industrial wastes which available everywhere (Singh, Kapoor, & Kumar, 2012). Sugarcane bagasse mainly consists of cellulose (45%), hemicelluloses (28%), and lignin (18%) (Du et al., 2018). It contains carboxylic and hydroxyl groups, which show the capacitate to adsorb the BOD, COD, Cr(VI), Zn(II) and dye molecules by the ion exchange phenomena and complexation which called adsorption technology (Lee, 2011). Hence it is a cheap, attractive and effective technology for those pollutant removals from wastewater (Rezania et al., 2015).

The daily estimated discharge of Ayika Addis textile industry waste water about 725m^3/day with high concentration of reactive dye, which is used by industries found in Ethiopia have great environmental problem. According to EPA (2016) report, environmental pollution derived from domestic and industrial activities is the main threat to the surface and groundwater qualities in Ethiopia (Maschal Tarekegn & Truye, 2018). It is reported that the majority of industries in the country discharge their wastewaters into nearby water bodies and open land without any form of treatment (Liew, Kassim, Muda, Loh, & Affam, 2015). However, the survival of the ecosystem depends on the ability to manage wastes in an environmentally sound manner (Heacock et al., 2016). This can only be achieved through establishment and enforcement of appropriate standards and guidelines set to ensure that one does not destroy the environment.

All the research done in the previous articles were made by stock solution preparation rather than direct applying on the wastewater, and such experimental result does not suitable and acurate for the treatment application area. Therefore, for the textile wastewater needs the treatment, directly simple experimental methods are required.

The table 1 shows the some textile waste water guideline for release to water surface by EPA.

Table 1: Textile wastewater limit Values for discharges to Water bodies according to EPA (Tomei, Pascual, & Angelucci, 2016)

Parameters measured	Textile effluent value
pH	6-8
Turbidity	-
Suspended solid	40-80 mg/l
Total dissolved solid	80-110mg/l
Chemical oxygen demand (COD)	150-200mg/l
TSS mg/L	40-60
Biological oxygen demand (BOD)	50-100mg/l

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1.1 Material and method

The study conducted in the Jimma University, Jimma technology institute, in the chemical engineering laboratory school 365km south western from Addis ababa. Textile wastewater collected from ayka addis textile industry and sugarcane bagasse from Didesa sugare industry.

1.2 Materials

The materials used to conduct this study: were oven, sieve, magnetic stirrer, filter paper, refrigerator, pH meter, condenser, spectrophotometer, weighting balance, beaker, pipette, sugar cane bagasse and textile wastewater.

1.3 Chemicals

The chemicals used: concentrated sulphuric acid, concentrated phosphoric acid, BOD regent, distilled water, NaOH, EDTA solution, silver nitrate, potassium chromate, potassium iodide, starch solution and sodium thiosulphate.

1.4 Methods

The method used to conduct the study was laboratory scale determination of removal efficiency of textile waste water pollutants using sugar cane bagasse at different dosage, pH value, contact time and stirring rate.

1.5 Data Collections

1.5.1 Collection and processing of the bagasse

The bagasses were collected from Finca Sugar factory eastern Ethiopia. The bagasse was allowed to dry in the laboratory oven at a temperature of 110°C for 6 hours and followed by sieving with mesh of pore size between 500μm-250μm. The sieved particles were washed several times with water and again dried at 110°C for 6 hours in hot air oven to remove all the moisture content. The dried bagasse was then treated in combination with concentrated H_2SO_4 and H_3PO_4 in ratio of 1:1 by volume, as activating agent to produce activate the bagasse functional group. The sample was then washed with distilled water and soaked in 1% sodium carbonate solution for about 8 hours. The washing of sample with distilled water was continued until the pH the acidity of bagasse removed and sample diluted by sodium hydroxide (0.1M) to make the sample to neutral. The samples were dried in hot air oven at 110°C for 24 hours. The final adsorbent was stored in plastic bag before using for adsorption studies.

1.5.2 Collection of Raw Effluent sample from Textile Industry

The raw effluent was collected from the textile Industry called Ayka Addis textile and investment group found in Addis Ababa, Ethiopia. The samples were collected directly from the outlet of the static screen. 5L of waste wastewater Samples were taken and preserved at 4 °C in the refrigerator for sustain the wastewater constituents for one day.

1.6 Experimental Procedure

Physiochemical characteristics of wastewater such as total suspended solid, COD, BOD, turbidity and light absorbance determined before experiment proceeded. After wastewater characterized, 100ml was taken for experimental process. The study variables were adsorbent dose (sugarcane bagasse), pH value and time. Adsorbent dose ranges from 0.5 to 2g, pH from 3 to 11 and time from 3 to 7days.

The experiment was done using different dosage of prepared Sugarcane bagasse performed, the same volume (100ml) of textile wastewaater prepared in 3 beakers, then 0.5g, 1g and 2g of prepared sugarcane bagasse added in to 1st, 2nd and 3rd beaker respectively. Then after were stirred at constant stirring rate 200rpm and stirring time (45min), then the next step was putting the sample for 3, 5 and 7 days at room temperature. Disolved oxygen and chemical oxygen were measured before and after 3, 5 and 7 days at 3, 7 and 11 pH values. The repetition was done until to obtain the maximum BOD, COD removal.

The interactions of two variables was done using response surface methodology

The BOD and removal were calculated using equation 1 and 2 respectively in experimental result (Gajewska et al., 2020).

$$BOD = (DO - DOn - BC) * \frac{Diluted\ volume\ of sample}{p} \quad (1)$$

Where DO is dissolved oxygen in 0 day, DOn is dissolved oxygen in nth days, p is numeral decimal (10) and BC is the difference of CO and COn, CO and COn is chemical oxygen at 0 and nth day respectively.

The chemical oxygen demands calculated using equation 2

$$COD = 2BOD \quad (2)$$

COD is chemical oxygen demand

The percent of BOD and COD removal efficiency also calculated using equation 3 and 4 below respectively

$$\%BOD\ removal = (BODi - BODf) * \frac{100}{BODi} \quad (3)$$

Where BODi and BODf are biological oxygen demand at initial and final respectively

$$\%COD\ removal = (CODi - CODf) * \frac{100}{CODi} \quad (4)$$

Where CODi and CODf are chemical oxygen demand initial and final respectively.

2. Results and Discussion

2.1 Characteristics of Textile Wastewater Effluent

The collected waste water sample was bluish in colour with bad odour and alkaline as its pH was recorded 8.9. This showed that, the waste water has high alkalinity with high light absorbance. Such waste water discharging to environment without treatment can damage the fauna, flora. High alkalinity is a measure of waste water strength due to dyeing process. The physicochemical characteristics of raw textile waste water collected from Ayka Addis textile industry were in Table 1

Table 2: Physicochemical characteristics of collected raw wastewater from Textile effluent

Parameters measured	Unit	Value
pH		8.9
Turbidity	NTU	13
Suspended solid	mg/L	78
Total dissolved solid	mg/L	37600
Chemical oxygen demand (COD)	mg/L	960
Biological oxygen demand (BOD)	mg/L	430

This implies that the waste water is highly polluted and needs farther treatment. These values are above Textile wastewater limit Values for discharges to Water bodies according to EPA 2003, so such high concentration of pollutant of the textile waste water will have great environmental impact.

2.1.1 Effects of adsorbent dose on the BOD and COD removals

Table 3: Effects of bagasse Dose on BOD and COD removal by fixing pH at 7 and time 5 days

Dose (g)	Diluted Sample volume (ml)	Time in Days	DO (mg/L)	CO (mg/L)	BOD (mg/L)	COD (mg/L)	BOD Removal %	COD Removal %
0.5	200	0	7.9	8.2	215	480	58.14	62.5
	200	5	3.2	8	90	180		
1	200	0	7.9	8.2	215	480	52	66.7
	200	5	2.5	8	103.2	160		
2	200	0	7.9	8.2	215	480	39.3	46
	200	5	1.3	8	130.5	259.2		

The table 3 shows that as adsorbent dose increases from 0.5 g to 2 g in 200mL diluted wastewater sample, BOD removal effective at 0.5 g adsorbent dosage in 200mL while 1 g adsorbent dosage was effective for COD removal.

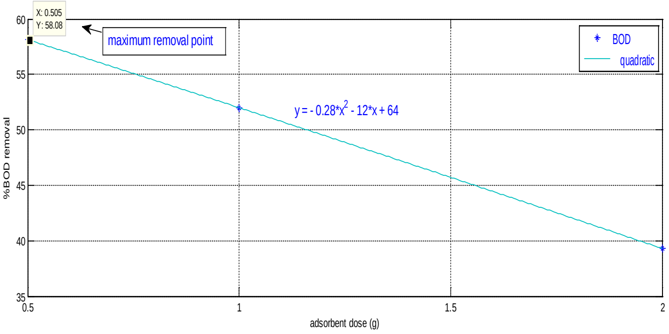


Figure 1: BOD removal efficiency versus adsorption dose

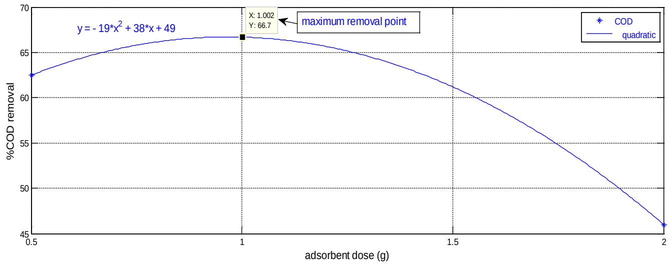


Figure 2: COD removal efficiency versus adsorption dose

From experimental graph the effect of sugarcane bagasse dosage is studied by fixing pH at 7 and time 5days. The dosage is one of the most important factors that have been considered to determine the optimum condition for the performance. Maximum point was 58% BOD removal at initial dosage of 0.5 g and as increasing the adsorbent dosage results decreasing in BOD removal figure 1. COD removal increases up to same extents point from 0.5 to 1 g dosage and the maximum 66.7% COD, and then the COD removal decreases as dosage increases from 1 to 2 g figure 2. Therefore the removal of adsorbent for turbidity, BOD, COD and colour from dyeing textile wastewater was dosage effective (Verma, Dash, & Bhunia, 2012)

2.1.2 Effects of pH on the BOD and COD removals

Table 4: Effects of pH on BOD and COD removal by fixing adsorbent dose 0.5g and time 5 days

pH	Diluted Sample volume (ml)	Days	DO (mg/L)	CO (mg/L)	BOD (mg/L)	COD (mg/L)	BOD Removal %	COD Removal %	Colour removal %
3	200	0	7.9	8.2	215	480			
	200	5	3.3	8	55	111	74.4	77.1	59.14
7	200	0	7.9	8.2	215	480			
	200	5	2.5	8	35	70.1	83.7	85.4	92.26
11	200	0	7.9	8.2	215	480	81.4	83.3	92.26
	200	5	2	8	40	80.2			

The effects pH on the BOD and COD removal, the pH ranges between 3 and 11, the sugarcane bagasse adsorption performance was at pH 7 for both BOD and COD those 83.7% and 85.4% respectively which were maximum removal capacity shown Table 4.

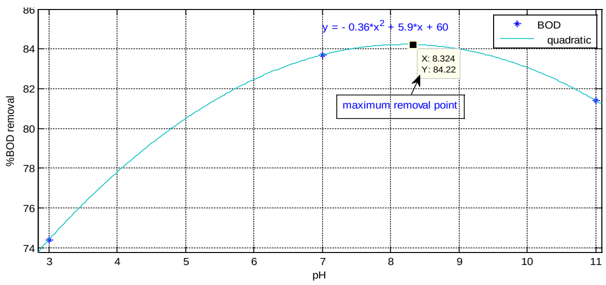


Figure 3: BOD removal efficiency versus pH values

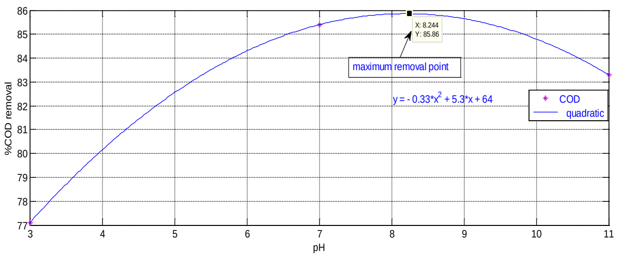


Figure 4: COD removal efficiency versus pH values

The Effect of pH on the BOD and COD removal; as pH increases from 3 to 8.3, BOD and COD removal efficiency increases from 74 to 84% and 77 to 85% respectively. The peak point of BOD removal was 84.22% at pH 8.32 as shown figure 3 and peak point for COD removal 86.86% at pH 8.24 as shown figure 4. As pH farther increases BOD and COD removal efficiency declines as shown figure 3 and 4 by fixing adsorbent dose and time (0.4 g bagasse dose for BOD test and 1g for COD tests and at time 5 days).

At lower pH adsorption efficiency is law, is probably due to the presence of excess H+ ions competing with phenol molecules for the adsorption sites of sorbents and at higher pH, the adsorption efficiency is law, because the adsorbent structure distract in the solution (Zhan, Lin, & Li, 2013).

2.1.3 Effects of retention time on the BOD and COD removals

The retention time of adsorbent is, one of factor variable that affects the sugarcane bagasse adsorption performances (Esfandiar, Nasernejad, & Ebadi, 2014).

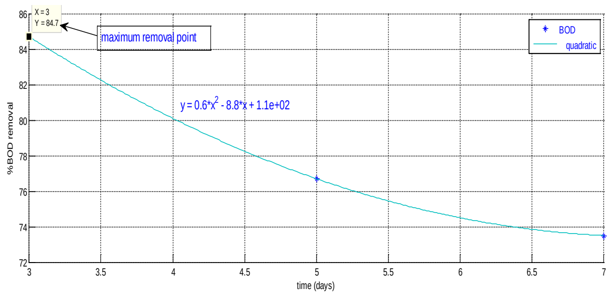


Figure 5: BOD removal efficiency versus contact time

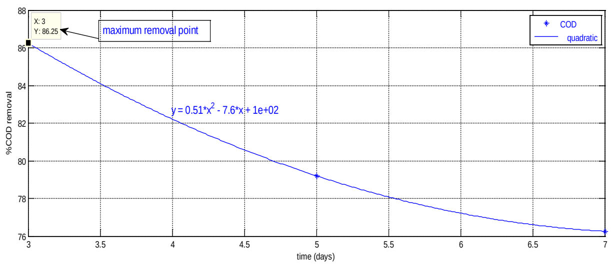


Figure 6: COD removal efficiency versus contact time

Table 5: Effects of time on BOD and COD removal by fixing pH at 7 and adsorbent dose 0.5g

Diluted Sample volume (ml)	Days	DO (mg/L)	CO (mg/L)	BOD (mg/L)	COD (mg/L)	BOD Removal %	COD Removal %	Colour removal %
200	0	7.9	8.2	215	480	84.7	86.25	59.14
200	3	4.5	8.1	33	66			
200	0	7.9	8.2	215	480	76.7	79.2	76.25
200	5	2.7	8	50.1	100			
200	0	7.9	8.2	215	480	73.5	76.25	92.26
200	7	2	8	57	114			

The effect of retention time was from 3 to 7 days. Maximum BOD and COD removal located at the first 3 days which 84.7% and 86.25 BOD and COD respectively shown table 5.

The factor of retention time was the major which affects adsorption performance capacity of sugarcane bagasse on BOD and COD removal. Maximum points of removal occur at the first 3 days for both BOD and COD that 84.7% and 86.25% respectively shown figure 5 and 6. As the time farther increases the removal capacity decreases up to 73.5% and 76.3 at the end 7 days shown figure 5 and 6. At the first 3 days many hole and spaces of adsorbent can uptake in high rate on BOD and COD from waste water. As the farther time increases up to 7 days, the adsorption capacity become decline due to adsorbent in solution become saturated by taking enough amounts BOD and COD (Santos & Boaventura, 2015).

2.2 Two Variables interaction on the BOD removal

One variables interaction to another's results the change of BOD removal, all the interaction result negative effects on the removal capacity. pH and dosage interaction on the BOD removal shown in figure 7.

In figure a shows peak point and two interact points; the peak point was 85% BOD removal at 0.5g adsorbent dose, pH 7and time 3days. Adsorbent dose and pH variable interaction on the BOD removal shows negative responses. 76% BOD removal at interact point of 2 g adsorbent dose and pH 3. 79% BOD removal at interact point of 0.5g adsorbent dose and 11 pH values figure 7a. Dosage and time interaction also responses negative effects on the BOD removal. while the peak point was 85% BOD removal, 82% BOD removal at time 3days and 0.5 g adsorbent dose and 76% BOD removal at interaction points of 2 g adsorbent dose and 7 days shown figure 7b. Also, in the time and pH interaction shown figure 7c; results 82% BOD removal at 3 days and 3 pH values and 79% BOD removal at 7days and 11 pH values. Time and pH variable interaction on the BOD removal also leads negative responses.

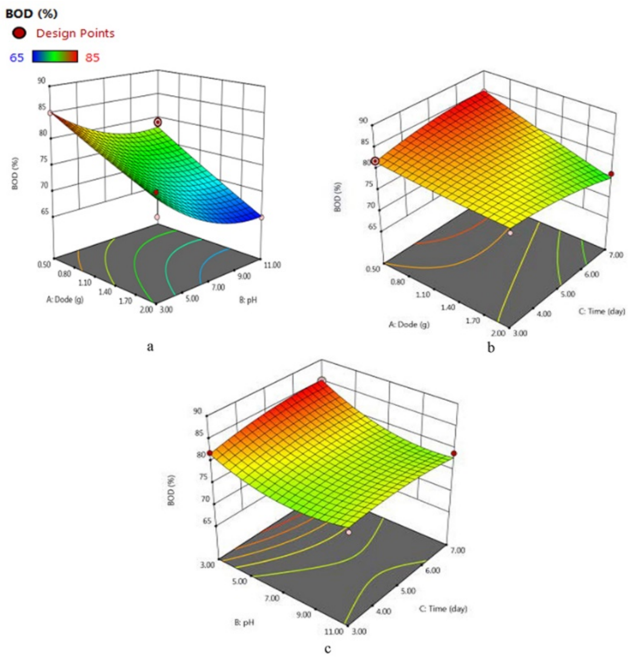


Figure 7: Two variable interactions on BOD removal efficiency

2.3 Two Variables interaction on the COD removal

There were also two variable interaction effects on the COD removal shown in Figure 8

The peak point was 86% COD removal at 0.5 g adsorbent dose 3 pH and 3 days. The figure 8a shown that the interaction of dosage and pH values on the removal of COD, in the interaction of pH and dosage three critical valuable points were shown 84% COD removal at 0.5 g adsorbent dose and 3 pH, 80% COD removal at 0.5g adsorbent dose and 11 pH value and 74% COD removal at 2 g adsorbent dose and 11 pH value by time retaining 3 days. The adsorbent dosage and time interaction also influences the COD removals, there were three critical valuable points for evaluating the interaction of these two variables, 84% COD removal at 0.5g adsorbent dose and 3 days, and 80% COD removal at 2 g adsorbent dose and 7 days by retaining pH value at 3 shown figure8b. The other were time and pH variable interaction shown in figure 8c. there were identified COD removal points 84% COD removal at 3 days and 3 pH values, 80% COD removal at 3 days and 11pH, 79% COD removal at 7 days and 11pH values.

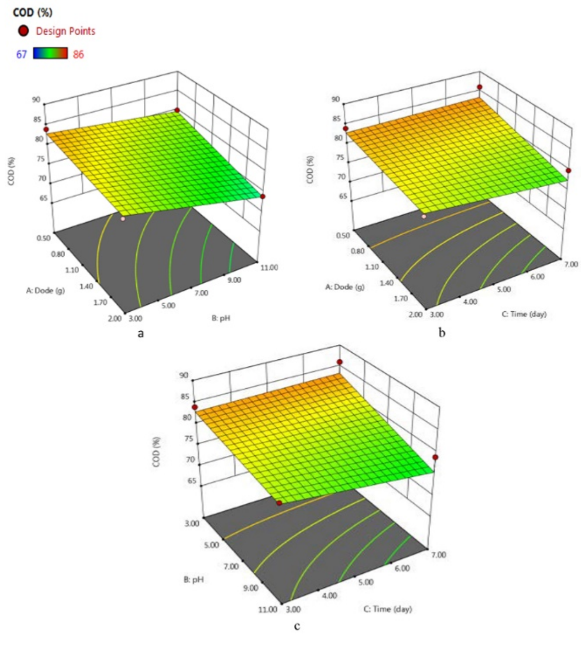
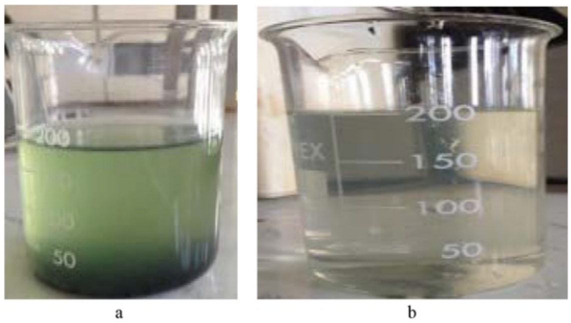


Figure 8: Two variable interactions on COD removal efficiency



a b

Figure 9: Diluted textile wastewater colour changes from green to colourless (a before treatment b after treatment)

Table 6: waste water pollutant parameters after experimental treatment by sugarcane bagasse

Parameters	After		Before	
	Unit	Values	Unit	Values
Colour removed	%	92.49	%	-
BOD	mg/L	60	mg/L	430
BOD removal	%	86.05	%	-
COD	mg/L	120	mg/L	960
COD removal	%	87.5	%	-
TDS	mg/L	90	mg/L	37600
TSS	mg/L	70	mg/L	78
Chlorine Ion Removal	%	100	%	-
Magnesium ion Removal	%	68.4	%	-

In this research the adsorbent was directly applied on the textile wastewater and the target pollutants where focused on BOD, COD and colour change only without any another pollutant consideration. This may reduces the capacity of sugarcane bagasse removal efficiency that leads pollutants computations on the hole of adsorbent and when the sugarcane bagasse preparation there were the formation of the functional groups which negative ions created that capacitate or energize for adsorption of metal ion in water pollutants. Therefore I forecasting that the future research studies on the all measure pollutant parameters that existing in wastewater can interact on the adsorbent efficiencies.

3. Conclusion

Sugarcane bagasse have high performance on adsorption of BOD, COD and other pollutants form textile wastewater. Adsorbent dose, pH and retention time are significant factors on the competitive pollutant removal even sample wastewater direct taken from the sources and the interaction of two factor variables shows negative effects on both BOD and COD removals. Textile Wastewater treatment by sugarcane bagasse adsorption process is latest technology, high performance adsorbent, low cost and environmental friendly. Therefore the sugarcane bagasse adsorbent is best for application of textile wastewater treatment according to these experimental result shows and it is not selective pollutants treatments.

Author Contributions

Desalegn Abdissa (M.Sc. Ass-professor and researcher) planned, organized and wrote the manuscript. Ketema Bayecha (M.SC. academic lecturer) Experimental data organized and analyzed.

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