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COMPARATIVE PERFORMANCE OF *SACCHARUM OFFICINARUM* (SUGAR CANE) BAGASSE AND *PARKIA BIGLOBOSA* (LOCUST BEAN) IN WASTEWATER TREATMENT

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ABSTRACT
The application of agricultural by-products for the removal of contaminants in water and wastewater is receiving significant attention as their applications reduce their level of the agricultural by-products in the environment there by reducing pollution. Activated carbons were formed from the saccharum officinarum (sugarcane) bagasse and parkia biglobosa (locust bean) pods and their effectiveness in the treatment of domestic wastewater were compared. The activated carbons were obtained from carbonised sugarcane bagasse and locust beanpod at a temperature of 350-500^{o}C, followed by the modification with phosphoric acid for 12-18 hours. The result revealed that the parkia biglobosa recorded higher removal efficiencies of: Turbidity, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and nitrate than the saccharum officinarum. The parkia biglobosa recorded BOD removal efficiencies of: 77.19, 77.81, 78.13, 87.50, 90.63 and 93.75% at the dosages of: 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00g/500ml, respectively; while the saccharum officinarum recorded removal efficiencies of: 15.63, 25.00, 34.38, 43.44, 46.88 and 65.00% at the same dosages, implying that the parkia biglobosa was more effective than saccharum officinarum. In terms of turbidity, the saccharum officinarum recorded removal efficiencies of: 5.44, 17.86, 31.90, 34.29, 46.51 and 57.02%, respectively at the dosages of: 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00g/500ml; while parkia biglobosa recorded removal efficiencies of: 14.99, 25.50, 37.63, 43.84, 56.07 and 68.39%.The study also revealed that the higher the dosages, the higher the removal efficiencies of the organic and inorganic pollutants. It was recommended that removal of heavy metals using the parkia biglobosa and saccharum officinarum should be studied to ascertain their effectiveness in such dimension.

Keywords: *wastewater, activated carbons, saccharum officinarum, parkia biglobosa and removal efficiency*

1. INTRODUCTION
Wastewater contains about 99.9% of water by mass, while the remaining 0.1% is solids. The contaminants in wastewater include: suspended solids, biodegradable organic compounds, inorganic solids, nutrients, heavy metals as well as pathogens. Wastewater is usually treated in order to be discharged safely, without any health implication or water pollution [1].

Saccharum officinarum (sugarcane) bagasse is the solid remains obtained after the extraction of juice from the sugarcane [2,3,4]. Sugarcane bagasse is composed of: 43.6% by mass cellulose, 33.8% hemi-cellulose, 18.1% lignin, 2.3% ash and 0.8% wax on a dry weight basis [3,5]. The lignocelluloses (cellulose, hemi-cellulose and lignin) can be used to produce ethanol which is an alternative source of energy [6]. The *saccharum officinarum* bagasse is inexpensive and readily available as agricultural by-product with significant carbon content [6, 7, 8]. Moreso, a pyrolysed sugarcane bagasse has elemental composition of: 22.36% carbon, 30.69% nitrogen and 30.52% oxygen [9]. The chemical composition of raw *saccharum officinarum* bagasse depends upon multiple factors such as: crop variety, climate condition, location, mode of growth and chemical composition of the soil [4].

The *parkia biglobosa*, commonly known as the African locust bean [10], is a perennial tree of legume, belonging to the family of leguminosae [10, 11, 12]. The seeds of the plant are enclosed in a yellowish, mealy, sweet tasting edible pulp. The leaf extract

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contains cardiac, saponin glycosides and phenolic content [10]. The fruit pulp and seeds are rich in protein and lactose constituting vital form of energy [10, 13]. The roots, barks, leaves, stem, flowers, fruits and seed of a *parkia biglobosa* are all medicinal [14]. The *parkia biglobosa* tree reaches 7 – 20m in height and the crown is large and wide spreading with low branches on a stout bole [11].

The *parkia biglobosa* seeds number 5 – 20 per pod. The seeds are brown, oval, and smooth with a length of 0.9 – 1.5cm each, 0.8-1.1cm width and a weight of 0.25g [11]. However, the plant has the capacity to resist drought situation due to its deep tap root system [15].

The application of agricultural by-products for the treatment of water and wastewater is currently receiving great attention. The mechanism through which the treatment occurs is referred to as adsorption which is a surface phenomenon [16, 17]. The adsorption could be physical or chemical [18]. The applications of *saccharum officinarum* bagasse and *parkia biglobosa* in wastewater treatment involve their modifications to produce activated carbon. The effectiveness of the activated carbon depends upon the production process and modification [19]. The aim of this research is to compare the effectiveness of activated carbons produced from *parkia biglobosa* pod and *saccharum officinarum* bagasse in wastewater treatment based on the removal of organic pollutants.

2. MATERIALS AND METHODS

2.1 Materials

The materials used in this research are categorized as: glassware, equipment or apparatus and reagents:

2.1.1. Glassware

The glassware used were: test tubes, petri-dish, desiccators, burette, pipette, conical flask, measuring cylinder, Biochemical Oxygen Demand (BOD) bottle, beaker, glass beads and reflux apparatus/flask.

2.1.2. Equipment/apparatus

pH meter (HI 83200), weighing balance (P160N), retort stand, sterilizing machine, Turbid meter (HACH 2100N), water bath, funnel, filter paper, crucible, sag, furnaces, griffen oven, 20 litregaloon, hand glove, magnetic stirrer, multi-parameter photometer, spatula and forcept.

2.1.3 Reagents

Molybdate reagent, methylated spirit, manganous sulphate, ferrous ammonium sulphate, phenolphthalein indicator, methyl ferroin indicator, sodium thiosulphate, concentrated phosphoric acid, concentrated tetraoxosulphate (VI), magnesium sulphate, alkali-iodide/azide,starch solution, sodium thiosulphate, mercury sulphate, buffer solution 4, 6 and 9, distilled water, starch solution, potassium choromate and silver sulphate all of analytical grade.

2.2 Methods

2.2.1 Preparation of *Saccharum officinarum* Bagasse and *Parkia biglobosa* Activated Carbons

The *saccharum officinarum* bagasse was collected from Makarfi Local Government Area of Kaduna state; while the *parkia biglobosa* was obtained from Ahmadu Bello University, Zaria -Nigeria; opposite the University reservoir. They were washed separately with distilled water to remove dirt and surface impurities, and then oven dried at 100^{o}C for 24hours [20, 21]. They were then cut into smaller pieces and placed in a miller which consists of a series of rollers that crush them. They were then placed in a crucible and charred in a furnace at 350^{o}C-500^{o}C. The furnace was allowed to cool down for 24hours before the charred were removed and sieved to obtain 5-50μm grain size for material that passes through sieve number 200. The sieved materials were then soaked in phosphoric acid for 12-18hours to become activated carbons. They were then washed with distilled water, spread on tray at room temperature to be drained. The product was then dried at temperature at 105°C for 3 hours and kept in desiccators to cool down.

2.2.2 Sampling

Wastewater was collected from maturation pond effluent of Ahmadu Bello University waste treatment plant in a 20 litres gallon. It was then taken to the Environmental Health Laboratory, Department of Water Resources and Environmental Engineering, Ahmadu Bello University, Zaria for the physico-chemical analysis using standard methods for water and wastewater quality assessment. The parameters analysed are: turbidity, total solids, suspended solids, pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), nitrate and phosphate.

2.2.3 Batch Adsorption Experiment

The batch adsorption was carried out by measuring: 0.25, 0.5, 1.5, 2.5, 3.75, and 5.0 g of the *saccharum officinarum* bagasse and *parkia biglobosa* pod activated carbons each in a 500 ml of waste water. The mixture of activated carbons and the wastewater sample were stirred at 100 rpm high speed for 5minute and 10rpm low speed for 15 minute using magnetic stirrer. The samples were then removed from the magnetic stirrer and the flocs were allowed to settle down.

3. RESULTS AND DISCUSSION

The results obtained in this study were presented in Tables 1 – 8, showing the performances of the *saccharum officinarum* bagasse and *parkia biglobosa* for the removal of both physical and chemical pollutants in the wastewater. Table 1 revealed the removal of turbidity of the wastewater at an initial turbidity value of 10.47 NTU. The *saccharum officinarum* bagasse recorded removal efficiencies of: 5.44, 17.86, 31.90, 34.29, 46.51 and 57.02%, respectively at the dosages of 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00 g/500ml. This implied that the highest removal efficiency of 57.02% was recorded at the dosage of 5.00g/500ml, while the lowest removal efficiency was recorded at the dosage of 0.25 g/500ml. The result implied that the removal efficiencies of the turbidity in the wastewater increases with the increase in the dosage of the adsorbent. On the other hand, the *parkia biglobosa* recorded removal efficiencies of the turbidity of: 14.99, 25.50, 37.63, 43.84, 56.07 and 68.39%, respectively at the dosages of 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00 g/500ml. The highest removal efficiency of 68.38% occurred at the dosage of 5.00 g/500ml, while the lowest removal efficiency of 14.99% occurred at the dosage of 0.25 g/500ml. The *parkia biglobosa* recorded higher turbidity removal efficiency than the *saccharum officinarum* bagasse at all the adsorbent dosages. Moreover, modified cassava species (*manihot palmate* and *manihotaipi*) can also be used to remove turbidity in water and wastewater [22].

Table 1: Turbidity values(NTU)

Dose (g/500ml)	Comparison in turbidity		Removal efficiency (%)	
	Saccharum officinarum (NTU)	*Parkia biglobosa*(NTU)	*saccharum officinarum*	*Parkia biglobosa* Pod
0.00	10.47	10.47	0.00	0.00
0.25	9.90	8.90	5.44	14.99
0.50	8.60	7.80	17.86	25.50
1.50	7.13	6.53	31.90	37.63
2.50	6.88	5.88	34.29	43.84
3.75	5.60	4.60	46.51	56.07
5.00	4.50	3.31	57.02	68.39

Table 2: Suspended solids values (mg/l)

Dose (g/500ml)	Comparison in concentration of suspended solids		Removal efficiency (%)	
	Saccharum officinarum (mg/l)	*Parkia Biglobosa* (mg/l)	*saccharum officinarum*	*Parkia biglobosa*
0.00	8.50	8.50	0.00	0.00
0.25	0.02	0.02	94.12	94.12
0.50	0.02	0.02	94.12	94.12
1.50	0.01	0.01	99.88	99.88
2.50	0.01	0.01	99.88	99.88
3.75	0.01	0.01	99.88	99.88
5.00	0.01	0.01	99.88	99.88

Table 3: Total solids values (mg/l)

Dose (g/500ml)	Comparison in concentration of total solids		Percentage Removal (%)	
	saccharum officinarum(mg/l)	*Parkia biglobosa*(mg/l)	*saccharum officinarum*	*Parkia biglobosa*
0.00	9.70	9.70	0.00	0.00
0.25	0.016	0.030	99.84	99.69
0.50	0.016	0.030	99.84	99.69
1.50	0.015	0.026	99.85	99.73
2.50	0.014	0.025	99.86	99.74
3.75	0.013	0.023	99.87	99.76
5.00	0.011	0.021	99.89	99.78

The suspended solids removal was as shown in Table 2. The initial concentration of the suspended solids in the wastewater was 8.50mg/l. The *saccharum officinarum* bagasse and *parkia biglobosa* had removal efficiencies of: 94.12, 94.12, 99.88, 99.88, 99.88 and 99.88%, respectively at the dosages of 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00 g/500ml. This implied that the same removal efficiencies were obtained for both the *saccharum officinarum* bagasse and *parkia biglobosa* at all the dosages considered. The result also revealed that higher dosages of the adsorbent are accompanied with higher removal efficiencies [23] and 1.5 g/500ml dosage recorded the highest removal efficiency.

The result of the total solids was as shown in Table 3. The initial concentration of the total solids in the wastewater was 9.70mg/l. The *saccharum officinarum* bagasse recorded removal efficiencies of: 99.84, 99.84, 99.85, 99.86, 99.87 and 99.89%, respectively at the dosages of 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00 g/500ml. On the other hand, the *parkia biglobosa* recorded removal efficiencies of: 99.69, 99.69, 99.73, 99.74, 99.76 and 99.78%, respectively at the dosages of 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00 g/500ml. The result implied that higher dosages of the adsorbent are accompanied by higher removal efficiency of the adsorbent [23] as shown in the Table 3.

Table 4 contained the pH values of the waste water before and after the application of various dosages of the adsorbents. The initial pH of the waste water was 6.13, but it was reduced to 2.55, 2.64, 2.78, 3.05, 3.02 and 4.15, respectively at the dosages of 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00 g/500ml for the activated *saccharum officinarum* bagasse. On the other hand, the application of the 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00 g/500ml of the adsorbent dosage, respectively reduced the pH to 2.10, 3.08, 4.12, 2.03, 2.05 and 3.15 for the *parkia biglobosa*. This implied that the application of both the adsorbents at all the dosages dropped the pH of the waste water making it to be more acidic. This signified that the waste water will require pH adjuster in order to neutralize the waste water.

The result of the BOD was as shown in Table 5. The initial concentration of the BOD in the waste water was 3.2mg/l. The applications of: 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00 g/500ml, respectively of the activated *saccharum officinarum* bagasse dosages reduced the BOD to 2.70, 2.40, 2.10, 1.81, 1.70 and 1.20mg/l. This corresponds to the BOD removal efficiencies of: 15.63, 25.00, 34.38, 43.44, 46.88 and 65.00%. It was discovered that the removal efficiencies of the BOD increases with the increase in the adsorbent dosages as shown in the Table 5 as observed by [22]. The increase in the adsorbent dosage causes the number of sites available for solute-solvent interaction to increase thereby improving the removal efficiency [23,24].

Table 4: pH values

Dose (g/500ml)	Comparison(pH values)		Removal efficiency (%)	
	saccharum officinarum	*Parkia biglobosa*	*saccharum officinarum*	*Parkia biglobosa*
0.00	6.13	6.13	0.00	0.00
0.25	2.55	2.10	58.40	65.74
0.50	2.64	3.08	56.90	49.76
1.50	2.78	4.12	54.50	32.79
2.50	3.05	2.03	50.25	66.89
3.75	3.02	2.05	32.30	66.56
5.00	4.15	3.15	32.30	48.61

Table 5: Biochemical Oxygen Demand (BOD) values (mg/l)

Dose (g/500ml)	Comparison in concentration of BOD		Removal efficiency (%)	
	saccharum officinarum	*Parkia biglobosa*	*saccharum officinarum*	*Parkia biglobosa*
	BOD (mg/l)	BOD (mg/l)		
0.00	3.20	3.20	0.00	0.00
0.25	2.70	0.73	15.63	77.19
0.50	2.40	0.71	25.00	77.81
1.50	2.10	0.70	34.38	78.13
2.50	1.81	0.40	43.44	87.50
3.75	1.70	0.30	46.88	90.63
5.00	1.20	0.20	65.00	93.75

Table 6: Chemical Oxygen Demand (COD) values (mg/l)

Dose (g/500ml)	Comparison in concentration of COD		Removal efficiency (%)	
	saccharum officinarum(mg/l)	*Parkia biglobosa*(mg/l)	*saccharum officinarum*	*Parkia biglobosa*
0.00	25.0	25.0	0.00	0.00
0.25	17.20	8.20	31.20	67.20
0.50	14.70	7.70	41.20	69.20
1.50	13.90	6.50	44.40	74.00
2.50	11.40	6.50	54.50	74.00
3.75	11.12	6.30	55.52	74.80
5.00	10.20	6.20	59.20	75.20

Table 7: Nitrate values (mg/l)

Dose (g/500ml)	Comparison in concentration of nitrate		Removal efficiency (%)	
	saccharum officinarum(mg/l)	*Parkia biglobosa*(mg/l)	*saccharum officinarum*	*Parkia biglobosa*
0.00	37.0	37.0	0.00	0.00
0.25	25.5	22.3	31.07	39.73
0.50	13.3	16.0	64.10	56.76
1.50	14.2	11.9	61.62	67.84
2.50	20.2	14.7	45.40	60.27
3.75	12.9	13.5	65.14	63.51
5.00	18.8	11.1	49.20	70.0

Table 8: Phosphate values (mg/l)

Dose (g/500ml)	Comparison in concentration of phospate		Removal efficiency (%)	
	saccharum officinarum(mg/l)	*Parkia biglobosa*(mg/l)	*saccharum officinarum*	*Parkia Biglobosa* Pod
0.00	1.13	1.13	0.00	0.00
0.25	0.63	0.81	44.23	28.32
0.50	0.76	0.80	32.74	29.20
1.50	0.71	0.79	37.17	43.09
2.50	0.74	0.74	34.51	34.51
3.75	0.60	0.73	46.90	48.40
5.00	0.55	0.54	51.33	52.21

On the other hand, the activated *parkia biglobosa* recorded higher removal efficiencies of the BOD than the sugarcane bagasse. It recorded removal efficiencies of: 77.19, 77.81, 78.13, 87.50, 90.63 and 93.75%, respectively at the dosages of 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00 g/500ml. This signified that the *parkia biglobosa*is more effective in terms of organic matter removal than *saccharum officinarum*as the result revealed.

The result of the COD was as shown in Table 6. The initial concentration of the COD in the waste water was 25.0mg/l. The applications of: 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00 g/500ml, respectively of the activated *saccharum officinarum* led to the removal efficiencies of: 31.2, 41.2, 44.4, 54.5, 55.52 and 59.2% of the COD. It was discovered that the removal efficiencies of the COD increases with the increase in the adsorbent dosages as it was previously discussed earlier. On the other hand, the activated *parkia biglobosa* recorded higher removal efficiencies of the COD than the activated *saccharum officinarum*. It recorded removal efficiencies of: 67.2, 69.2, 74.0, 74.0, 74.8 and 75.2%, respectively at the corresponding dosages of: 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00g/500ml. This signified that the activated *parkia biglobosa* is more effective in terms of organic matter removal than *saccharum officinarum* as the result revealed.

Table 7 showed the removal efficiencies of the nitrate in the wastewater. The activated *saccharum officinarum* recorded removal efficiencies of: 31.07, 64.10, 61.62, 45.40, 65.14 and 49.2%, respectively at the corresponding dosages of: 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00g/500ml. This implied that the activated *saccharum officinarum* had the lowest removal efficiency of: 31.07% and highest removal efficiency of 65.14% at the dosages of 0.25g/500ml and 3.75, respectively. On the other hand, the activated *parkia biglobosa* recorded removal efficiencies of: 39.73, 56.76, 67.84, 60.27, 63.51 and 70.0%, respectively at the dosages of: 0.25, 0.5, 1.5, 2.5, 3.75 and

5.00g/500ml. This signified that the activated *parkia biglobosa* had the lowest removal efficiency of: 39.73% and highest removal efficiency of: 70.0% at the dosages of 0.25g/500ml and 5.00g/500ml, respectively. The result also revealed that the performance of the activated *parkia biglobosa* is more than the activated sugar cane bagasse for nitrate removal.

Table 8 showed the removal of the phosphate for both the activated *saccharum officinarum* bagasse and *parkia biglobosa* at an initial phosphate concentration of 1.13mg/l. The activated *saccharum officinarum* bagasse recorded removal efficiencies of: 44.23, 32.74, 37.17, 34.51, 46.90 and 51.33%, respectively at the dosages of 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00g/500ml. The result implied that the highest removal efficiency of: 51.33% was recorded at the dosage of 5.00g/500ml, while the lowest removal efficiency of: 32.74% was recorded at the dosage of 0.5g/500ml. On the other hand, the *parkia biglobosa* recorded removal efficiencies of: 28.32, 29.20, 43.09, 34.51, 48.40 and 52.21%, respectively at the corresponding dosages of: 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00g/500ml. The highest removal efficiency of 52.21% was recorded at the dosage of 5.00g/500ml, while the lowest removal efficiency of 28.32% was recorded at the dosage of 0.25g/500ml.

4. CONCLUSION

Based on the experiment carried in this research, it was discovered that both the *saccharum officinarum* bagasse and *parkia biglobosa* can be used for the removal of organic and inorganic pollutants in wastewater. The comparative results revealed that the *parkiabiglobossa* had higher removal effienciencies of the: turbidity, BOD, COD and nitrate removal from the wastewater than the *saccharum officinarum* bagasse. However, the *parkia biglobosa* recorded BOD removal efficiencies of: 15.63, 25.00, 34.36, 43.44, 46.88 and 65.00%,respectively at the dosages of 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00g/500ml; while the *saccharum officinarum* bagasse recorded removal efficiencies of: 77.19, 77.81, 78.13, 87.50, 90.63 and 93.75% at the same dosages. In terms of turbidity, the *saccharum officinarum* recorded removal efficiencies of: 5.44, 17.86, 31.90, 34.29, 46.51 and 57.02%, respectively at the dosages of: 0.25, 0.5, 1.5, 2.5, 3.75 and 5.00g/500ml; while *parkia biglobosa* recorded removal efficiencies of: 14.99, 25.50, 37.63, 43.84, 56.07 and 68.39%.The study also revealed that the higher the dosages, the higher the removal efficiencies of the pollutants. It is recommended that removal of heavy metals using the *parkia biglobosa* and *saccharum officinarum* bagasse should be studied to ascertain their effectiveness in such dimension.

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