INDUSTRIAL LIQUID EFFLUENT PURIFICATION USING LOCALLY DEVELOPED ADSORBENTS

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Abstract
Purification of wastewaters from Nicon Nuga Hotel Abuja and a cassava processing industry in Bida, Niger state was undertaken with a view of treating these effluents with locally developed adsorbents. Bone and coconut shells were obtained from a local market in Bida and were used to produce activated carbons. These carbonaceous materials were carbonized in a muffle furnace at 700 and 800 degree Celsius, while another portion was ashed at atmospheric conditions. These ashed materials were thermally and chemically activated separately after which they were size reduced to workable size of 75 micro meters. Chemically activation was achieved using KOH and HCl acid as activating agents while thermal activation was done by passing steam through the carbonized samples. The physicochemical properties such as surface area, moisture content, Bulk density, porous diameter, and pore volumes of the untreated and treated adsorbents are analysed. The properties such as turbidity, concentration, pH, refractive index, viscosity, total dissolved solids (TDS), colour, Biochemical oxygen demand (BOD) and odour for both cassava processing industry and Hotel effluents before and after treatment were determined. The results show that the effluents are treated by the locally developed adsorbents, with the coconut shell adsorbents performing better than the bone based adsorbents. In general, the chemically treated adsorbents purify the effluents more successfully than the thermally treated samples with the samples treated with KOH solution being the best. The absorptive capacities of the bone and coconut shells based absorbents were determined with varying masses of 2.0, 4.0 and 6.0 grams of the absorbents by measuring the absorbance of the treated effluents. Graphs of absorbance were plotted against time and it was observed that there was a drastic reduction in absorbance as time progressed for both bone and coconut shell based adsorbents.

Introduction
The improper disposal of industrial, commercial and domestic wastes has adverse effect on human health and resources. This is why it has become imperative that these effluents should be purified in order to eliminate or amelerioate the harmful effects of these waste materials on the welfare and well being of the citizenry (Aneke & Okafor, 2007). Industrial pollution is one of the problems faced in Nigeria and several efforts are made to control it in various industries in different parts of the country (Yusuff & Sanibore, 2004). Effluents generated by the industries are one of the sources of pollution. Contaminated air, soil, and water by effluents from the industries are associated with heavy disease burden (WHO, 2002) and this could be part of the reason for the current shorter life expectancy in the country (WHO, 2003) when compared to developed countries.

Population explosion, haphazard rapid urbanization, industrial and technological expansions such as that of Garri process industry and Hotel, energy utilization and waste generation from domestic and industrial sources have rendered many waters unwholesome and hazardous to man and aquatic biota. There are little or no stringent laws guiding environmental pollution in Nigeria unlike the European Union that enforces the integrated pollution control and landfill directives (Adewoye, 1998). Hence many industries discharge untreated or inadequately treated wastes into water ways (Amuda and Ibrahim, 2006).

However, various methods have been reported in literature for the treatment of these wastes (Sawyer et al, 2000). Some technologies have been developed over the years to remove organic matter and other dissolved substances from industrial wastes. Some of these technologies include Coagulation/Filtration process (Amuda et al, 2006), membrane filtration (Galambos et al, 2004), oxidation process (Martinez et al, 2003). These methods are generally expensive, complicated, time consuming and requires skilled personnel. The high cost of coal based activated carborns has stimulated the search for cheaper alternatives (Amuda and Ibrahim, 2006).

Many agricultural wastes are not put into proper use in Nigeria. Some of these wastes are not properly disposed and becomes a nuisance to our environment. This work is therefore focused on the development of cheap and readily available adsorbents made from bones and coconut shells which are agricultural wastes for the treatment of effluents from Garri processing industry and Hotel. This will go a long way in improving on indigenous technology by way of developing our local raw materials for use in our industries and reduce interdependent on imported raw materials and technologies which do not favour our economy.

Materials and Methods

Sources of materials: The major materials used include bone and coconut shell that were purchased from Bida, Niger state, while the effluents samples were collected from a cassava processing industry in Bida and Nicon Nuga Hilton Hotel Abuja.

Sample handling and preservation: The effluents collected from the cassava processing industry in Bida and Nicon Nuga Hilton Hotel Abuja are placed in resistance plastic bottles. The samples were placed in a refrigerator (Thermocool H-R 317) at 4^oC up to the time of analysis to minimize microbiological decomposition
(Ademoroti, 1986)

Carbonisation: Both bone and coconut shell samples were separately charged into a muffle furnace (Model FSSE 250-010-F/7B-11711) and were carbonised at 800^oC and 700^oC respectively in a limited supply of air. After cooling the carbonized products to room temperature, they were reduced to workable size of 75µm. These samples were chemically modified using 0.5M HCl solution and later rinsed with distill water to remove the excess acid. These activated carbons were dried in an oven (Gallikamp, SG 97-03-243) at 105^oC for one hour (Aneke and Okafor, 2007).

Thermal Activation: The carbonized samples were activated thermally with a locally made steam generator. The samples were placed in turn on top of the chest and steam was passed through the samples for six hours (Odebunmi and Okeola, 2001).

Chemical Activation: A carefully weighed 25.0g of carbonised bone sample was put in a beaker containing $500cm^3$ of 0.5M potassium hydroxide. The content of the beaker was thoroughly mixed and heated until it forms a paste. The paste formed was transferred into a crucible and placed in a furnace (Model FSSE 250-010-F/7B-11711) and heated to a temperature of 500^oC for two hours (Odebunmi and Okeola, 2001). It was cooled to room temperature and washed with distilled water and dried in an oven at 105^oC. The product was kept in an air-tight vial ready for use (Gimba et al, 2001). This procedure was repeated using concentrated HCl for coconut shell carbonaceous material.

Determination of physicochemical properties of adsorbents: The activated carbons characteristics (moisture content, bulk density, surface area, porous diameter and pore volumes) were determined using the methods described by Ahmedna et al (1997). Table 1.0 gives the characteristics of the activated carbons.

Effluent Treatment: 2.0, 4.0 and 6.0 grams of activated carbon was weighed carefully and added to 100cm^3 of effluent in a test tube. The mixture was intermittently shaken and was allowed to stand for 5, 10, 20, 30, 40, 50 and 60 minutes. At the end of these intervals of time, the mixture was filtered and the turbidity, concentration, pH, refractive index, viscosity, TDS, odour, colour, and BOD were determined. The measurements above were done at the end of 60 minutes, while changes in the absorbance were monitored with changes in time. The readings were as shown in Table 1.0. The graphs of absorbance against time were plotted as shown in figure 1.0 to 4.0.

Properties of Cassava and Hotel effluents

All equipment are checked and calibrated according to manufacturer specifications. The pH meter was calibrated using HACH (1997) buffers of pH 4.0, 7.0 and 10.0. TDS meter was calibrated using the potassium chloride solution provided by the manufacturer (HACH, 1997). The spectrophotometers (HACH DR 1997 and HACH DR 2010) were tested by passing standard solutions of all parameters to be measured. Reproducibility of results was achieved and all results are averages of two measurements (Yusuff and Sonibare, 2004).

The pH was measured using the pH meter. Total dissolved solids (TDS), Turbidity, and colour were determined using the spectrophotometer (Yusuff and Sonibare, 2004). The Biochemical oxygen demand (BOD) was determined by the method of Ademoroti (1986). The odour was determined by the method of Robert and Don (1997). The refractive index was determined by the method described by Gregory (2005).

Results

Table 1.0: Physicochemical properties of adsorbents before and after treatment

Property	Untreated Adsorbent		Adsorbent treated thermally		Adsorbent treated with HCl		Adsorbent treated with KOH	
	Bone	Coconut shell	Bone	Coconut shell	Bone	Coconut shell	Bone	Coconut shell
Moisture content (%)	2.98	3.01	3.31	3.52	2.82	2.91	2.90	3.01
Bulk density (g/cm^3)	3.12	2.98	2.86	2.75	2.61	2.32	2.52	2.01
Surface area (m^2/g)	512	564	705	812	729	895	809	921
Porous diameter (µm)	39.2	44.3	47.8	54.6	48.2	55.6	52.1	58.3
Pore volume (cm^3/g)	0.2971	0.3842	0.3189	0.4210	0.3821	0.4910	0.4010	0.5270

Table 2.0: Properties of Cassava and Hotel effluents before and after treatment with activated carbon

Property	Untreated Effluent		Bone treated thermally		Coconut shell treated thermally		Bone activated with KOH		Coconut shell Activated with KOH		Bone activated with HCl		Coconut shell Activated with HCl	
	Cassava	Hotel	Cassava	Hotel	Cassava	Hotel	Cassava	Hotel	Cassava	Hotel	Cassava	Hotel	Cassava	Hotel
Turbidity (NTU)	123.3	108.4	63.4	48.0	47.0	42.0	32.0	26.0	29.5	22.2	34.0	28.0	31.0	23.2
Concentration (ppm)	1.79	1.8	1.1	1.25	1.00	1.22	0.60	0.75	0.5	0.72	0.5	0.65	0.54	0.73
pH	3.28	8.35	4.29	7.70	5.45	7.66	6.54	7.04	6.80	7.05	6.45	7.10	6.88	7.20
Refractive index	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
Viscosity (centipoise)	5.55	1.01	5.47	2.00	5.50	0.60	5.40	0.90	5.44	0.90	4.46	1.00	5.54	1.00
TDS (mg/l)	272.94	323.07	38.77	58.92	41.45	59.82	27.00	39.00	25.04	39.83	26.00	38.00	26.05	42.80

Colour (Hazen)	10.0	15.0	5.0	8.0	4.0	7.0	3.0	6.0	1.0	2.0	3.0	5.0	2.0	3.0
BOD (mg/l)	18.0	54.0	14.0	49.0	9.0	35.0	7.0	32.0	9.0	35.0	11.0	32.0	10.0	38.0
Odour	offensive	offensive	Partially removed	Partially removed	Partially removed	Fairly removed	Fairly removed	Fairly removed	Removed	Removed	Fairly removed	Fairly removed	Fairly removed	Fairly removed

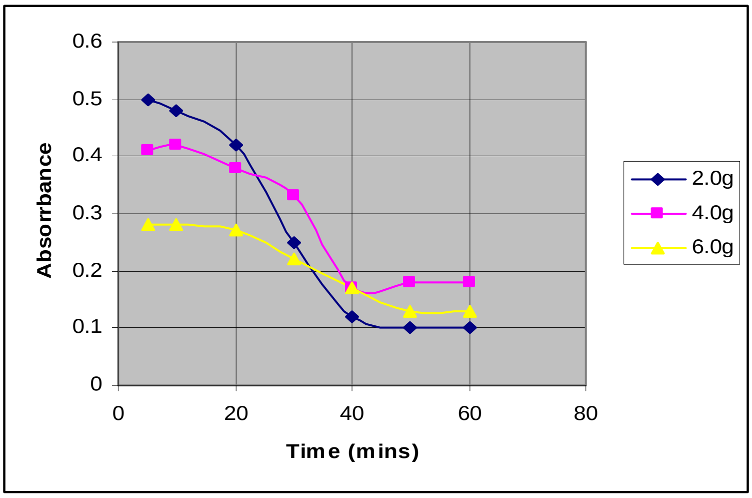

Figure 1.0: The effect of time on the absorbance of thermally treated bone on Hotel effluent

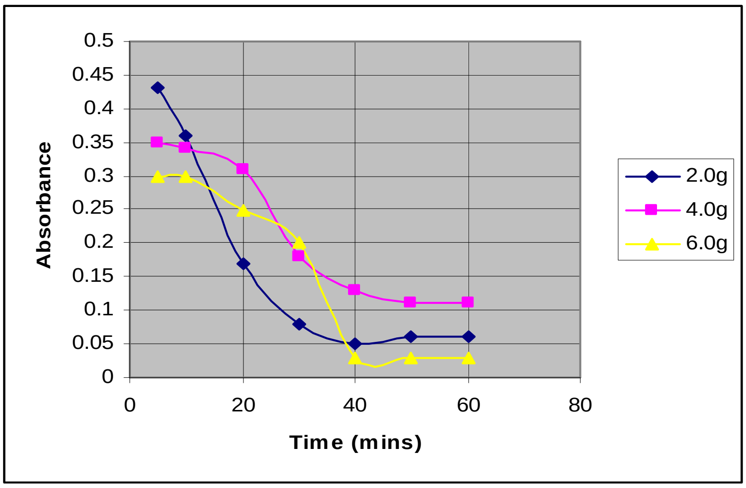

Figure 2.0: The effect of time on the absorbance of thermally treated coconut shell on Hotel effluent

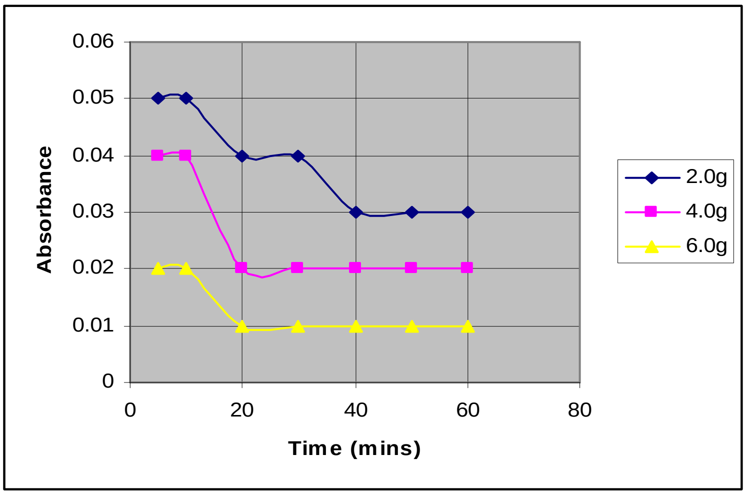

Figure 3.0: The effect of time on the absorbance of chemically treated bone on cassava effluent

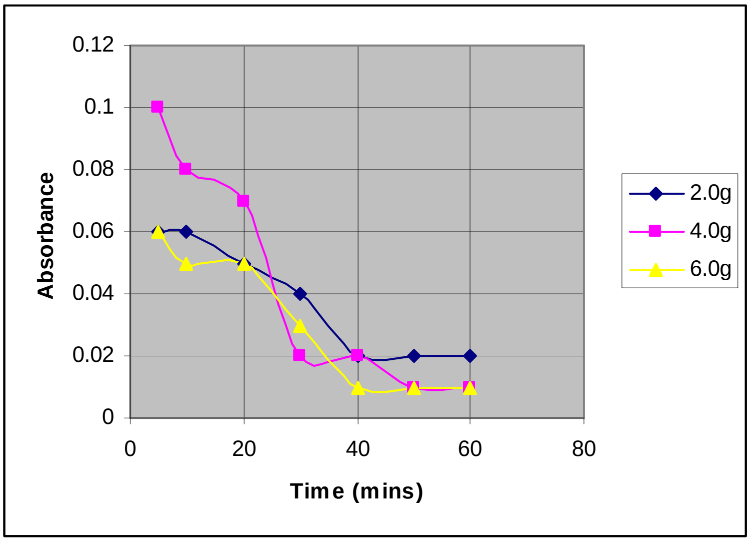

Figure 4.0: The effect of time on the absorbance of chemically treated coconut shell on cassava effluent

Discussion

The physicochemical properties of the bone and coconut based adsorbent were determine before and after treatment and the results shown in Table 1.0. As can be seen from the table, the untreated bone and coconut shell have surface areas, pore diameter and pore volumes of 512/564 m^2/g, 39.2/44.3 µm, and 0.2971/0.3842 cm^3/g respectively. After treating the bone and coconut shell adsorbents with steam the above properties changes to 705/895 m^2/g, 47.8/54.6 µm and 0.3189/0.4211 cm^3/g respectively. Improvement on these properties is achieved when bone and coconut shell adsorbents are treated with HCl acid and the results obtained are 729/895 m^2/g, 48.2/55.6 µm and 0.3821/0.4910 cm^3/g respectively. Better results were obtained as can be seen from the table when the adsorbents are treated with KOH solution. An increase in the values of these three properties (surface area, pore diameter and pore volume) results in increase in absorbance of the adsorbents. The results of the physicochemical properties of the adsorbents therefore show that the thermal and chemical treatment of the adsorbents results in the improvement of these properties which will consequently increase there absorptive capacities.

The efficiencies of the bone and coconut shell based adsorbents was assessed by treating the effluents with the adsorbents and measuring the physical and biochemical properties of the effluents before and after treatment with the various samples of the adsorbents. As can be seen from table 2.0 there was drastic reduction in the properties measured. The percentage reduction in the pollution indicator range from 75-90%.

Untreated cassava has a pH of 3.28 and the range of the pH for the treated effluent is 6.45-6.54 for activated bone and 5.45- 7.20 for activated coconut shell and this is within the limit of 5-9 which is the standard set by the Environmental protection Act 2002 except for bone activated thermally which is 4.29.This is also true for the Hotel treated effluents whose pH ranges from 7.1- 7.7 for activated bone and7.05-7.66 for activated coconut shell. The Biochemical oxygen demand (BOD) for all the treated samples using chemically treated bone and coconut shell adsorbents are lower than the standard limit of 40 mg/L in the environmental protection Act 2002. Also satisfactory results was obtained for the total dissolved solids (TDS) with all samples treated with bone and coconut shell adsorbents recording TDS values less than the 500 mg/L standard limit in the environmental protection Act 2002.

In all cases, treated coconut shell adsorbents performed better than the treated bone adsorbents with the coconut shell treated with KOH giving the best result. This is no doubt due to better physicochemical properties offered by the said treated sample.

It was also observed that equilibrium is altered in all the four samples (figure 1.0 to 4.0). Adsorption of these pollutants was also instantaneous taking about forty minutes to reach break through absorbance (constant absorbance).

Conclusion

Bone and coconut shell which are agricultural waste can be used to produce cheap and readily available adsorbent for effective treatment of effluents from Garri processing industry and Hotel. These adsorbents could serve as useful alternatives to the imported commercial activated carbon. The result of this research is a welcome development in the area of indigenous raw material development for our industries and reduce interdependent in foreign technology.

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