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Analyzing the Efficiencies of Two Locally-Produced Adsorbents (Plantain Peels and Elephant Grass) for Treatment of Food Industry Effluent

O. B. Ogunwole[1], O. L. Lasebikan[2], B. O. Banigo[3], A. Aseminaso[4], N. O. Okechukwu[5]
[1,2,3,4,5]Department of Chemical Engineering Technology, School of Engineering Technology, Federal Polytechnic of Oil and Gas, P.M.B. 5027, Bonny Island, Rivers State, Nigeria
([1]log_olalekan@yahoo.com)

Abstract-This research analyzed the efficiencies of plantain peels and elephant grass as adsorbents needed for the treatment of food industry effluent in a selected drain site in Rivers State, Nigeria. The two locally-made adsorbents were pyrolyzed at 550^0C. Here are some characterization properties done on the samples and these include porosity, surface area, organic content, moisture content and pH. The physico-chemical and structural properties evaluated for the plantain peels were: surface area (54.70cm^2/g), moisture content (3.62%), pH (8.1), bulk density (0.32ml/g), pore volume (0.28g/ml), porosity (95%), ash content (9.06) and metal ions present in varying proportions, with zinc ion (Zn^{2+}) having the largest value, followed by iron (Fe^{2+}), the elephant grass were surface area (29.01cm^2/g), moisture content (3.47%), pH (8.02), bulk density (0.45ml/g), pore volume (0.43g/ml), porosity (91.2%), ash content (8.16%), and metal ions present gave varying amount as in plantain peels. Wastewater from Genesis foods was treated with activated carbon from both plantain peels and elephant grass each with a view to determining the extent of treatment with time. Important wastewater parameters analyzed include: Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD); Dissolved Oxygen (DO), Turbidity and Ph. The observation is that the plantain peels activated carbon has larger surface area of 54.70cm^2/g comparatively. There is change in the physico-chemical parameters as the raw waste water was treated with varied time, this indicates that there is actual improvement of these physico-chemical parameters with time, the drop in their values with time (with plantain peels recording higher drop) also shows that it is more efficient than elephant grass in the treatment, and thus it is a better adsorbent.

Keywords- *Adsorbents, Activated Carbon, Wastewater, COD, BOD, Physico-Chemical Characterization*

I. Introduction

Sources of industrial waste water can be traced to food and beverage industries, and the wastewater produced from their operations possess distinctive qualities that differentiate it from common municipal wastewater managed by public or private wastewater treatment plants throughout the world. It is biodegradable and harmless, with the exception of some toxic cleaning products, but has high concentration of Biological Oxygen Demand (BOD), and suspended solids. The constituents of this wastewater are often complex to predict due to the differences in BOD and pH in effluents from vegetable, fruit, and meat products and due to the seasonal nature of food processing.

The development of low-cost materials especially agricultural wastes for treatment of industrial effluent or wastewater is essential because of high cost of available adsorbents and technologies involved in producing them.

Considering a developing country like Nigeria, agriculture contributes to the nation's economy after crude oil. The presence of industries across the country has contributed to level of pollution in the country. Pollution of water and soil by organic and inorganic chemicals is of serious environmental concern. One of the accepted methodologies for waste reduction in domestic as well as an industrial waste management is to find some use for the waste products so that these may become resource materials for some useful products at the same time cease to be waste products (Veglio and Beolchini, 1997). This research finding is undertaken to address such issue.

The presence of heavy metal ions in industrial discharges has caused serious environmental problems, mainly because of unwanted bioaccumulation in humans. Consistent use of metals and chemicals in process industries has resulted in generation of large quantities of effluent that contains high level of toxic heavy metals and their presence poses environmental – disposal problems due to their non-degradable and persistence nature (Olayinka et al, 2009). Effluents from process industries contain heavy metals such as Cr(III), Cr(IV), Zn, Cd, Cu, Ni, Hg and Pb. Coupled with mineral processing and extractive metallurgical operations generate toxic liquid wastes (Goyal and Ahluwalia, 2007). Adsorption on low cost adsorbent for removal of toxic metals from wastewater has been investigated extensively. These materials include thioglycolic acid modified oil-palm (Akaniwor et al, 2007), wild cocoyam biomass (Horsfall and Spiff, 2004), brewery biomass.

Activated charcoal is the adsorbent of choice, but high costs are a concern. Therefore, cheap bio-derived materials of renewable sources are suitable alternatives. Many researchers have identified the low-cost adsorbents like sawdust, rice husk, coir pith, coconut shell, waste tea powder, sugar cane bagasse and others, and included in this study are plantain peels and elephant grass.

The plantain (Musa Paradisiaca) is a major group of banana varieties (genus Musa) that are stable foods in many tropical areas. The edible fruit of plantain bananas has large starch, sweet-taste, and tuberous roots than roots of common vegetables. The young leaves and shoots are sometimes eaten as greens. Of the several genera and multiple species of plantain, musa paradisiaca is the crop plant of major importance – some are used consumed locally, and some for other purposes. The cooked plantains are nutritionally very similar to a potato, calorie-wise, but contain more of certain vitamins and minerals. They are a rich source of fiber, vitamins A, C, and B, and minerals magnesium and potassium.

Meanwhile, the elephant grass (Pennisetum Purpureum Schumach) is majorly tropical grass. It is one of the highest yielding tropical grasses. Its versatility and ability to grow in a variety of conditions make it popular in high-traffic areas as well as areas with diverse weather conditions throughout the year. Grass is an environmentally friendly, low cost and abundant material after mowing gardens, lawns and parks. Few researches were performed on the use of gardens grass (GG) as biosorbent.

Adsorption is a mass transfer process that involves the accumulation of substances at the interface of two phases, such as, liquid-liquid, gas-liquid, gas-solid or liquid-solid interface.

The substance being adsorbed is the adsorbate and the adsorbing material is termed the adsorbent. The properties of adsorbates and adsorbents are quite specific and depend upon their constituents. Senthilkumaar et al, (2005) studied adsorption of dissolved reactive red dye from aqueous phase on to sweet potato skin prepared from agricultural waste-yellow sweet potato. The overall rate of dye adsorption appeared to be controlled by chemisorption, in this case in accordance with poor desorption studies. (Gimba and Turoti, 2006) studied the adsorption efficiency of $FeCl_3$, $CaCl_2$ and K_2CO_3 garden city grass for the 500um particle size produced from previously carbonized grass on some adsorbates obtained from an industrial effluent and waste waters as well as the colour of molasses has been studied.

Egwaikhide et al, (2007) studied utilization of garden grass in the removal of soluble petroleum fraction polluted water. Also, Hameed et al, (2007) worked on preparation of activated carbon from garden grass with optimization study on removal of 2,4,6 trichlorophenol using response surface methodology. Effluent is water that has been adversely affected in quality by anthropogenic influence. It can be described as water generated along process operation in any industry. Waste water is sometimes used to describe liquid waste. These waters can come from human waste, septic tank discharge, sewage treatment plant discharge, industrial cooling waters etc.

This paper therefore seeks to compare the efficiencies of plantain peels and elephant grass for the treatment of food industry effluent.

II. MATERIALS AND METHODS

Both the plantain peels and elephant grass were sourced from the market and road-side respectively. Plantain was peeled and then dried under the sun for three days while, the elephant grass was kept in the sun for four days to dry.

The dried plantain peels and the elephant grass samples needed for activated carbon were prepared by washing properly with water, dried in an oven and then pulverized separately.

III. Determination of the Physical Properties of the Plantain Peels and Elephant Grass Generated Activated Carbon

The following are some of the determined physical properties of the plantain peels and elephant grass:

Moisture content which was determined using the ASTM method, D280-33. The samples were weighed and dried at 115^0C for 1hr 30 minutes. It was calculated using the formula:

$$\%\ moisture\ content = \frac{Loss\ in\ weight\ of\ sample}{Original\ weight} \times 100$$

Surface area of the two samples was determined by the iodine adsorption method. It is calculated as:

$$Surface\ area = \left(\frac{X - S}{X} \times \frac{VM}{W} \times 126.91 \right)$$

Ash content was determined by pulverizing the samples in the furnace at 850^0C for 3hrs and then allowed to cool in a desiccator before the weight of ash was taken.

Ash content = $W_2 - W_1$

IV. Determination of the Structural Properties of Plantain Peels and Elephant Grass Generated Activated Carbon

Bulk density of the samples was determined using the formula below;

$$Bulk\ density = \frac{mass\ of\ adsorbent\ sample}{Volume\ of\ water\ displaced}$$

Porosity of the samples was determined using the expression below;

$$Porosity\ (f) = \frac{pore\ space}{Total\ volume} \times 100$$

Pore volume was determined as the product of porosity and bulk volume. That is;

Pore volume = V_b x ϕ

Also, Tortuosity was measured as the inverse of the value obtained from the porosity.

V. Analysis of the Waste Water Quality Parameters

Dissolved Oxygen (DO) was measured using APHA, (1998) method and analyzed by Winkler's method. DO was calculated by DO (mg/L) = (mL x N) of titrant×8×1000V_2× (V_1 – V) V_1.

Where; V_1 = volume of sample bottle after placing the stopper.

V_2 = volume of part of content titrated

V = volume of $MnSO_4$ and KI added

pH measurement was done by automatic digital pH meter. The pH meter was first calibrated with a standard buffer solution and the glass electrode was properly rinsed with distilled water. The glass electrode was dipped in the beaker containing water sample until the reading stabilized at a certain point.

Biological Oxygen Demand (BOD) was determined by measuring the dissolved oxygen level in a freshly collected waste water sample and compared to the dissolved oxygen level in a sample collected at the same time but incubated under specific condition for 5 days. A BOD value was obtained and recorded.

Chemical Oxygen Demand (COD) was determined in the same manner as BOD and a value was obtained and recorded.

VI. Analysis of Particle Size of the Plantain Peels and Elephant Grass Activated Carbon

The particle size was determined by first of all removing the organic materials, and subjects it to centrifugation and dispersion of the aggregates of sample particle sizes and finally sieved into fine and coarse fractions using wet sieve.

VII. RESULTS AND DISCUSSION

Analyzing the results of the experiment as computed in Table 1, it is observed that the values obtained for moisture content, ash content, pH and surface area are higher for plantain peels than for the elephant grass. For instance, the activated carbon generated from plantain peels has a surface area of 56.75 cm^2/g which is bigger than of elephant grass at 29.78 cm^2/g, and it is found to be as a result of higher porosity (96%) of the sample which is more than that of elephant grass at 91.7%. Comparing the bulk density and pore volume of the two feed stocks,

The pH indicates that elephant grass generated activated carbon is less acidic than the plantain peels generated activated carbon and the ash contents of both are close.

The result of the chemical properties of both activated carbons shows that there are significant metal ions in the samples. Sodium (Na^+) has biggest metal ions in the plantain peels while calcium (Ca^{2+}) has the largest value of metal ions in elephant grass activated carbon.

The bulk density of plantain peels (0.45 g/cm^3) is higher than that of elephant grass (0.33 g/cm^3). It helps to determine the quantity of carbon contained in a filter of a given solid capacity during filtration.

From Tables 4 and 5, it is seen that the range of particle sizes most predominant in the samples were 0.393mm – 1.20mm and 0.063mm – 0.150mm respectively. The former shows a coherence with the sieve diameter, 600µm (0.6mm) used in the process and the latter comes as a result of impact used as the technique for crushing plantain peels and the elephant grass, which is a single acting force in a particular direction.

Table 6, indicates there is a clear concentration decrease after treatment of water by plantain peels generated activated carbon. The concentration of TSS in the solution decreased from 1574mg/l – 190mg/l (87.9%) after treatment and shows great improvement in the absorption capacity of the activated carbon.

Similarly, treatment of the waste water with elephant grass generated activated carbon caused concentration of TSS in the solution to decrease from 1574mg/l – 688mg/l (56.3%) as shown in Table 7.

TABLE I. PHYSICAL PROPERTIES OF THE PLANTAIN PEELS AND ELEPHANT GRASS BASED ACTIVATED CARBON

S/N	Property	Plantain peels	Elephant grass
1	Moisture content (%)	5.61	3.52
2	Ash content (%)	9.07	8.15
3	pH	6.03	6.25
4	Surface area (cm^2/g)	56.75	29.78

TABLE II. CHEMICAL PROPERTIES OF PLANTAIN PEELS AND ELEPHANT GRASS BASED ACTIVATED CARBON

S/N	Property	Plantain peels	Elephant grass
1	Iron, Fe^{2+} (mg/kg)	176.3	320.1
2	Sodium, Na^+ (mg/kg)	742.4	228.6
3	Magnesium, Mg^{2+}(mg/kg)	328.6	415.0
4	Calcium, Ca^{2+}(mg/kg)	282.5	554.3

TABLE III. STRUCTURAL PROPERTIES OF PLANTAIN PEELS AND ELEPHANT GRASS BASED ACTIVATED CARBON

S/N	Property	Plantain peels	Elephant grass
1	Bulk density (g/ml)	0.45	0.33
2	Porosity (%)	95	91.7
3	Pore volume (ml/g)	0.44	0.28
4	Tortuosity	1.06	1.13

TABLE IV. PARTICLE SIZE DISTRIBUTION OF PLANTAIN PEELS ACTIVATED CARBON

Sieve Diameter (mm)	Limits of the Particle size (mm)	Mass of particles retained (g)	% Retained	% Cumulative Retained	% Cumulative passing
1.80	1.80 – 3.500	0.20	0.10	0.13	99.76
1.20	1.20 – 1.800	0.56	0.32	0.43	99.3
0.393	0.393 – 1.20	48.4	28.4	33.1	68.2
0.261	0.261-0.393	38.7	26.8	62.6	39.4
0.142	0.142-0.261	27.3	15.1	66.7	36.6
0.078	0.078-0.142	49.1	27.46	96.4	4.8
PAN	0.000-0.078	14.6	-	-	-

TABLE V. PARTICLE SIZE DISTRIBUTION OF ELEPHANT GRASS ACTIVATED CARBON

Sieve Diameter (mm)	Limits of the Particle size (mm)	Mass of particles retained (g)	% Retained	% Cumulative Retained	% Cumulative passing
1.80	1.80 – 3.500	0.92	1.08	0.9	99.4
1.20	1.20 – 1.80	4.81	2.80	4.82	96.1
0.393	0.393 – 1.20	58.2	36.02	44.9	55.6
0.261	0.261-0.393	27.3	29.4	69.01	32.5
0.142	0.142-0.261	21.9	13.1	78.4	24.3
0.078	0.078-0.142	35.6	20.46	98.1	1.88
PAN	0.000-0.078	5.4	-	-	-

TABLE VI. ADSORPTION OF WATER QUALITY PARAMETERS OF PLANTAIN PEELS GENERATED ACTIVATED CARBON

S/N	Parameters	Concentration before treatment	Concentration after treatment
1	TSS (mg/l)	1578	191
2	COD (mg/l)	876	0.794
3	BOD (mg/l)	3.485	0.531
4	pH	7.8	8.4

TABLE VII. ADSORPTION OF WATER QUALITY PARAMETERS OF ELEPHANT GRASS GENERATED ACTIVATED CARBON

S/N	Parameters	Concentration before treatment	Concentration after treatment
1	TSS (mg/l)	1578	690
2	COD (mg/l)	876	54.46
3	BOD (mg/l)	3.485	1.040
4	pH	7.8	8.02

From the outcome of the experiment, it can be inferred that high pore volume and porosity are very important properties of the adsorbents and the values obtained are comparable with other commercially produced activated carbon. These properties are higher in plantain peels generated activated carbon than in elephant grass generated activated carbon.

It is also correct to conclude that the larger surface area of the plantain peels means it has significant active sites for adsorbate molecules than the elephant grass activated carbon. Likewise, the experimented samples have relatively permissible ash content because if its value is very high, it will impact the mechanical strength and its absorptive power of the adsorbents hence reduces the overall activity of the activated carbon.

Consequentially, locally produced activated carbon from agricultural wastes should be used as a substitute for the commercially produced activated carbon as adsorbents because they are economically viable, cost effective, readily available and very efficient for the removal of heavy metals.

VIII. CONCLUSION

The results of this experimental findings shows that locally produced adsorbents from agricultural wastes have a great potential for the adsorption of heavy metals from wastewater. The physicochemical and structural properties of the two adsorbents indicate that plantain peels generated activated carbon is more efficient adsorbent than elephant grass generated activated carbon. Their qualities are highly dependent on the preparation methods and experimental techniques.

REFERENCES

[1] Ahluwalia, S.S., and Goyal, D. (2007): "Removal of heavy metals by waste tea leaves from aqueous solution" Engg in Life Sci 5: 158-162.

[2] Akaniwor, S. (2007): "A survey of potential industrial products of the coconut". A symposium paper on problem of coconut plantation and industry, Quezon city, p.23.

[3] Egwaikhide, P.A., Akporhonor, E.E; and Okieimen, F.E. (2007); "Utilization of coconut fibre carbon in the removal of soluble petroleum fraction polluted water", Int. J. Phys. Sci. vol.2 (2), pp.47-49, February, 2007.

[4] Gimba, C.E; and Turoti, M. (2006): "Adsorption efficiency of coconut shell-based activated carbons on colour of molasses, oils, dissolved

oxygen and related parameters from industrial effluent", science world Journal, vol.1 (No.1), pp 21-26, 2006.

[5] Horsfall and Spiff (2004): "Comparative study on biosorption of Zn(II), Cu(II) and Cr(VI) from textile dye effluent using activated risk husk and activated coconut fibre" Indian J. Chem Technol, vol.18(2011), pp.61-66.

[6] Okieimen, C.O; and Okieimen, F.E. (2001): "Enhanced metal sorption by groundnut (Arachis hypogea) husks modified with thiglycollic acid". Bull Piere Appl. Sci. 20C: 13-20.

[7] Olayinka, K.O. Alo, B.I. and Adu, T. (2007): "Sorption of heavy metals from electroplating effluents by low cost adsorbents II: use of waste tea, coconut shell and coconut husk, J. Applied Sci. 7 (2007) 2307 – 2313.

[8] Olayinka, K.O., Oyedeji, O.A. and Oyeyiola, O.A. (2009), "Removal of Chromium and nickel ions from aqueous solution by adsorption on modified coconut husk", Afr. Environ. Sci. Technol. Vol.3 (10), pp.286-293, 209.

[9] Senthilkumaar, S., Kalaamani, P., Porkodi, K., Varadarajan, P.R., and Subburaan, C.V. (2006), "Bioresource Technology, 2006, 97, 1618 – 1625.

[10] Tan, I.A., Ahmad, A.L., and Hameed, B.H. (2007), "Preparation of activated carbon from coconut husk": Optimization study on removal of 2,4,6 – trichlorophenol using response surface methodology", Journal of Hazardous materials 153 (2008) pp.709-717.

[11] Veglio and Beolchini, (1997): "Wastewater Eng. Treatment and Reuse". 4th Edition ed. McGraw – Hill Edition, New York, NY, USA.

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