Comparative Study of the Physicochemical and Structural Characteristics of Lipton and Green Tea Wastes as Low Cost Adsorbent Using HNo₃ As Activating Agent

Evbuomwan B.O and Boyle S .K

Department of Chemical Engineering, University of Port Harcourt, Port Harcourt, Nigeria

Abstract: - **The comparative study of the physiochemical and structural characteristics of green and lipton tea wastes as low cost adsorbents using nitric acid had been studied. . The two tea waste samples were carbonized at 160°C for one hour 10 mins. The properties evaluated were surface area, moisture content, pH, bulk density, pore volume, porosity, tortuocity, ash content, metal ions present. One way analysis of variance was done to known the level of significance.**

The results obtained from the analysis for green and lipton tea were surface area, (839m²/g) and (711m²/g), ash content, (57%) and (49.56%), moisture content, (38.53%) and (40.76%), pH, (6.0) and(6.0), bulk density, (0.303g/cm³) and (0.312g/cm³), porosity, (0.594) and (0.585), pore volume, (6.3) and (7.71), tortuocity, (1.68) and (1.71) respectively. This study showed that green tea waste has better adsorptive capacity than lipton tea waste with a larger surface area, porosity, and ash content.

The following heavy metals where tested for Lead (1.13576), Magnesium (0.62114) for green tea waste and Lead (0.82043), Magnesium (0.51931) for lipton tea using an electro-photo spectrometer. With these results, it was observed that the heavy metal content were insignificant in the adsorbents and they are good for such metal adsorption from waste water.

Keywords: **Green tea, Lipton tea, physicochemical, Heavy metal, Adsorbent, and Activating agent**

I. INTRODUCTION

The high increase in demand for portable water for domestic and industrial uses cannot be over emphasized [1]. Treatment of raw water to remove unwanted materials has been a long term practice, being of utmost importance, the need of its quality improvement and preservation is growing continuously. The rapid growth of the world population, industrialization, unplanned urbanization, agricultural activities, as well as the excessive use of chemicals has contributed to environmental pollution[2]. Inorganic and organic wastes produced by human activities have resulted in high volumes of contaminated water which threatens human health and other living organisms, these discharge of pollution into water bodies not only can aesthetically cause issues, but also it is harmful to biological organisms and ecology [3].Considering the fact that removal of these toxic pollutions from wastewater is highly essential for the well-being of humans, it is however very expensive. Recently numerous approaches have been studied for the development of cheaper and effective adsorbents[4].Different methods have now been used for removal of such metal ions and dyes such as reduction, precipitation, adsorption, oxidation, and ion exchange. However, adsorption process is known to be the most suitable method because of its high efficiency and economic consideration. Many low-cost adsorbents, including natural materials, biosorbents, and waste materials from agriculture and industry, have been proposed by several researchers. These materials could be used as adsorbents for the removal of heavy metal ions and dyes from wastewater. These methods differ in their effectiveness and cost. Therefore, there is a need to look into alternatives to investigate a low-cost method which is effective and economical. For high strength and low volumes of wastewater, heavy metal removal by adsorption technique is a good proposition. Adsorption I sone of the alternatives as it is the tendency of molecules, from an ambient fluid phase to adhere to the surface of a solid. Solids that are used to adsorb gases or dissolved substances are called adsorbents; the adsorbed molecules are usually referred to collectively as the adsorbate. It is an effective purification and separation technique used in industry especially in water and wastewater treatments. Adsorption has advantages over other methods as the design is simple, sludge-free and can involve low investment in terms of both the initial costs and work area[5]. Adsorption is often used to extract pollutants by causing them to be attached to adsorbents; they are porous solids which bind liquid or gaseous molecules to their surface. Highly porous substances like tea ash are great adsorbents. The process for adsorption often involves what's called a fixed bed adsorber, in which a substance such as air passes through a solid adsorbent. As the air passes the adsorbent it attracts the unwanted particles contained in the air. Materials known as adsorbent are essential for cleanup processes, adsorbents attracts other liquids or gases onto its surface only. However, the "surface" can include internal surfaces, like pores and capillaries. Industrially, adsorbent materials are used in a wide range of applications, including purification, separations, drying, spill management, catalysis, pollution control and others across a large number of industrial sectors. Adsorption is driven generally by the reduction in surface tension between

the fluid (liquid or gas) and the solid adsorbent that results when the adsorbate molecule adheres to the surface of the adsorbent. Adsorption differs from absorption in that adsorption describes accumulation of molecules at the interface between the solid and fluid phases, while absorption involves one substance entering the bulk or volume of another. Adsorption has been found to occur in many natural physical, biological, and chemical systems. It is widely used in laboratory research, industrial applications, and water purification systems. Tea is obtained from the leaves of the Camellia sinensis L Camellia assamica and Cambodiensis plants[6]. It is without doubt that the tea is the most popular and widely consumed beverage that is consumed around the world. The consumption of tea alone equals that of coffee, chocolate, soft drinks, and alcohol combined [7]. Such a staggering level of consumption brings forth with the issues regarding the safe disposal of the tea leaves as about 90% of the tea is left behind post- extraction and consumption [8]: [9]off in the small bays surrounding Black Sea [10].The aim of this paper is to determine and compare the adsorptive properties of two different tea wastes as a low cost adsorbents and to select the adsorbent with higher adsorptive properties.

II. MATERIALS AND METHODS

Sample collection and preparation

Lipton and green waste tea bags were collected from some houses in Choba, Rivers State, Nigeria. All chemicals used during the experiment are of analytical grades, The contents of the bags were emptied, weighed with beam balance, soaked in 200ml of distilled water overnight and then washed several times. It was then dried using a tray dryer at $80^{\circ}C$ for three hours.

The dried tea waste were weighed using a weighing balance. Then, they were wrapped in a foil and placed in the muffle furnace which was preheated in and set to a temperature of $160^{\circ}C$. The temperature was confirmed with the aid of thermocouple and the sample was heated in the furnace for 1hour 10minutes. At this point, carbonization has taken place. Afterwards, the carbonized sample was removed from the muffle furnace and placed in a desiccator for cooling in the absence of oxygen. After cooling, the carbonized sample was weighted using the electrical weighing balance.

Activation

The carbonized tea wastes were crushed, crushing provided smaller particles with increased surface area and also to enable more efficient chemical activation of the tea wastes, ensure surface exposure and also make it easier to carry out the analysis. The chemicals were mixed with water before the tea waste was put in for impregnation. The tea waste was sieved, collected and washed with distilled water until the wastes were free from colour. It serves the purpose of reducing the pH of the activated carbon since it will be increased by the acid during the activation. Afterwards, the water was filtered-off and the sample was dried in a tray drier at $80^{\circ}C$.

HNO_3 was used for the activation because it yields higher porosity in the activated carbon. The activated Carbon was then dried and stored for characterization.

Determination of Physicochemical Properties of Activated Tea waste (Tw)

pH

The pH was measured by electronic method using laboratory pH meter, Hanna model H1991300

Bulk Density

A 25ml beaker was heated to dryness after which it was allowed to cool. The beaker was weighed after cooling w_1. The beaker was then filled to a predetermined point/mark w_2. The beaker containing the activated carbon (TW) sample was then weighed accordingly w_3.Since bulk density D_b, was a measure of the mass of simple per volume (solid + pore space) and was usually reported on an oven dry basis.

$$D_b = \frac{mass\ of\ dry\ sample}{volume\ of\ solid\ and\ pore\ spaces} = \frac{W_3 - W_1}{W_2} \qquad 1$$

Pore Density

A 25ml beaker was heated to dryness after which it was allowed to cool. The beaker was weighed after cooling w_1. The beaker was then filled to a predetermined point/mark w_2. The bottom of the beaker containing the TW sample was then continually bumped on a solid surface to ensure the pore spaces are closed. As the volume of the sample reduces from the initial mark, more TW sample was added to the beaker to close up the pore spaces. This was done until the entire pore spaces are completely filled, and the TW sample was returned to the initial point mark. The beaker containing the TW sample devoid of pore was then weighed accordingly w_3

Pore density D_p was a measure of the mass of sample per unit volume and was usually reported on an oven dry basis.

$$D_p = \frac{mass\ of\ dry\ sample}{volume\ of\ sample} = \frac{W_3 - W_1}{W_2} 1 \qquad 2$$

Porosity

Porosity is related to bulk density and pore density through the relationship

$$Porosity = 1 - \frac{D_b}{D_P} \qquad 3$$

Where D_b= Bulk density

D_p=Pore density

Surface Area

The surface area of the green and lipton waste samples were estimated using the sear's method [11] by agitating 1.5g of teawastes sample in 100mL of diluted HCL of a pH = 3. Then 30g of NaCL was added with stirring and the volume was

made up to 150mL with deionized water. The solution was titrated with 0.10 N NaOH and the volume, V, needed to raise the pH from 4-9 was then recorded. The surface area according to this method was calculated by the following equation:

$$S(m^2g^{-1}) = 32V-25 \qquad 4$$

Where S = surface area

V = Volume of Sodium hydroxide required to raise the pH of the sample from 4-9. This volume was measured in replicate and the average value was taken for the surface area calculation.

Ash Content

An empty crucible was washed, dried and weighed w_1 on the electronic balance. 2g of TW sample was then weighed into the crucible using spatula and then weighed (crucible + sample) w_2 recorded. The crucible and its contents are placed inside the muffle furnace 750^oC for 2 hours, The sample was removed from the furnace, cooled in a desiccators and the weight W_3 taken.

The % ash contentment was then calculated from

$$\% \text{ Ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100 \qquad 5$$

where

W_1 = Weight of empty crucible

W_2 = Weight of crucible + TW sample before burning

W_3 = Weight of platinum ash

Moisture Content

The hydroscopic moisture content was determined using ASTM method D280-33 [12].

Pore Volume

1g of sample was collected and transferred completely into a 10ml measuring cylinder in order to get the volume of the sample. The sample was then poured into a beaker containing 20ml of distilled water and boiled for 5minutes. The content of the beaker was then filtered, superficially dried and weighed. The pore volume of the sample was determined by dividing the increase in weight of the sample by the density of water.

$$Pore\ volume = \frac{w_2 - w_1}{\rho_w} \qquad 7$$

Where w_1 = initial weight of sample

W_2 = final weight of sample after boiling

ρw = density of water

Heavy Metal Determination

The samples were digested with H_2SO_4 and then analysed using Perkin Elmer Atomic Absorption Spectrophotometer model number Buck Scientific 210.

III. RESULTS AND DISCUSSION

Table 1: Physical properties of green and lipton tea waste

S/N	PROPERTY	GREEN TEA WASTE	LIPTON TEA WASTE
1	pH	6.0	6.0
2	Moisture content %	38.53	40.76
3	Ash content %	57	49.56
4	Surface area (m^2/g)	839	711

Table 2: Structural properties of green and lipton tea wastes

S/N	PROPERTY	GREEN TEA WASTE	LIPTON TEA WASTE
1	Bulk density(g/cm3)	0.3033	0.312
2	Porosity (%)	0.594	0.585
3	Pore density (g/cm3)	0.7514	0.760
4	Pore volume(cm/g)	6.3	7.71
5	Tortuocity	1.68	1.70

Table 3: Chemical properties of green and lipton tea wastes

S/N	HEAVY METAL	GREEN TEA WASTE	LIPTON TEA WASTE
1	Lead	1.13576	0.82043
2	Magnesium	0.62114	0.51931

TABLE 4: Parameters for Two Way Analysis Of Variance

PARAMETERS	GREEN TEA WASTE	LIPTON TEA WASTE
Ph	6.0	6.0
Bulk density (g/cm3)	0.3033	0.312
Ash content(%)	57	49.56
Porosity (%)	0.594	0.585
Surface area	839	711
Pore volume (cm3/g)	6.3	7.71
Moisture content(%)	38.53	40.7

TABLE5: Two Factor Without Replication

SUMMARY	Count	Sum	Average	Variance
pH	2	12	6	0
bulk density	2	0.6153	0.30765	3.78E-05
ash content	2	106.56	53.28	27.6768
Porosity	2	1.179	0.5895	4.05E-05
surface area	2	1550	775	8192
pore volume	2	14.01	7.005	0.99405
moisture content	2	79.29	39.645	2.48645
GREEN TEA WASTE	7	947.7273	135.3896	96736.38
LIPTON TEA WASTE	7	815.927	116.561	69104.86

TABLE 6

ANOVA				
Source of Variation	*SS*	*Df*	*MS*	*F*
Rows	988065.1	6	164677.5	141.509
Columns	1240.809	1	1240.809	1.066239
Error	6982.349	6	1163.725	
Total	996288.3	13		

Results obtained from the physiochemical characteristics of TW samples are shown in tables 1 to 6. From the result in table 1, it can be observed that the pH of the spent green and lipton tea wastes samples are slightly acidic at 6.0, which is considered ideal for adsorption purposes as maximum adsorption of heavy metals by most activated carbon occurs at low pH than at high pH The reported moisture content of green tea waste (38.53%) and lipton tea waste (40.76%). was very small showing that the adsorbent was properly prepared. It should be noted that when exposed to air, the TW samples or other agricultural waste by-product activated carbon is capable of adsorbing moisture from the atmosphere. For many purposes, the moisture content does not affect the adsorptive power, but obviously it dilutes the carbon. Therefore, an additional weight of moist carbon needed to provide the required dry weight. The presence of ash has been shown to inhibit surface development, consequently low surface area is observed in carbons with high ash content. The raw material, the particle size range used and the degree of activation affect bulk density which does have an effect on adsorption per unit volume . Ash content can lead to increase hydrophilicity and can have catalytic effects, causing restructuring. The inorganic material contained in activated carbon is measured as ash content.

The most important property of activated carbon is it adsorptive capacity, which is related to its specific surface area. Generally, the higher the surface area, the larger is its adsorptive capacity and the better its adsorptive performance.

Other results obtained from the physiochemical characterization of TW samples include bulk density($0.303g/cm^3$) for green tea waste and lipton tea waste ($3.12g/cm^3$), porosity(0.594%) for green tea waste and (0.585%) of lipton tea waste . The density of an activated carbon depends on not only the nature of its raw material but also its preparation, resulting in a reduction of porosity.

The pore density obtained from the green tea sample is $0.7514g/cm^3$ and ($0.760g/cm^3$) compares favorably with that of palm kernel shell activated carbon $0.69g/cm^3$ and oil palm fibre activated carbon $0.58g/cm^3$ in the comparative study of physiochemical properties of activated carbon from oil palm waste by [13].

Besides surface area, pore diameter is also an important characteristic of the activated carbon. The decrease in pore diameter increases the total pore volume of activated carbon. Hence, it increases the distribution of surface area. The pore volume limits the size of the molecules that can be adsorbed whilst the surface area limits the amount of material which can be adsorbed,

The concentration of these heavy metals in green and lipton tea wastes are deemed too small (trace quantity) to have any appreciable influence on any adsorption process involving the analyzed sample of TW. The insignificant values of these heavy metals do not in any way pose any significant threat to the environment neither are they deemed as health hazard.

IV. CONCLUSION

The results obtained from the physicochemical characteristics of green and liptontea wastes as low-cost adsorbents showed that the tea wastes is a viable low-cost adsorbent which can compete favorably with most of the adsorbents commonly used in the industry in terms of cost, selectivity, regenerability, capacity, compatibility and availability. This study showed that green tea waste has better adsorptive capacity than lipton tea waste with a larger surface area, porosity, and ash content.

The result from the heavy metal analysis shows that activated carbon made from tea waste is suitable for removing heavy metals and other contaminants from effluents.

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