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TREATMENT OF DOMESTIC WASTE WATER WITH ACTIVATED CARBON FROM LOCUST BEAN (*PARKIA BIGLOBOSA*) POD

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ABSTRACT
Adsorption with activated carbon is widely used in water treatment for removal of various micro organic pollutants. The study was carried out in other to compare the effects of African Locust Bean (*Parkia biglobosa*) pod as compared to Bone Char as activated carbon in waste water treatment. The activated carbon was obtained from carbonized *P. biglobosa* pod with a temperature range from 350 to 500ºC and activated by Phosphoric acid for 12-18hrs. Turbidity removal efficiency for *P. biglobosa* was found to be higher than Bone char with percentage values of 70.9% and 43.6% respectively. Chemical Oxygen Demand (COD) significantly reduced from 250mg/L to 6.2mg/L and 5.8mg/L for *P. biglobosa* and Bone char with equivalent percentages of 97.52% and 97.7% respectively. Nitrate reduction for Bone char was high as compared to *P. biglobosa* with values of 72.5% and 87.5% respectively. Phosphate reduction for Bone char was high as compared to Parkia biglobosa with values of 22% and 51.2% respectively. The results showed that *P. biglobosa* activated carbon has the potential for wastewater quality parameters improvement. This is significant since the *P. biglobosa* pod is treated as a waste after removing the yellowish pulp and seed and is less expensive than bones.

Keywords: *Pakia biglobosa*, activated carbon, adsorption, wastewater

INTRODUCTION
Wastewater is a term that is used to describe waste material that includes industrial liquid waste and sewage waste that is collected in towns and urban areas and treated at urban wastewater treatment plants (UWWTPs) as well as sewage that comes from single houses in the countryside that is treated on-site in either septic tanks or individual wastewater treatment systems (domestic waste water treatment systems - DWWTS). (http://www.epa). The traditional aim of wastewater treatment is to enable wastewater to be disposed safely, without being a danger to public health and without polluting watercourses or causing other nuisance. Increasingly another important aim of wastewater treatment is to recover energy, nutrients, water, and other valuable resources from wastewater. The contaminants in wastewater include suspended solids (faeces, food waste and toilet paper), biodegradable dissolved organic compounds (proteins, carbohydrate and lipids), inorganic solids (salts and metals), nutrients (nitrogen and phosphorus), and pathogenic microorganisms (Michael and Butler, 2011). Water pollution issues now dominate public concerns about national water quality and maintaining healthy ecosystems. In earlier years, the natural treatment process in streams and lakes was adequate to perform basic wastewater treatment, as our population and industry grew to their present size increased levels of treatment prior to discharging domestic wastewater became necessary.

Basic wastewater treatment processes includes physical, biological and chemical processes. Physical processes were some of the earliest methods to remove solids from wastewater, usually by passing wastewater through screens to remove debris and solids. In addition, solids that are heavier than water will settle out from wastewater by gravity. Particles with entrapped air float to the top of water and can also be removed. These physical processes are employed in many modern wastewater treatment facilities today. In biological processes, bacteria and other small organisms in water consume organic matter in sewage, turning it into new bacterial cells, carbon dioxide, and other by-products. The bacteria normally present in water must have oxygen to do their part in breaking down the sewage. In the 1920s, scientists observed that these natural processes could be contained and accelerated in systems to remove organic material from wastewater. With the addition of oxygen to wastewater, masses of microorganisms grew and rapidly metabolized organic pollutants. Any excess microbiological growth could be removed from the wastewater by physical processes. Chemicals can be used to create changes in pollutants that increase the removal of these new forms by physical processes. Simple chemicals such as alum, lime or iron salts can be added to wastewater to cause certain pollutants, such as phosphorus, to floc or bunch together into large, heavier masses which can be removed faster through physical processes. Over the past 30 years, the chemical industry has developed synthetic inert chemicals know as polymers to further improve the physical separation step in wastewater treatment. Polymers are often used at the later stages of treatment to improve the settling of excess microbiological growth or bio-solids (USEPA, 2004).

African locust bean (*P. biglobosa*) is medium-sized tree up to 20–30 m tall; ash-grey exuding an amber gum; crown dense, wide spreading and umbrella-shaped, consisting of heavy branches. The Genus *Parkia* comprises about 30 species and has a Pantropical distribution. Only 3 species, all belonging to the section Parkia, occur in continental Africa, and a fourth one on Madagascar. The African *Parkia* species seem to be closely related. *P. biglobosa* is found in savanna woodland of the Sudanian region, Atlantic coast in Senegal to southern Sudan and northern Uganda, whereas the other 2 continental African species *Parkia bicolor* A. Chev. and *Parkia filicoidea* Welw. ex Oliv. are principally rain forest species. African locust bean is protected and planted in agricultural fields and wasteland in savanna regions. It tolerates a wide variety of climatological conditions, the principle constant being a dry season of 5–7 months/year. It may grow in regions with an annual rainfall of 500–800 mm in the Sahel, but occurs in regions with much higher rainfall as well, e.g. 2200 mm in Guinea Bissau, and it has even been recorded in regions with over 3500 mm in Sierra Leone and 4500 mm in Guinea. It prefers regions with a mean annual temperature of 26–28°C, but tolerates lower temperatures and occurs up to 1350 m altitude. Although it prefers deep soils with good drainage and fertility, African locust bean can also be found on shallow lateritic soils, stony slopes and rocky hills (Carter et al, 1992).

African locust bean is a multipurpose tree that is as highly valued as shea butter tree Fermented seeds (‘soumbala’, ‘dawadawa’, ‘netetu’) serve primarily as a condiment for seasoning sauces and soups. Roasted seeds are used as a coffee substitute known as ‘Sudan coffee’ or ‘café nègre’. Ground seeds are mixed with Moringa oleifera Lam. leaves to prepare a sauce, and are also used to make doughnuts. The mealy pulp from the fruits is eaten or is mixed with water to make a sweet and refreshing drink rich in carbohydrates. Boiled pods are used to dye pottery black; the ash is applied as a mordant. The bark is rich in tannins and may be used for tanning hides, but the resulting leather is often of moderate quality especially with regard to colour, which is often reddish, uneven, and darkens when exposed to light. The leaves are sometimes eaten as a vegetable, usually after boiling and then mixed with other foods such as cereal flour. Young flower buds are added to mixed salads. In West Africa the bark, roots, leaves, flowers, fruits and seeds are commonly used in traditional medicine to treat a wide diversity of complaints, both internally and externally, sometimes in combination with other medicinal plants. The bark is most important for medicinal uses, followed by the leaves. Medicinal applications include the treatment of parasitic infections, circulatory system disorders, such as arterial hypertension, and disorders of the respiratory system, digestive system and skin. In veterinary medicine, a root decoction is used to treat coccidiosis in poultry. Green pods are crushed and added to rivers to kill fish. The nutritional value of the fish is not adversely affected so long as they are cooked or dried. The fruit pulp is used as an ingredient of feed for pigs and dogs. The leaves are a useful, but not very palatable fodder. The wood is suitable for making kitchen implements, such as mortars, pestles and bowls, and handles of hoes and hacks, and it is occasionally also used for house building, mainly for indoor construction. It is also used as firewood, and may be suitable for paper production. The fibers of pods (husks) and roots are used as sponges, strings of musical instruments and for the production of small baskets. African locust bean has a reputation for soil improvement; its leaves are applied as green manure. It is also important in apiculture, being a good source of nectar and suitable for the placement of hives. It may serve as a decorative avenue tree. African locust bean is very important in West African culture. It plays a role in all major rituals, including those associated with birth, baptism, circumcision, marriage and death. (http://www.prota, org).

Adsorption is the adhesion of atoms, ions, or molecules of gas, liquid, or dissolved solids in a solution to the surface of a suitable solid. Adsorption is used in tertiary dissolved wastewater treatment to improve the quality of wastewater effluent by removing part of organic matter toxicity (Metcalf and Eddy, 1991). Activated carbon has long been recognized as one of the most versatile adsorbents to be used for the effective removal of contaminants in wastewater treatments. Charcoal is the fore runner of modern activated carbon whose ability to purify water dates back to 2000 B.C. Lately during the past few decades, there has been an increased awareness of the existence of organic and inorganic pollutants and their toxic effects in natural water. Consequently, urgent need has been exhibited by various public and health agencies for the removal of these contaminants in streams and natural water and has resulted in the emergence of activated carbon adsorption as one of the most effective methods for removing these contaminants in wastewater treatments (Bansode et al., 1998). Activated carbon is porosity (space) enclosed by carbon atoms used for purification of water and of air and separation of gas mixtures. It is a unique material because of the way it is filled with holes (voids, spaces, sites, pores,) of zero electron density, these pores possess intense vander Waals forces (from the near proximity of carbon atoms) and these are responsible for the adsorption process. It can be made from hard woods, coconut shell, fruit stones, coals and synthetic macromolecular systems (Harry and Francisco, 2006).

In this work the chemical treatment process of domestic wastewater was utilized using activated carbon from locust bean (*Parkia biglobosa*) pod to remove nitrogen and phosphorus that may cause eutrophication if released into the water body. Although various carbonaceous materials are used in the production of activated carbons, abundance, availability and low cost of agricultural by-product such as African locust bean (*Parkia biglobosa*) pod of which about 201, 000 ton of its fruit is being produced annually in northern Nigeria (Isa, 2009) makes them good sources of raw materials for activated carbon. Conversion of these agricultural by-products into activated carbon which can be used as adsorbents for wastewater treatment, help reduce the cost of waste disposal, and provide a potentially cheap alternative to existing commercial carbonaceous adsorbents. This research was aimed to assess the performance of active locust bean (*P. biglobosa*) pod relative to bone char in the treatment of abattoir wastewater sample. There are two basic methods of activation - steam activation and chemical activation, in this work the steam activation method was applied to produce the activated carbon from locust bean (*P. biglobosa*) pod.

MATERIALS AND METHOD

The materials used in production of the activated carbon from locust bean (*P. biglobosa*) pod includes; Bowl, Funnel, Furnace, Conical flasks, Cow bones, Griffen oven, PH meter, Crucible, 20litres gallon, Petri dish, watch glass, Desiccators, Hand gloves, Reflux apparatus/flask, Draining tray, Locust bean pod, Spatula, Forcept, Filter paper, Magnetic stirrer, Turbidity meter (HACH2100 China), Burette, Weighing balance (Metler), Measuring cylinders, Beaker, Multi parameter photometer, Pipette, water bath, Sack, Measuring Cylinder (Hanna, Romania), Wash Bottle, BOD bottles, Glass beads, Retort stand/clamp. The chemical regents used were Alkali-azide/Iodide, Methylated spirit, Buffer 4,6,9, Concentrated phosphoric acid, Molybdate reagent, Mercury Sulphate, Concentrated sulphoric (H_2so_4), Starch solution, $K_2Cr_2O_7$, Distilled water, Sodium thiosulphate, Manganous sulphate, Stannous chloride, Ferroin Indicator, Ferrous Ammonium Sulphate, PhenoldiSulphuric acid, Phenolphthalein, Phosphoric acid. The procedure followed during the process of activation of the pods and bone was; sourcing and pretreatment of raw materials, charring, crushing, sieving and activation of raw material. The wastewater sample was collected by grab method. Some selected water quality parameter which includes Nitrate, Phosphate, Biological Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), pH, Turbidity, Suspended soils and Total Solid were determined in Water Resources and Environmental Engineering Laboratory ABU Zaria as prescribed by APHA (2005).The raw locust bean pod was sourced from Ahmadu Bello University Zaria, Nigeria. It was ripped open while the yellowish pulp and seed were removed from the pods. The empty pods were the raw material needed. The pods were washed with water to remove impurity then dried in the open for 2 days. The pods were then placed in a crucible and charred in a furnace at 350 to 500^oC. The furnace was allowed to cool down for 24 hours before the charred pods were removed and grinded with a commercial miller to obtain 5-50µm grain size for material that passes through sieve number 200. The sieved charred pods were then soaked in phosphoric acid for 12-18hours to become activated locust bean charred pods. The locust bean charred pods was 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. The same procedure was repeated for the cow bones expect that it was dried in the sun for 7 days.

Using the grab sampling method 20 liters of wastewater effluent was collected from Ahmadu Bello University, Zaria waste maturation pond for analysis. The adsorption study consisted of mixing activated carbons - *Parkia biglobosa* pod and Bone char-respectively with a 500 ml wastewater sample. The carbon dosages used in the study were 0.25, 0.5, 1.5, 2.5, 3.75, and 5.0 g per 500 ml of the wastewater sample. Each of the mixture of activated carbons and the wastewater sample were stirred at 100 rpm high speed for 5minutes and 10rpm low speed for 15 minutes using magnetic stirrer. At the end of the specified period, the samples were removed from the corning magnetic stirrer and the flocs were allowed to settle and determination of wastewater quality parameters of solution was done accordingly.

RESULTS AND DISCUSSION

The experimental results of using activated locust bean pod and activated bone char are as presented in Table. 1. From the results presented in Table 1, it is observed that the Chemical Oxygen Demand (COD) significantly reduced from 250mg/L to 6.2mg/L and 5.8mg/L for *Parkia biglobosa* and Bone char with equivalent percentages of 97.52% and 97.7% respectively. Nitrate reduction for Bone char was high as compared to *Parkia biglobosa* with values of 72.5% and 87.5% respectively.

Table 1: Concentration removal by activated pod as compared to activated bone char

Parameter con. in the sample	S/N	Dose (g/500ml)	Con. (mg/l) of parameter after treated sample with	
			Activated *P. biglobosa* pod	Activated Bone Char
Nitrates (4.0 mg/l)	1	0.25	2.3	2.1
	2	0.50	2.0	1.6
	3	1.50	1.9	1.3
	4	2.50	1.7	0.7
	5	3.75	1.5	0.6
	6	5.00	1.1	0.5
Phosphate (0.82 mg/l)	1	0.25	0.80	0.81
	2	0.50	0.76	0.80
	3	1.50	0.74	0.79
	4	2.50	0.72	0.74
	5	3.75	0.60	0.73
	6	5.00	0.40	0.64
BOD_5 (0.9 mg/l)	1	0.25	0.73	0.7
	2	0.50	0.71	0.6
	3	1.50	0.70	0.5
	4	2.50	0.40	0.4
	5	3.75	0.3	0.3
	6	5.00	0.2	0.1
pH (7.94)	1	0.25	6.10	6.00
	2	0.50	6.08	6.12
	3	1.50	6.12	6.08
	4	2.50	6.03	6.17
	5	3.75	6.05	6.18
	6	5.00	6.15	6.20
COD (250 mg/l)	1	0.25	8.2	6.6
	2	0.50	7.7	6.5
	3	1.50	6.5	6.3
	4	2.50	6.5	6.3
	5	3.75	6.3	6.2
	6	5.00	6.2	5.8
Turbidity (10.74 NTU)	1	0.25	8.90	10.30
	2	0.50	7.80	9.27
	3	1.50	6.53	8.82
	4	2.50	5.88	8.39
	5	3.75	4.60	6.35
	6	5.00	3.05	5.90
Suspended Solids (8.5 mg/l)	1	0.25	0.02	0.01
	2	0.50	0.02	0.01
	3	1.50	0.01	0.01
	4	2.50	0.01	0.01
	5	3.75	0.01	0.01
	6	5.00	0.01	0.01
Total Solids (9.7 mg/l)	1	0.25	0.016	0.030
	2	0.50	0.016	0.030
	3	1.50	0.015	0.026
	4	2.50	0.014	0.025
	5	3.75	0.013	0.023
	6	5.00	0.011	0.021

Phosphate reduction for Bone char was high as compared to *Parkia biglobosa* with values of 22% and 51.2% respectively. From the results it can be inferred that *Parkia* *biglobosa* activated carbon has the potential for wastewater quality parameters improvement. This is significant since the *Parkia biglobosa* pod is treated as a waste after removing the yellowish pulp and seed and is less expensive than bones. That instead of wasting the pod of *Parkia biglobosa* as done in most rural communities in Nigeria, the use of locust bean pod as an activated carbon should be encouraged since it is cheap and abundant in Nigeria.

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