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Comparative Performance Analysis of Recycled Animal-Based Activated Carbon for Cassava Wastewater Treatment: Case Study of Periwinkle and Oyster Shells

Churchill Ebinimitei Simon

Department of Civil Engineering, Federal University Otuoke, P.M.B. 126, Yenagoa,

Bayelsa State, Nigeria.

Abstract: *Cassava wastewater management have been a serious concern for local industries across the developing world. As such, different cassava wastewater treatment strategies have been adopted across the world, particularly the developing Nations to curb the proliferation of toxins. This work therefore is to evaluate the toxins removal efficiency of two animal-based activated carbon products for the treatment of the cassava wastewater effluents. The two animal-based treatment media used for comparison were periwinkle and oyster shell activated carbon samples Parameters analysed were Total Dissolved Solids (TDS), Sulphate (SO42-), Iron (Fe2+), Total Suspended Solids (TSS), Electrical Conductivity (EC), Chloride, pH, and Cyanide. Out of the eight (8) parameters analyzed, TDS concentration was lowered equally by the two treatment media. Whereas, 50% removal efficiency of treated parameters (TSS, EC, Chloride, and Cyanide) was achieved with the periwinkle shell activated carbon, the remaining 37.5% of parameters (Sulphate, Fe, and pH) treatment efficiency was attributed to the oyster shell activated carbon treatment. Though treated with the animal-based activated carbon samples, the levels of TSS, EC, Chloride and Cyanide were well above the Nigerian Federal Environmental Protection Agency (FEPA) Surface water and land disposal limits and Environmental Protection Agency (EPA)/World Health Organisation (WHO) effluents discharge standards. This implied that further treatment was required before it can released into the environment.*

***KEYWORDS*:** Cassava Wastewater, Toxins, Removal Efficiency, Activated Carbon, Treatmen

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1. INTRODUCTION

Sometimes harmful solid and liquid wastes are emitted into the environment when cassava is processed into its many products (Cumbana, et al., 2007). The wastewater from the dewatering of the grated paste has a high contaminating load of Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and high cyanide content, and when released into the environment untreated, poses a serious threat to the ecosystem (Eze, et al., 2010). In contrast, the wastewater from washing the tubers during processing contains a large amount of inert materials with low COD (Oghenejoboh, 2015). Simple and effective procedures for treating cassava wastewater have developed as a result of the hazardous compounds found in the wastewater. Depending on the effluents' source, content, and characteristics, a wide range of technologies (chemical, physical, and biological) are available for their treatment [4]. Activated carbon derived from plants or animals can be used to treat cassava mill effluents before they are released, which reduces the effects on the receiving environment (Okoduwa, et al., 2017.

Almost any kind of carbonaceous (plant and animal based) material, including coconut, palm kernel, nut, olive, oil-palm, and agricultural wastes, oyster, periwinkle, and many more, can be used to make activated carbons. Due to their use of dumpsites designated for low-cost activated carbon-based adsorbents and straightforward protocols, advanced adsorption technologies like activated carbon have garnered significant interest from the academic and industrial sectors in the water treatment process (Ali, et al., 2006).

By reusing waste materials, the use of these plant-based activated carbons for cassava waste water treatment will not only increase the output of the cassava processing industries but also contribute to a more sustainable environment. These materials' ability to remove pollutants depends on a number of variables, including their physical, chemical, and biological composition. Thus, the purpose of this study is to evaluate the efficacy of two animal-based activated carbon products (oyster shells and periwinkles).

The overall aim of this study is to identify a most suitable material needed to detoxify and degrade cassava wastewater using periwinkle and Oyster shells activated carbon, before discharging to the environment. The objectives are;

(i) To produce activated carbon from periwinkle shell.

(ii) To produce activated carbon from oyster shell.

(iii) To collect and analyze the characteristics of cassava wastewater.

(iv) To compare and determine the effectiveness of these two materials on cassava wastewater treatment.

II. MATERIALS AND METHODOLOGY

The following equipment was utilised in the laboratory to produce the animal-based activated carbon. Vecstar Furnace, Sample Collectors, Desiccators, Sewers, Grinders, Conical Flask Water Bath, Electronic Weighing Balance, and Conical Flask were among the lab equipment utilised.

Washing and sun-drying the oyster and periwinkle shells to eliminate moisture was the first step in the carbonisation process. After that, the materials were placed in the Vecstar Furnace to undergo carbonisation at a temperature of 750^{0}C for 30 minutes at a time. After letting the samples cool, they were cleaned with tap water and then distilled water. After being cleaned, the samples were dried for half an hour in the oven.

The carbonised samples were ground into a powder and sieved following the carbonisation step. An electronic weighing balance was used to weigh the sieved carbonised samples before they were added to the conical flask. For impregnation/activation, 0.1 mol of hydrogen tetraoxosulphate (iv) acid was applied to the conical flask. After properly stirring the mixture with a stirrer, it was placed in a hot water bath set at 850 degrees Celsius and agitated for six hours at a rate of 120 revolutions per minute (rpm). For an additional twenty-four hours, the impregnation proceeded at ambient temperature. Following impregnation, the samples were rinsed with water and filtered through a funnel and filter paper. After that, the samples were dried for 24 hours at 110^{0}C in an oven (Saite, *et al.*, 2015.

The laboratory examination was carried out at the Chemical Laboratory of Niger Delta University Amassoma Bayelsa State, while the cassava wastewater was gathered from a cassava processing facility in Yenagoa. The batch adsorption method was used; for instance, 30g of activated carbon from oyster and periwinkle shells and 30g of periwinkle were weighed separately, combined with 50ml of cassava wastewater in a conical flask, and stirred for 60 minutes at 40^{0}C and 120 rpm in a hot water bath. The mixes were filtered and examined independently for the identification of several poisons after 60 minutes (Olaoye, *et al.,* 2019).

A. Sample collection

After collection of samples, it was immediately placed in iced coolers for transportation to the laboratory and stored in a refrigerator. The water quality parameters dealt with were Physico-Chemical and heavy metals, (Simon, *et al.,* 2023), and were analyzed in accordance with standard laboratory methods. The parameters were; Total Dissolved Solids (TDS), Sulphate (SO_4^{2-}), Iron (Fe^{2+}), Total Suspended Solids (TSS), Electrical Conductivity (EC), Chloride, pH, Cyanide, etc.

Following the production of the activated carbon from oyster and periwinkle shells, it was introduced to the raw cassava wastewater for filtration in this investigation, and data were recorded. These findings were compared with the raw wastewater values and the effluent disposal guidelines for surface water and land set out by the Nigerian Federal Environmental Protection Agency (FEPA, 1991). Additionally, the results were compared with the effluent discharge standards set by the World Health Organization (WHO, 2014) and the Environmental Protection Agency (EPA, 1991), as indicated in Tables 1.0 and 2.0 below, respectively. The tables also showed how well activated carbon made from oyster and periwinkle shells removed contaminants from cassava wastewater.

III. RESULT AND DISCUSSIONS

Table 1.0: Result of Parameter levels (TDS, Sulphate & Fe) from Cassava Wastewater and Efficiency of Removal Using Periwinkle and Oyster Shell-Based Activated Carbon

Sample	Raw Untreated Cassava Wastewater Sample	Activated Carbon Shells of Periwinkle Treated Sample	Activated Carbon Shells of Oyster Treated Sample	EPA/WHO EFFLUENT DISCHARGE STANDARDS (2004; 2014)	LIMITS FOR DISCHARGE INTO SURFACE WATER (FEPA, 1991)	LIMITS FOR LAND APPLICATION (FEPA, 1991)
TDS(mg/l)	557	257	257	1200	2,000	2,000
Sulphate (mg/l)	12.82	17.99	15.52	750	500	1000
Iron (mg/l)	0.6	0.66	0.8	2	20	NS

Fig.1.0 is a chat of the treatment efficiency of the animal-based activated carbon produced from periwinkle and oyster shells. The chat compared the treatment results of parameters such as Total Dissolved Solids (TDS), and Sulphate to the EPA/WHO and FEPA standards.

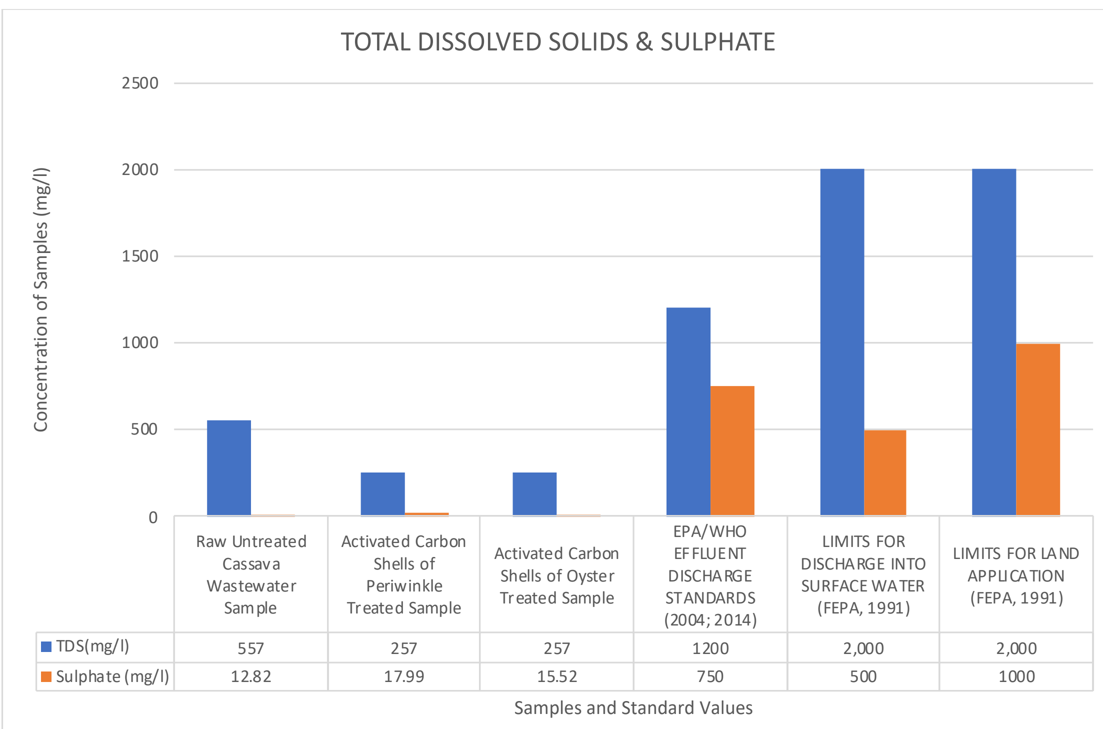

Fig. 1.0: Treatment Efficiency of Periwinkle and Oyster Activated Carbon for some Parameters (TDS, and Sulphate) as Compared to local (FEPA) and global (WHO) Effluent Discharge Standards

Fig. 1.0 above showed the trend of pollutants removal form the cassava wastewater as a reduction of parameters was observed. Total dissolved solids concentration (TDS) of the raw untreated cassava wastewater sample was reduced from 557mg/l to 257mg/l for both periwinkle and oyster shells activated carbon treated samples. However, the trend for Sulphate concentrations increased from12.82mg/l of the untreated sample to 17.99mg/l and 15.52mg/l of the periwinkle and oyster shells activated carbon treated samples respectively. The periwinkle activated carbon treated samples showed a higher concentration than the oyster shell activated carbon treated sample. This meant that the oyster shell activated carbon was more efficient in treating sulphate than the periwinkle shell activated carbon. It was further observed that the TDS and Sulphate concentrations of this analysis were both below the FEPA (surface water and land disposal limits), as well as the EPA/WHO effluent discharge standards.

Similarly, Fig.2.0 below showed the treatment efficiency of periwinkle and oyster shells activated carbon treatment media.

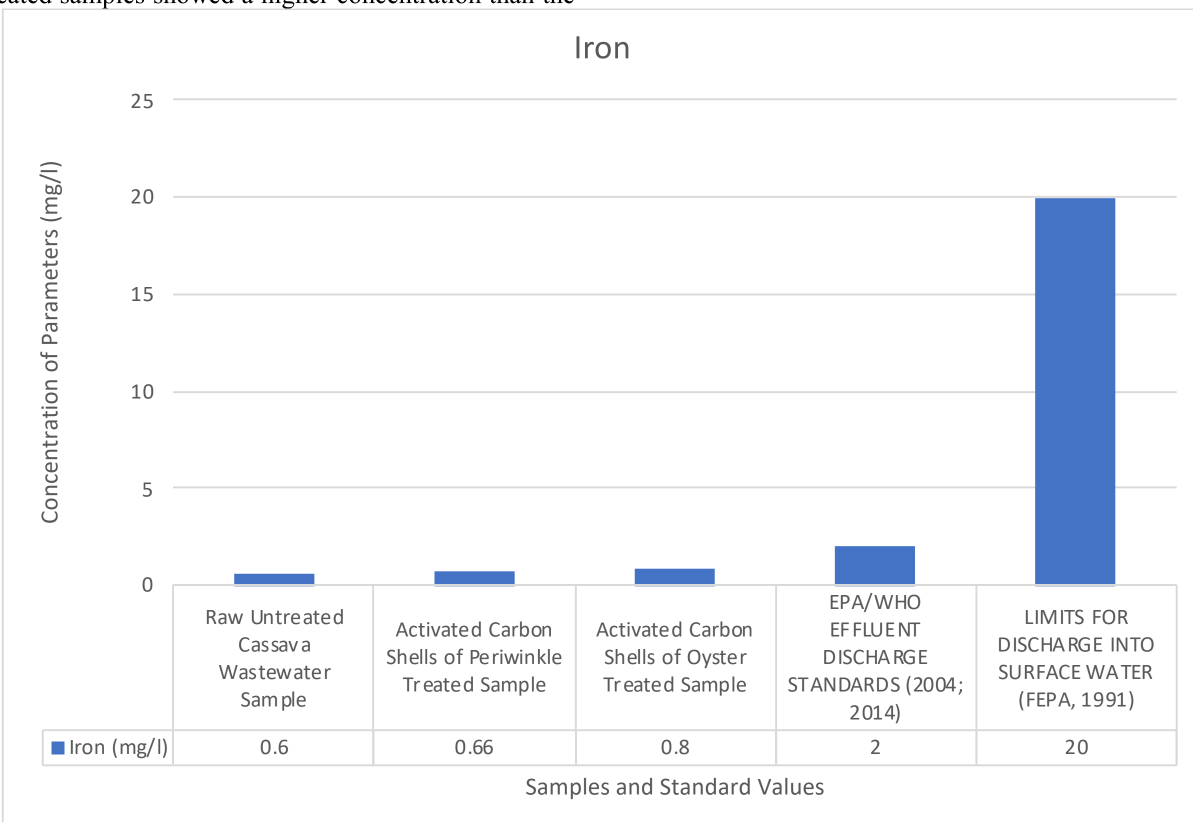

Fig. 2.0: Treatment Efficiency of Periwinkle and Oyster Activated Carbon for Iron as Compared to local (FEPA) and global (WHO) Effluent Discharge Standards

Just like Sulphate, Iron concentration also increased from 0.6mg/l in the raw untreated wastewater sample to 0.66mg/l and 0.80mg/l of periwinkle and oyster activated carbon treated samples respectively. In this case, the oyster shell activated carbon treated sample showed a higher concentration of iron than the periwinkle shell activated carbon treated sample. However, both the local (FEPA) and global (WHO) effluent disposal standards were above the levels of iron concentration of the raw untreated and treated samples.

Table 2.0: Result of Parameter levels (TSS, EC, Chloride, pH & Cyanide) from Cassava Wastewater and Efficiency of Removal Using Periwinkle and Oyster Shell-Based Activated Carbon

Sample	Raw Untreated Cassava Wastewater Sample	Activated Carbon Shells of Periwinkle Treated Sample	Activated Carbon Shells of Oyster Treated Sample	EPA/WHO EFFLUENT DISCHARGE STANDARDS (2004; 2014)	LIMITS FOR DISCHARGE INTO SURFACE WATER (FEPA, 1991)	LIMITS FOR LAND APPLICATION (FEPA, 1991)
TSS (mg/l)	783	1463	1283	100	30	NS
Conductivity (us/cm)	1212	1198	1213	750.5	1000	NS
Chloride (mg/l)	437	1126	1307	500	600	600
pH	4.4	5.3	5.4	6.0 - 9.0	6.0 - 9.0	6.0 - 9.0
Cyanide (mg/l)	0.622	0.441	0.726	0.1	0.1	NS

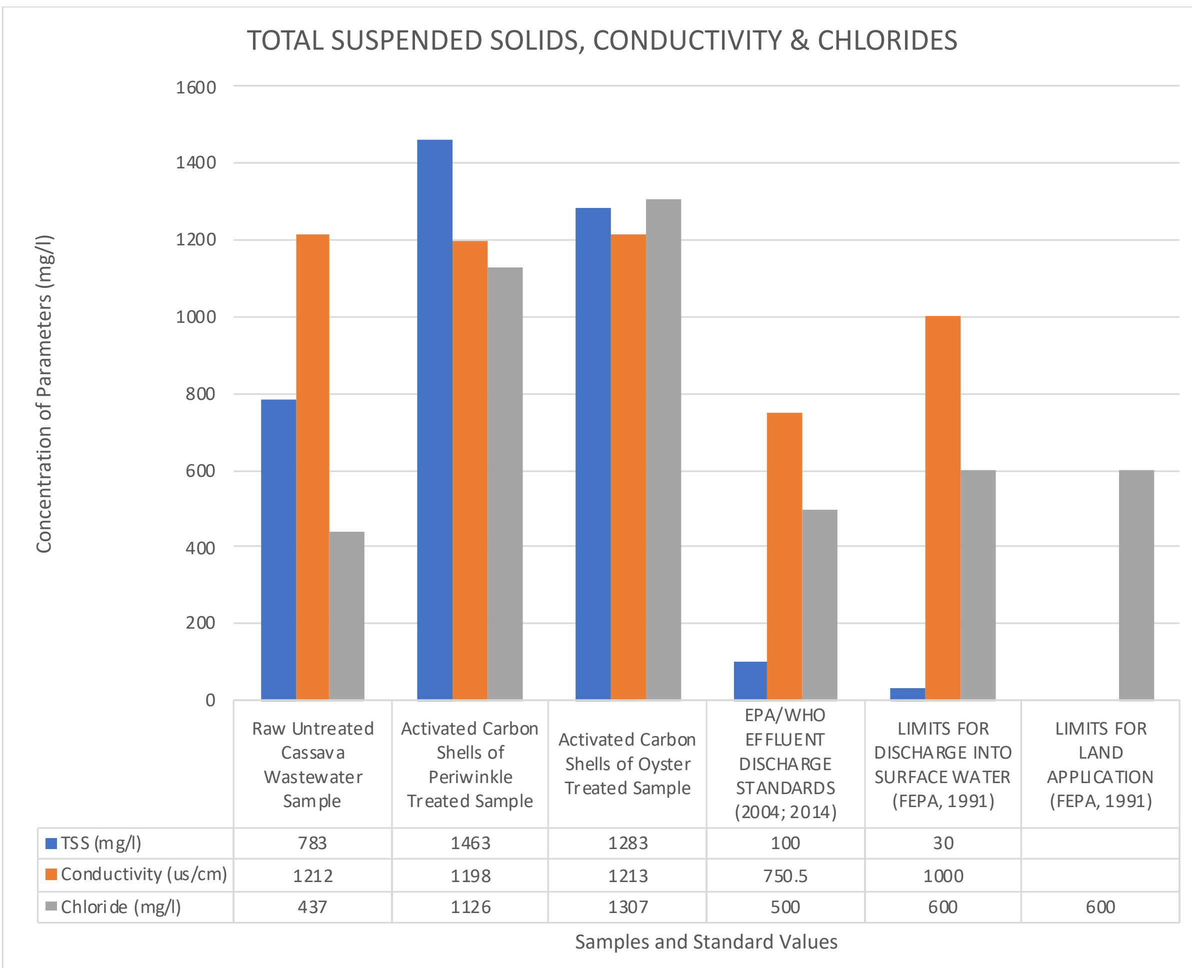

Fig. 3.0: Treatment Efficiency of Periwinkle and Oyster Activated Carbon for some Parameters (TSS, EC and Chloride) as Compared to local (FEPA) and global (WHO) Effluent Discharge Standards

Total Suspended Solids (TSS) concentration increased from 783mg/l of the raw untreated wastewater sample to 1463mg/l and 1283mg/l of the periwinkle and oyster shells activated carbon treated samples. The TSS of periwinkle shell activated carbon treated sample was higher than that of the oyster shell activated carbon treated sample. The TSS concentration of all the samples (raw, periwinkle and oyster shell treated samples), were higher than both the local (FEPA) and global (WHO) effluent discharge standards. Similarly, the Electrical Conductivity levels of the cassava wastewater samples also increased from 1212 µS/cm of the raw untreated sample, to 1198 µS/cm and 1213 µS/cm of the periwinkle and oyster shells activated carbon treated samples. The results showed that the Periwinkle shell activated carbon reduced Electrical Conductivity slightly better than the Oyster shell activated carbon. It was also observed that the EC of all the samples (raw, periwinkle and oyster shell treated samples), were higher than both the local (FEPA) and global (WHO) effluent discharge standards.

Furthermore, Chloride levels also increased from 437mg/l of the untreated sample to 1126mg/l and 1307mg/l of the periwinkle and oyster treated samples. The results showed that the oyster shell activated carbon treated sample had higher concentrations of chloride, while the periwinkle shell activated carbon treated sample showed a lower concentration of chloride. This indicated that the addition of chloride was more with the oyster shell activated carbon than that of the periwinkle shell activated carbon. It was also observed that the Chloride level of all the samples (raw, periwinkle and oyster shell treated samples), were higher than both the FEPA (Surface water and land disposal limits) and global (EPA/WHO) effluent discharge standards.

Fig. 4.0 is a chat of the treatment efficiency of the animal-based activated carbon produced from periwinkle and oyster shells. The chat compared the treatment results of parameters such as pH, and Cyanide to the FEPA (Surface water and land discharge limits) and EPA/WHO effluents disposal standards.

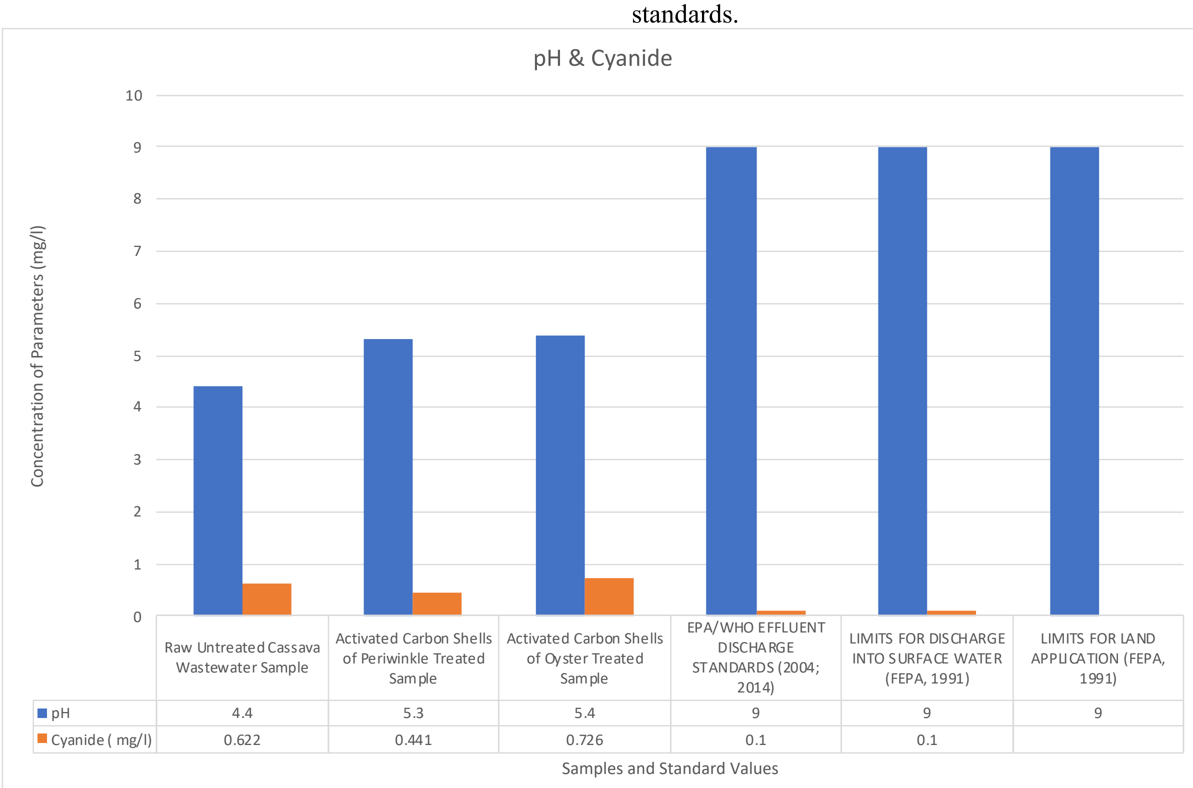

Fig. 4.0: Treatment Efficiency of Periwinkle and Oyster Activated Carbon for some Parameters (pH and Cyanide) as Compared to local (FEPA) and global (WHO) Effluent Discharge Standards

pH values were increased from 4.4 in the raw untreated cassava wastewater sample to 5.3 and 5.4 for the periwinkle and oyster shell activated carbon treated wastewater samples respectively. All the samples analyzed were below the FEPA and WHO effluent disposal standards, 6.0-9.0. Cyanide concentrations reduced from 0.622mg/l in the raw untreated cassava wastewater sample to 0.441mg/l in the periwinkle shell activated carbon treated sample, whereas, it showed increased concentration of 0.726mg/l in the oyster shell activated carbon treated sample. It was further observed that the concentration of cyanide in all the samples (raw untreated sample, periwinkle and oyster shell treated samples), were higher than both the local (FEPA) and global (WHO) effluent discharge standards.

Summarily, out of the eight (8) parameters analyzed with the periwinkle and oyster shells activated carbon. TDS concentration was lowered equally by the periwinkle shell activated carbon, as well as the oyster shell activated carbon. Whereas, 50% efficiency of treated parameters (TSS, EC, Chloride, and Cyanide) was achieved with the periwinkle shell activated carbon, the remaining 37.5% of parameters (Sulphate, Fe, and pH) treatment efficiency was attributed to the oyster shell activated carbon treatment. Though treated with the animal-based activated carbon samples, the levels of TSS, EC, Chloride and Cyanide were well above the FEPA (Surface water and land disposal limits) and EPA/WHO effluents discharge standards.

IV. CONCLUSION

An improvement of the pH of wastewater after absorption or adsorption is a key performance indicator that shows the cleanliness and environmental friendliness of the wastewater. Generally, the shells of periwinkle, and oyster are very good absorbents because of their ability to reduce the concentration of physio-chemical parameters, as well as heavy metals. The uptake efficiencies of absorbents are affected by their loading weight, contact time, mesh size, temperature of environment as well as the temperature at which the absorbents were heated before use which is also known as calcination. Results obtained by (Osuji, 2024), showed that oyster shell has the highest uptake efficiency while periwinkle shell had the least absorption capacity. However, this study showed that the activated carbon shells of periwinkle had higher efficiency of toxins removal than the Oyster shell activated carbon, because they had more percentage of removal. The uptake efficiency of the absorbents increases with increase in the temperature of calcination, all other factors remaining constant.

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