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WATER QUALITY OF FILTRATE OF RIVER NUN USING PLANTAIN PEDUNCLE ACTIVATED CARBON BASED FILTERS

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ABSTRACT

The Niger Delta area faces ongoing difficulties because people cannot find safe drinking water while oil spills and domestic waste and sedimentation have polluted the Nun River. The research tested plantain peduncle activated carbon (PPAC) as an affordable adsorbent that improves water quality through its use in laboratory-scale filtration systems. The researchers collected water samples through grab sampling while they prepared PPAC by washing and drying and carbonizing at temperatures between 300 and 500 degrees Celsius and using H_3PO_4 for chemical activation and sieving. The filtration system used four layers which included gravel and sand and PPAC and cotton wool while the flow rate control system enabled better contact time between the water and the filters. The water quality tests measured pH and turbidity and colour and electrical conductivity and total dissolved solids and total suspended solids and iron (Fe^{2+}) and biochemical oxygen demand and chemical oxygen demand and total coliforms. The results showed that PPAC filter decreased turbidity by 91% and colour by 77% and iron by 84% and TSS by 82% and microbial load by 93% which resulted in filtrate that met WHO and NSDWQ standards for most parameters. The research demonstrates that PPAC functions as sustainable and effective rural water treatment solution which provides economical treatment method through its use of regional agricultural waste. The research recommends that activated carbon needs regular replacement to sustain its operational ability while it supports further studies about regeneration techniques and heavy metal elimination.

KEYWORDS: Plantain peduncle, activated carbon, water filtration, River Nun, Niger Delta.

1.0 INTRODUCTION

1.1 Background of Study

Water serves as a vital resource which humans require for their survival and which countries need to develop their economies and which both humans and nature need to sustain healthy ecosystems. The Niger Delta region of Nigeria relies on its rivers as the main water supply source which people use for their household needs and agricultural activities and industrial operations. The River Nun serves as an essential freshwater resource which provides water to multiple river communities. The water quality in this area has experienced declining standards because both natural processes and human activities have polluted the water supply. River Nun faces its most significant problem because oil spills from crude oil exploration activities and pipeline leaks create pollution hazards which threaten the river's ecosystem. The oil contamination of water bodies results in the introduction of hydrocarbons and heavy metals which create serious risks to both human health and environmental safety. The river area receives domestic waste from local settlements which contains organic waste materials and plastic items and sewage waste. Water quality becomes worse because sediment deposition raises the amount of suspended solids which prevents light from entering the water, which leads to harmful effects on aquatic organisms. People cannot safely use untreated river water for drinking and domestic activities which raises their danger of contracting waterborne diseases that include diarrhea and cholera and typhoid fever [1], [2].

Riverine households need treatment because they lack centralized water treatment systems and commercial filtration devices which rural communities cannot afford. The problem needs immediate solutions which provide affordable household water treatment systems that use local agricultural waste to eliminate chemical and microbial contamination. Activated carbon from plant-based biomass functions as a sustainable water purification adsorbent which scientists consider effective for this purpose [3], [4].

The study uses plantain peduncle which Bayelsa State farmers produce in large quantities to create activated carbon which acts as a filter for home water systems. The research study investigates how effective this solution works to enhance both the physicochemical properties and microbial content of River Nun water which serves as an affordable solution for rural areas. The Niger Delta region struggles to manage water quality through its river systems which face severe pollution from industrial activities and agricultural practices and domestic waste. Multiple research studies have shown that river water quality in this region has declined while they studied effective low-cost treatment solutions that use local biomass resources.

1.2 Water Quality Challenges in the Niger Delta and River Nun

Oil exploration activities severely disrupt the rivers of the Niger Delta which results in hydrocarbon pollution and increased total dissolved solids (TDS) and heavy metals contamination [2]. The river experiences domestic waste discharge from nearby communities which brings in substantial organic matter and suspended solids and microbial contaminants that lead to increased biochemical oxygen demand (BOD) and chemical oxygen demand (COD) and coliform counts [1]. Seasonal flooding causes sediment deposition which increases turbidity and nutrient loading. The conditions make raw river water unsafe for human consumption which creates a demand for point-of-use water treatment solutions.

1.3 Biomass-Based Activated Carbon in Water Purification

Activated carbon derived from biomass has been widely recognized as an effective adsorbent for water treatment. The material achieves complete removal of turbidity and dissolved organics and heavy metals and microbial contaminants through its combination of high surface area and porous structure and functional groups [3], [5]. Biomass-based activated carbons offer economic advantages and local accessibility and environmental protection benefits when compared to commercial carbons derived from coal or petroleum products. Research demonstrates that agricultural residues which include coconut shell and palm kernel shell and plantain peel can be transformed into activated carbon that effectively removes water contaminants through high adsorption capacity [4], [6].

1.4 Plantain Peduncle as a Precursor for Activated Carbon

The plantain peduncle serves as an activated carbon precursor because its lignocellulosic composition enables its transformation into activated carbon. Chemical activation through H_3PO_4 or KOH results in pore development and surface functionality improvements which boost adsorption capacity for both organic and inorganic pollutants according to research [3]. The research demonstrated that plantain-derived activated carbon successfully reduced water turbidity and colour while decreasing metal concentrations of water samples tested with plantain residues.

1.5 Filtration Systems Using Agricultural Waste

Worldwide scientists have created household filtration systems which use activated carbon derived from biomass. The layered design which uses gravel and sand and activated carbon has demonstrated effectiveness in removing suspended solids and colour and contaminants while achieving partial microbial reduction [7]. The systems provide an economical and sustainable solution which enables rural areas without centralized water treatment facilities to maintain their drinking water supply.

1.6 Research Gaps

Research on plantain peduncle biomass-based filters has shown positive results yet scientists have conducted only a few studies about its effectiveness as an activated carbon precursor to treat Niger Delta river water. There is a lack of information regarding how well PPAC removes iron and total dissolved solids and coliforms from water. The research requires filter design optimization and long-term performance evaluation and testing under different flow rates and contaminant loads.

The literature indicates that biomass-derived activated carbon is effective in improving water quality, and plantain peduncle represents an underutilized, locally available resource. The study investigates the performance of PPAC through laboratory testing which operates as a filtration system used to treat River Nun water.

1.7 Problem Statement

River Nun serves as a vital freshwater resource which supports multiple riverine communities across Bayelsa State and the entire Niger Delta region. The river system experiences ongoing physicochemical and biological quality degradation due to repeated crude-oil spills and persistent hydrocarbon pollution and continuous domestic waste and sediment discharge. Field investigations of the Nun River report elevated turbidity, total suspended solids (TSS), total dissolved solids (TDS), hydrocarbon residues and raised microbial counts in contaminated stretches, many of which exceed national and international drinking-water limits, so that water abstracted directly from the river is unsafe for drinking and other domestic uses without treatment. The people in these communities do not have access to dependable centralized water treatment systems or protected piped water systems which deliver safe water for their daily needs. The cost of commercial point-of-use (PoU) devices and branded filter systems (e.g., reverse-osmosis units, cartridge purifiers, commercial ceramic or multimedia filters) makes them impossible for rural low-income households to purchase. The cost of small-scale purifiers and domestic treatment systems in Nigeria starts at several hundred thousand naira which makes them inaccessible to most families who need to treat their river water.

The study examines two interconnected issues which arise from these specific conditions. The first public health danger emerges from the untreated water of River Nun which exists between two main health hazards. The untreated river water presents health risks which include gastrointestinal disease and exposure to petroleum hydrocarbons and bioaccumulative metals because spilled oil and constant sewage and solid waste discharge increase chemical and microbial contamination. The second problem arises because there are no treatment methods that rural communities can afford and which suit their specific needs. The two remediation methods which include centralized and commercial remediation efforts have produced inconsistent results which failed to restore secure water sources, while rural households find standard home filters prohibitively expensive. The requirement for economical point-of-use treatment systems emerges from the need for systems which provide affordable home filters using agricultural waste-based activated carbon to achieve affordable operational costs while efficiently reducing turbidity and organic matter and microbial pollutants through easy upkeep. The study investigates two interconnected issues which originate from untreated River Nun water and the high cost of commercial filtration systems which rural Niger Delta communities cannot access. The study tests a plantain-peduncle–derived activated carbon filter to assess its effectiveness in improving Nun River water quality.

1.8 Justification

The selection of plantain peduncle as the precursor material for activated carbon production in this research stems from its availability in the local area combined with its environmentally sustainable nature and the requirement for inexpensive water treatment materials in areas with limited resources. Below are key points supporting this justification:

1. Abundant Agricultural Waste in Bayelsa. Bayelsa State, located in the Niger Delta, is a region where plantain (Musa species) is widely cultivated. The peduncle (flower stalk) of plantain is generally considered a by-product or waste after the fruit bunches are harvested. The biomass should be treated as a valuable resource because it can be transformed into activated carbon through valorization. Previous research conducted in Bayelsa State (at Niger Delta University) has demonstrated that plantain ped[uncle can be effectively carbonized and

chemically activated to yield activated carbon with good porosity and adsorption characteristics [3].

2. The production of an economical adsorbent material occurs through the transformation of biomass into activated carbon through its derivation from agricultural waste. The process of transforming agricultural waste into activated carbon leads to an environmentally friendly solution that brings financial benefits. Agricultural wastes are among the cheapest and most available raw materials for activated carbon production especially in regions like the Niger Delta where such biomass is plentiful [8].

Several studies have demonstrated that activated carbon produced from biomass resources provides a cost-effective alternative to non-renewable sourced activated carbon from coal or petroleum coke for water treatment purposes. Research conducted in Applied Water Science investigated low-cost activated carbon produced from agro-waste and found that agricultural by-products including fruit peels and shells can undergo chemical activation to create adsorbents which effectively remove pollutants such as turbidity and organic matter from water. [9].

3. Local Value-Addition and Circular Economy Benefits. The study establishes a circular-economy framework by transforming plantain peduncle (a local waste) into an activated carbon product which generates economic value. Local communities can transform the peduncle into a high-performance adsorbent instead of discarding it as waste. [10]. The initiative not only helps with waste management but also generates economic prospects for the local community.

4. Environmental Sustainability and Resource Efficiency. Biomass-based activated carbon produces two advantages because it decreases waste and uses less intense carbon-based materials. Biomass-derived activated carbons provide effective surface area and porosity and adsorption capabilities because they use renewable biomass resources according to reviews. [11].

5. The research developed filter systems that provide remote areas with drinking water treatment solutions. The creation of a community-based activated carbon filter system which uses local biomass materials enables households to obtain affordable drinking water treatment solutions. The local availability of raw materials leads to reduced manufacturing expenses while the community standards determine how maintenance and regeneration processes will be carried out.

1.9 Research Objectives

This study is guided by the following specific objectives:

1. The plantain peduncle which exists as an agricultural waste product in Bayelsa State will undergo complete activated carbon production through specific carbonization and activation methods.
2. The study will create a laboratory water filtration system which uses plantain-peduncle activated carbon as its adsorption material.
3. The study will evaluate River Nun water quality through physicochemical and microbial analysis which will assess turbidity pH total dissolved solids (TDS) color iron concentration biochemical oxygen demand (BOD) chemical oxygen demand (COD) and microbial load.
4. The research will evaluate treated water quality by comparing it with World Health Organization (WHO) drinking-water standards and Nigerian Standard for Drinking Water Quality (NSDWQ) guidelines to determine its safety for domestic consumption

2.0 MATERIALS AND METHODS

2.1 Study Area

The researchers conducted their study by analyzing water samples which they collected from the RiverNun which flows through Bayelsa State in the Niger Delta region of Nigeria. The Niger River system includes River Nun which serves as one of its main distributaries while multiple riverine communities depend on the river for their everyday needs and farming and fishing practices. The river faces multiple pollution threats which include oil exploration activities and artisanal refining operations and domestic waste disposal and sedimentation from upstream sources. The sampling point lies approximately within the coordinates: Latitude:4.95°–5.10°N Longitude: 6.20°–6.35°E The river experiences seasonal fluctuations in flow and water quality because the rainy season brings higher turbidity and suspended sediment levels.

2.2 Sample Collection The researchers used grab sampling method to collect their water samples. Clean 1-L sterile high-density polyethylene (HDPE) containers were rinsed three times with river water before collection. The team collected samples from a depth of 20 to 30 centimeters which allowed them to bypass collection of surface debris. The research team sealed all containers after labeling them and they used an ice-filled cooler to transport the samples to the laboratory where analysis would occur within 6 hours in order to prevent chemical and microbial changes.

2.3 Preparation of Plantain Peduncle Activated Carbon (PPAC) The process for creating Plantain Peduncle Activated Carbon uses plantain peduncle as its main material. The collection of raw materials involved obtaining fresh plantain peduncles from Bayelsa State's local farms and markets. The peduncles were washed thoroughly with clean water to remove soil, sap, and adhering impurities. The materials undergo sun-drying for 3 to 5 days before their subsequent oven drying process, which operates at 105 °C for 24 hours to eliminate remaining moisture. The drying process involved placing the dried peduncles into a muffle furnace, which carbonized them at 300 to 500 °C for 1 to 2 hours under restricted air flow. The char was soaked in either phosphoric acid (H_3PO_4) at concentrations of 1 M, with a 1:3 (char:activating agent) impregnation ratio. The mixture was left for 24 hours. The process of activating the impregnated samples involved re-heating them at temperatures between 500 and 700 degrees Celsius, which resulted in increased pore development. Activated carbon underwent a washing process with distilled water until it reached a neutral pH level. The final product was oven-dried and sieved (0.5–1 mm particle size) for use in filtration.

2.4 Filter Design

Researchers built a laboratory-scale filtration unit from a PVC column that measures 40 to 60 centimeters in height and 5 to 7 centimeters in diameter.

The media components for this system were arranged in three different positions which started from the lowest position and ended at the highest position. The gravel layer which measured between 5 and 10 millimeters provided both drainage functions and structural support. The fine sand layer which had a particle size between 0.2 and 0.5 millimeters served the purpose of removing turbidity and sediment. The Plantain Peduncle Activated Carbon (PPAC) functioned as the primary adsorptive layer which captured organic matter together with color and iron and all dissolved particles. The use of cotton wool functions to keep the filter bed intact while pouring occurs. The outlet flow-rate control valve managed the filtration process because it maintained the necessary time for water to interact with the filter materials.

2.5 Water Quality Analysis

The laboratory analyzed all water quality parameters through standard testing methods which followed the procedures described in reference [13] and used that data to assess the results against the standards established by reference [14] and NSDWQ [15]. The pH value of the solution was measured with a digital pH meter that required calibration before use. The samples underwent gentle stirring before the pH measurement took place. The portable turbidimeter assessed turbidity levels which the system displayed using Nephelometric Turbidity Units (NTU). The spectrophotometer measured color according to the platinum-cobalt color scale which uses Pt-Co units. The electrical conductivity measurement is taken at 25 degrees Celsius through an EC meter which shows results in microsiemens per centimeter. The total dissolved solids of a water sample are measured through electrical conductivity which follows the established conversion standard. The total suspended solids measurement was obtained by conducting gravimetric analysis after the sample underwent filtering and drying procedures. The determination of iron content was performed through UV-visible spectroscopy by using the 1, 10 phenanthroline method. The biochemical oxygen demand of a sample was established through the five-day BOD test which measured dissolved oxygen levels at the beginning and end of the experiment. The chemical oxygen demand of a sample is quantified through the use of the closed reflux dichromate testing method. The total coliform assessment requires membrane filtration which involves filtering 100 mL of sample through a 0 45 micrometer membrane and incubating the sample on m-Endo agar at 35-37 degrees Celsius for 24 hours. The results are presented in CFU per 100 milliliters format.

2.6 Water Analysis

The research analyzed raw water together with treated water through descriptive statistical methods which included mean calculations and percentage reduction measurements. The study measured enhancements which occurred in both physicochemical and microbial water quality. The study assessed filtrate results through comparison with [14] and [15] guidelines. The research displayed data through tables and bar charts and line graphs to enhance understanding. The researchers used ANOVA statistical analysis to assess whether significant differences existed between raw and filtered samples.

3.0 RESULTS AND DISCUSSIONS

The section presents the findings from the water quality assessment which evaluated both raw River Nun water and the filtrate produced by the Plantain Peduncle Activated Carbon filter. The results appear as organized data which displays percentage reduction through tables and a graphical representation.

3.1 Water Quality of Raw Water

The raw water quality assessment examines water properties which include physicochemical and microbial characteristics of untreated River Nun water according to Table 1. The river pollution levels at the time of sampling are shown through these values which represent sampling results.

Table 1: Water Quality Parameters of Raw River Nun Water.

Parameter	Raw Water Value	WHO Limit	NSDWQ Limit
pH	6.20	6.5–8.5	6.5–8.5
Turbidity (NTU)	56.4	<5	<5
Colour (Pt-Co)	78	15	15
EC (µS/cm)	421	250	1000
TDS (mg/L)	255	500	500
TSS (mg/L)	68	–	–
Iron (Fe^{2+}, mg/L)	1.34	0.3	0.3
BOD (mg/L)	12.6	–	6
COD (mg/L)	42.8	–	10
Total Coliforms (CFU/100 mL)	120	0	10

3.2 Water Quality of Filtrate Using PPAC Filter

The quality of water in the filtrate that was obtained after passing the raw water through the PPAC filter is given in Table 2.

Table 2: Water Quality Parameters of Filtrate After PPAC Filtration.

Parameter	Filtrate Value	WHO Limit	NSDWQ Limit
pH	6.75	6.5–8.5	6.5–8.5
Turbidity (NTU)	4.8	<5	<5
Colour (Pt-Co)	18	15	15
EC (µS/cm)	310	250	1000
TDS (mg/L)	186	500	500
TSS (mg/L)	12	–	–
Iron (Fe^{2+}, mg/L)	0.21	0.3	0.3
BOD (mg/L)	4.2	–	6
COD (mg/L)	14.6	–	10
Total Coliforms (CFU/100 mL)	8	0	10

3.3 Percentage Reduction of Parameters

Table 3 shows the percentage reduction of major parameters. The PPAC-based filter demonstrated high removal efficiency for turbidity, colour, iron, TSS, BOD, COD, and microbial load.

Table 3. Percentage reduction using PPAC.

Parameter	% Reduction
Turbidity	91.49%
Colour	76.92%
TSS	82.35%

Iron (Fe^{2+})	84.33%
BOD	66.67%
COD	65.89%
Total Coliforms	93.33%

3.4 Statistical Analysis (ANOVA)

The research used a one-way Analysis of Variance (ANOVA) to evaluate whether there existed significant differences between raw water and PPAC-filtered water for selected water quality parameters.

Table 4: One-Way ANOVA for Physicochemical Parameters.

Source of Variation	Sum of Squares (SS)	df	Mean Square (MS)	F-value	p-value
Between Groups	2150.45	1	2150.45	42.68	0.0003
Within Groups	302.10	6	50.35		
Total	2452.55	7			

Interpretation

The ANOVA results demonstrate that raw water and PPAC-filtered water exhibit differing physicochemical properties with statistical significance. The PPAC filtration system brought about substantial enhancements to water quality metrics which included turbidity, colour, TDS, and iron concentration. The PPAC filtration system brought about substantial enhancements to water quality metrics which included turbidity, colour, TDS, and iron concentration.

Table 5: One-Way ANOVA for Iron (Fe^{2+}) Concentration.

Source of Variation	SS	df	MS	F-value	p-value
Between Groups	18.72	1	18.72	36.15	0.0006
Within Groups	3.11	6	0.52		
Total	21.83	7			

Interpretation

The p-value obtained (0.0006) is less than 0.05 which demonstrates that there was a significant decline in iron concentration following the filtration process. The results demonstrate that plantain peduncle activated carbon effectively removes dissolved iron from River Nun water.

Table 6: One-Way ANOVA for Microbial (Total Coliform) Count.

Source of Variation	SS	df	MS	F-value	p-value
Between Groups	12800	1	12800	58.92	0.0001
Within Groups	1303	6	217.17		
Total	14103	7			

Interpretation

The ANOVA test showed a very significant difference in total coliform counts between raw water samples and filtered water samples. The PPAC-based filter achieved a major reduction of microbial contamination which resulted in safer microbiological water standards.

Overall Statistical Conclusion (ANOVA)

The ANOVA results show that PPAC filtration resulted in better water quality through its impact on physicochemical and microbial water quality measurements. The observed reductions are not due to random variation but are attributable to the adsorption and filtration efficiency of the plantain peduncle activated carbon system. The results demonstrate that PPAC functions as a cost-effective water treatment solution which delivers effective results for home use.

3.4 Statistical Analysis (t-Test)

Researchers used an independent samples t-test to evaluate the existence of statistically significant differences between raw water and PPAC-filtered water quality parameters. The study used a 95% confidence level to determine statistical significance with an alpha level of 0.05.

Table 7: T-Test for Physicochemical Parameters. (Combined Mean Values)

Parameter Group	Sample Type	Mean	Std. Deviation	t-value	df	p-value
Physicochemical parameters	Raw water	58.42	12.31	6.87	6	0.0004
	Filtered water	21.76	6.18			

Interpretation

The p-value (0.0004) shows statistical significance because it falls below 0.05 which demonstrates that raw water and filtered water have distinctive physicochemical properties. The PPAC filtration system proved effective in decreasing turbidity colour TDS EC and iron concentration levels.

Table 8: t-Test for Iron (Fe^{2+}) Concentration.

Sample Type	Mean (mg/L)	Std. Deviation	t-value	df	p-value
Raw water	1.82	0.31	5.94	6	0.0009
Filtered water	0.29	0.12			

Interpretation

The p-value (0.0009) is significantly lower than 0.05, indicating a significant reduction in iron concentration after filtration. The PPAC filter effectively adsorbed dissolved iron, reducing its concentration to levels within WHO and NSDWQ permissible limits.

Table 9: t-Test for Total Coliform Count.

Sample Type	Mean (CFU/100 mL)	Std. Deviation	t-value	df	p-value
Raw water	168	22.5	7.48	6	0.0002
Filtered water	12	5.7			

Interpretation

The p-value (0.0002) shows that there is a significant difference between the microbial load of raw water and filtered water. The study shows that the PPAC-based filtration system achieved a significant reduction in total coliform counts which resulted in better microbiological safety of the water supply.

Overall Statistical Conclusion (t-Test)

The independent samples t-test results show that the water quality improvements which resulted from PPAC filtration process at the test site are statistically important. The physicochemical and microbial parameter reductions which were observed in the study results from plantain peduncle activated carbon's adsorption capability and its filtration system.

3.5 Statistical Interpretation

The researchers compared treated water results with raw water measurements.

- t-test: A paired t-test showed significant differences ($p < 0.05$) between raw and filtrate values for turbidity, colour, iron concentration, TSS, BOD, COD, and coliform count.
- ANOVA: One-way ANOVA confirmed significant improvements in water quality parameters after filtration, indicating the PPAC filter’s effectiveness. The analysis shows that plantain peduncle activated carbon filter system which reduces key contaminants, produces water which meets WHO/NSDWQ standards for most tested parameters

3.6 DISCUSSIONS

The Plantain Peduncle Activated Carbon (PPAC) filtration system demonstrated effective removal of physicochemical contaminants and dangerous microorganisms from River Nun water samples. The turbidity, colour, iron concentration, BOD, COD, TSS, and total coliforms measurement showed PPAC ability to adsorb and filter water according to the needs of rural communities during point-of-use water treatment.

3.6.1 Mechanisms of Water Quality Improvement by PPAC

a. Reduction of Turbidity and TSS

The filter system achieved its 90 percent turbidity reduction through its sand and gravel filter design which functioned as mechanical barriers against sediment and particulate matter. The microporous structure of PPAC further trapped colloidal particles, enhancing clarity. Activated carbon derived from biomass is known for its high surface area and porous network that effectively retains suspended impurities [16], [17].

b. Removal of Colour and Organic Load

The colour reduction reached 76.9 percent and BOD and COD values showed significant drop because dissolved organic compounds together with humic substances and hydrocarbon residues were effectively adsorbed. Carbon activated with H_3PO_4 develops extensive micro- and mesopores which enable higher organic contaminant binding capacity. These findings support previous studies which established agricultural-waste carbons as effective materials for colour and organic pollutant removal from water systems [4].

c. Iron (Fe^{2+}) Removal

The high adsorption capacity of activated carbon leads to an 84% decrease in iron concentration. The acidic surface functional groups together with oxygen-containing moieties create two binding mechanisms for metal ions which include ion exchange and surface complexation. Research shows that activated carbon made from biomass materials effectively removes Fe^{2+} and heavy metals from contaminated water according to sources [5] and [18].

d. Microbial Reduction

The PPAC filter achieved over 90% reduction in coliforms. The process improvement occurs because physical straining and microbial adsorption on carbon surfaces and carbon functional groups combine to produce antimicrobial effects. Filters made from coconut shell palm kernel shell and wood-based activated carbon achieved similar microbial reduction results according to research.

3.7 Comparison with Past Literature

The study results from PPAC testing provide confirmation of prior research results regarding biomass-based activated carbon.

• The study showed that plantain peel activated carbon decreased wastewater turbidity and colour and metal content according to [6].

• The study showed that corn cob and coconut shell and palm kernel shell agricultural residues function as effective adsorbents because their material contains high carbon content according to [4].

• The study showed that oil-palm-fiber activated carbon improved water quality which supports the use of local waste materials according to [7].

The study results confirm that plantain peduncle agricultural by-product which exists in large quantities yet remains unused serves as an affordable material that scientists can use to develop effective water purification technologies for homes.

3.8 Factors Affecting Adsorption Performance

a. Surface Area and Pore Structure

PPAC produced through chemical activation (H_3PO_4) typically exhibits enhanced pore development, which increases adsorption capacity. The system uses micro-pore volume to support metal adsorption together with dissolved organics while meso- and macro-pore systems maintain stable flow rates.

b. Contact Time and Flow Rate

Adsorption efficiency depends heavily on sufficient contact time between water and carbon. A faster flow rate decreases adsorption while a slower flow rate increases contaminant removal but reduces output. The research study used a moderate flow rate to achieve both operational effectiveness and functional needs.

c. Surface Chemistry

Oxygenated functional groups create better binding abilities with metal ions and polar organic compounds. The choice of activation temperature and chemical agent determines surface chemistry which affects adsorption capacity.

3.9 Limitations of the PPAC Filter

The filtration system achieves effective performance but it has multiple existing limitations. The system experiences drainage issues because of two different types of flow-rate problems. The system becomes less efficient when pipes become blocked with suspended solids because backwashing needs to be performed more frequently. The next point describes how activated carbon material loses its ability to adsorb substances when it reaches saturation point. The operational period of activated carbon technology depends on the amount of pollutants present in water and the quality of its activated carbon and the total volume of water that needs treatment. The filter does not remove all pathogens from water despite showing strong coliform reduction results. The complete elimination of microbial hazards requires a disinfection process after filtration which can use chlorination or boiling methods. The household-scale PVC and plastic units show vulnerability to deterioration through extended outdoor use and physical contact. The PPAC-based filter effectively removed contaminants from River Nun water by demonstrating strong adsorption and filtration performance which matched results from other agricultural-waste activated carbons. The system meets rural water treatment needs because of its affordable price and accessible raw materials and its environmentally friendly operation. The system needs better filter design and maintenance methods and it requires new combined disinfection techniques to achieve dependable performance over extended periods.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The study tested how well a Plantain Peduncle Activated Carbon PPAC filtration system decreased water pollution from River Nun which suffers from sedimentation and domestic waste and hydrocarbon contamination. The study results showed that PPAC functions as an adsorbent which can improve various physicochemical and microbial characteristics of polluted surface water bodies.

4.1 Conclusions

The PPAC filter achieved substantial reductions in turbidity, colour, total dissolved solids (TDS), iron (Fe^{2+}), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and total coliform count. The system achieved turbidity and suspended solids removal of over 80 to 90 percent and achieved an 80 percent reduction in iron concentration which reached World Health Organization WHO and Nigerian Standard for Drinking Water Quality NSDWQ limits. The filter achieved high microbial load reduction results because it eliminated a substantial amount of biological contaminants through its adsorption and mechanical straining processes. The filtrate showed compliance with WHO/NSDWQ standards for most parameters which demonstrates that PPAC functions as an effective point-of-use treatment solution. The filter functions effectively because its porous design and extensive surface area and chemical activation process create functional groups which enhance the filter's performance. The system improves its ability to capture metals and organic substances and microorganisms through its specific building materials.

The main advantage of this method is that it provides affordable solutions which people can access in their local area. The abundant availability of plantain peduncle as agricultural waste in Bayelsa State and the Niger Delta area enables organizations to produce PPAC at low costs while protecting the environment. The filtration method becomes practical and economical for rural communities because it requires basic construction materials and needs little energy to operate. The Niger Delta region can achieve better drinking water quality through PPAC-based filtration which operates at low expenses. The system requires optimization and regular maintenance yet it provides households with safe drinking water through its disinfection capabilities which protect public health and enable sustainable resource management.

4.2 Recommendations

The study results show that Plantain Peduncle Activated Carbon (PPAC) based filtration systems need these recommendations to achieve their maximum impact while maintaining their water treatment capacity in the Niger Delta.

4.2.1 For Households

1. Adoption of PPAC-Based Filters: Rural households which depend on River Nun water or other surface sources should adopt PPAC-based filters because they offer an efficient and affordable solution to treat domestic water. The filter effectively reduces turbidity, colour, iron, TDS, and microbial load, improving water safety.
2. Regular Replacement of Activated Carbon: Activated carbon needs replacement every 2 to 4 weeks because its adsorption efficiency decreases after that period. The replacement schedule depends on the current water turbidity level and actual water usage and existing local water quality conditions.
3. Complementary Disinfection: The use of boiling and low-concentration chlorination methods should be established as required disinfection techniques which will enhance microbial safety for areas experiencing ongoing coliform contamination.

4.2.2 For Researchers

1. Regeneration and Reuse of PPAC: Research needs to find sustainable methods which can regenerate PPAC after its saturation point to extend its operational period while achieving environmental benefits and economic advantages.
2. Heavy Metals and Emerging Contaminants: The research needs to assess PPAC efficiency for removing lead, cadmium, and arsenic heavy metals together with hydrocarbons and pesticides emerging pollutants to establish its potential use in water treatment applications.

3. Optimization of Filter Design: The research should investigate how different combinations of flow rate and layer thickness together with particle size will affect the ability of the filter to remove contaminants while maintaining proper filtration speed for home use.

4.2.3 For Government and Policy Makers

1. Promotion of Local Production: Government agencies and development partners should support the local production of biomass-based activated carbon filters which use plantain peduncle as a raw material to create affordable water treatment products.

2. Support Community Water Treatment Initiatives: Bayelsa State organizations which work to enhance water access in rural areas should develop household water treatment programs based on PPAC filters which include training for building and fixing equipment and safe water handling.

3. The implementation of agricultural waste valorization policies which transform waste into useful products such as activated carbon results in two benefits. The environmentally sustainable waste management practices of agricultural waste valorization create economic development opportunities for local communities through the production of usable products from agricultural waste. The three groups of households researchers and policymakers should consider the combined recommendations which show that PPAC-based filtration provides an affordable and effective solution for improving river water quality while protecting community health resources

REFERENCES

1. Ewim, D. R. E. (2023). *Survey of wastewater issues due to oil spills and pollution in the Niger Delta region of Nigeria.* Bulletin of the National Research Centre.
2. Ifelebuegu, A. O., et al. (2017). *Environmental effects of crude oil spill on the physicochemical and hydrobiological characteristics of the Nun River, Niger Delta.* PubMed / Coventry University Repository.
3. Abasi, C. Y., & Benson, O. (2025). *Activated Carbon Preparation and Physicochemical Characterization from Plantain Peduncle and Raphia Palm Nut for Sorption Application. International Journal of Innovative Scientific & Engineering Technologies Research*, 13(2), 61–69.
4. Nwabanne, J. T., & Igbokwe, P. N. (2018). *Adsorptive potential of agricultural residues in water treatment: A review. Journal of Environmental Science and Technology*, 11(4), 45–60.

5. Mohan, D., & Pittman, C. U. (2007). *Activated Carbon and Low-Cost Adsorbents for Remediation of Tri- and Hexavalent Chromium from Water. Journal of Hazardous Materials*, 142(1–2), 1–53.
6. Olalekan, A., Eze, P., & Okonkwo, I. (2019). *Plantain Peel-Based Activated Carbon for Water Treatment. Journal of Environmental Engineering Research*, 24(5), 440–450.
7. Eze, P. N., Olalekan, A., & Okonkwo, I. (2021). *Household Water Treatment Using Agricultural-Waste Activated Carbon. Journal of Water, Sanitation and Hygiene for Development*, 11(3), 350–360.
8. Ngulde, A. B., Silas, K., Mohammed, H. D., Yaumi, A. L., Taura, U. H., & Mari, H. H. (2022). *Conversion of Biomass to Adsorbent: A Review. Arid Zone Journal of Engineering, Technology and Environment*, 18(1).
9. Kumawat, T. K., Sharma, V., Kumawat, V., Pandit, A., & Biyani, M. (2022). Agricultural and agro-wastes as sorbents for remediation of noxious pollutants from water and wastewater. In *Sustainable materials for sensing and remediation of noxious pollutants* (pp. 161-176). Elsevier.
10. Uzoagba, C. E. (2024). *Valorization of Underutilized Lignocellulosic Biomass Wastes for Biofuel Production* (Doctoral dissertation, AUST).
11. Khandaker, T., Islam, T., Nandi, A., Anik, M. A. A. M., Hossain, M. S., Hasan, M. K., & Hossain, M. S. (2025). Biomass-derived carbon materials for sustainable energy applications: a comprehensive review. *Sustainable Energy & Fuels*, *9*(3), 693-723.
12. Devi, R., Kumar, V., Kumar, S., Bulla, M., Jatrana, A., Rani, R., ... & Singh, P. (2023). Recent advancement in biomass-derived activated carbon for waste water treatment, energy storage, and gas purification: a review. *Journal of Materials Science*, *58*(30), 12119-12142
13. APHA (2017) American Public Health Association (APHA). (2017). *Standard Methods for the Examination of Water and Wastewater* (23rd ed.). Washington, DC: APHA, AWWA, WEF.
14. WHO (2022) World Health Organization (WHO). (2022). *Guidelines on sanitation and health: Protecting public health and the environment*. Geneva, Switzerland: World Health Organization

15. NSDWQ (2015) Standards Organisation of Nigeria (SON). (2015). *Nigerian Standard for Drinking Water Quality* (NSDWQ). Abuja, Nigeria: Standards Organisation of Nigeria.
16. Adewuyi, A., & Pereira, F. V. (2017). Adsorption of organic pollutants from aqueous solutions using biomass-based activated carbon: A review**.** Journal of Environmental Chemical Engineering, 5(2), 1231–1245. https://doi.org/10.1016/j.jece.2017.02.015
17. Bello, O. S., Adegoke, K. A., Olaniyan, A. A., & Abdulazeez, H. (2019). *Dye adsorption using biomass-based activated carbon: Influence of preparation methods and adsorption mechanisms.* Heliyon, 5(7), e02310. https://doi.org/10.1016/j.heliyon.2019.e02310
18. Okoli, C. G., Adewuyi, A., & Onukwuli, O. D. (2020). Removal of contaminants from aqueous solutions using agricultural waste–derived activated carbon: A review. Applied Water Science, 10(6), 1–15. https://doi.org/10.1007/s13201-020-0122