International Journal of Scientific Research and Modern Technology (IJSRMT) ijsrmt.com
Volume 5, Issue 10, 2026
DOI: https://doi.org/10.38124/ijsrmt.v5i10.1764

Purification of Produced Water to Meet NUPRC Disposal Quality Using Activated Corncob

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Publication Date: 2026/11/16

Abstract

A big waste stream from oil and gas production is produced water, which can adversely affect soil, ground water and aquatic ecosystems if not disposed of properly. In this study, corncob was activated using potassium hydroxide (KOH) and its ability to remove the produced water pollutant, potassium (K+) was investigated and the result was the use of the material as a low-cost adsorbent for removal of the pollutant against NUPRC guidelines. Corncob was carbonised at 400°C for 1 hour, chemically activated with impregnation ratio of 1:3 with KOH at 400°C for 90 minutes, washed with distilled water and dried. The produced water from Egbaoma Field Flow Station, Umutu, Delta State, was collected and 10 g dose of activated corncob was added to the water and stirred for 45 minutes. The treated sample was filtered and then analysed for physicochemical properties. The percentage removal of TDS decreased from 4840 to 31.00 mg/L (99.36% removal) and the percentage removal of electrical conductivity decreased from 9680 to 62.00 µS/cm (99.36% removal). The percentage reductions for the Total suspended solids, total hydrocarbon content, iron and oil and grease were 67.18%, 59.96%, 58.89% and 26.67% respectively. The treated sample complied with NUPRC limits for pH, temperature, TDS, TSS, Oil and Grease, Lead, Copper, Chromium and Zinc. Iron levels were exceeded and have been reduced from 8.236 to 3.386 mg/L, exceeding the limit of 1.0 mg/L. The results showed that KOH-activated corncob was able to significantly improve the quality of the produced water, but was not able to meet the requirements in one batch.

Keywords: *Produced Water, Activated Corncob, Potassium Hydroxide, Adsorption, NUPRC, Wastewater Treatment.*

I. INTRODUCTION

Produced water is one of the primary waste streams from the production of oil and gas and if not treated appropriately contains serious environmental problems. It may contain hydrocarbons, dissolved and suspended solids, oil and grease, heavy metals and other components depending on the reservoir characteristics and production activities [1, 2]. When produced water is inadequately discharged into the environment, it can pollute the water, degrade water quality, and lead to degradation of agricultural lands especially for oil-producing communities in the Niger Delta region of Nigeria [2, 3]. Therefore, processing of produced water prior to disposal is crucial to minimize environmental pollution and to comply with regulatory requirements.

There are several technologies developed to treat produced water, such as gravity separation, hydrocyclone, coagulation–flocculation, biological treatment and membrane processes [4]. These techniques can be effective, but can often involve the use of specialized equipment, chemicals, technical know-how and significant operating expenses. Such difficulties have driven the research of locally available, low cost adsorbents for wastewater treatment. The agricultural residues are of interest, because they are easy to obtain and can be processed into carbon adsorbents. The agricultural waste material like corncob can be carbonized and chemically activated to produce an adsorbent material with adsorbent properties suitable for pollutant removal [5, 6]. But, the efficiency of an adsorbent needs to be tested with target wastewater and the corresponding disposal standards.

Although the agricultural waste adsorbents are gaining interest, the efficacy of activated corncob in treating a real field-produced water should be evaluated based on the variation of physicochemical parameters considered for the disposal compliance. Evaluating treated water against the Nigerian Upstream Petroleum Regulatory Commission (NUPRC) limits is practical way of establishing the treatment process effectiveness of treating produced water quality. The study, therefore, focused on treating produced water from Egbaoma Field

Esidje, U. S., Eseoghene, O., & Etim, U. E. (2026). Purification of Produced Water to Meet NUPRC Disposal Quality Using Activated Corncob. *International Journal of Scientific Research and Modern Technology*, *5*(10), 163–167. https://doi.org/10.38124/ijsrmt.v5i10.1764

Flow Station, Umutu, Delta State, Nigeria with potassium hydroxide (KOH)-activated corncob.

The primary goal of this project was to treat produced water by activated corncob as an adsorbent and to evaluate the quality of the treated water in comparison to the NUPRC disposal limits. The specific objectives were to prepare activated corncob by chemical activation, to establish the physicochemical properties of untreated water, to evaluate the removal efficiency for selected parameters and compare the quality of treated water with the permissible limits for disposal.

The study is significant as it examines how an agricultural waste product can be used as an adsorbent that can be produced locally and used to treat produced-water. The process may be a promising method for the treatment of selected contaminants and for the value added to an underutilized residue. The comparison of the characteristics of the treated-water with the reported NUPRC limit also assists in determining the parameters requiring additional treatment prior to disposal. The results can then be used to inform further research on future low cost produced water treatment methods for the Nigerian oil field.

II. MATERIALS AND METHODS

➢ *Materials and Equipment*

The materials used include corncob, potassium hydroxide (KOH), distilled water and produced water from Egbaoma Field Flow Station, Umutu, Delta State. The equipment reported in the project was a furnace, oven, measuring cylinder, mortar and pestle/blender, beakers, weighing balance, stirrer, pH meter, total dissolved solids (TDS) meter, steel container, instrument kit and UV spectrometer and reagent bottle.

➢ *Sample Collection and Preparation*

Corncobs were picked up from the market and washed and air dried until hard. The samples of produced water were collected from Egbaoma Field Flow Station, Umutu, Delta State in pre-cleaned plastic bottles.

➢ *Carbonization and Activation of Corncob*

The corncobs were broken up into smaller pieces and put in a steel container. The container was heated in a furnace at the temperature 400℃ for 1 hour. The carbonized material was taken and protected from air, cooled and ground to fine powders. Chemical activation involved mixing of corncob charcoal with 800 mL of KOH for impregnation ratio of 1:800 followed by stirring with laboratory glass rod. The mixture was activated in furnace at 400℃ for 90 minutes, rinsed with distilled water, shaken for 45 minutes, and then dried in a furnace at 400℃ for some minutes.

➢ *Produced-Water Treatment and Analysis*

Produced water was added to a clean bowl (1 litre) and 10 g of activated corncob was added. The mixture was stirred for 45 minutes, transferred to a conical flask and filtered. Physicochemical parameters were determined prior to treatment and after treatment, and compared with the NUPRC disposal limits given in the project. The percentage of removal efficiency was determined by the following equation:

$$\% \text{ Removal} = [(C_{before} - C_{after}) / C_{before}] \times 100$$

The concentration of the compound before and after treatment is represented by Cbefore and Cafter, respectively.

III. RESULTS AND DISCUSSION

➢ *Physicochemical Properties Before and After Treatment*

Table 1 presents the measured properties of the produced water before and after treatment with activated corncob.

Table 1 Physicochemical Properties of Produced Water Before and After Treatment.

Parameter	Unit	Before Treatment	After Treatment
pH	—	7.34	7.93
Temperature	°C	25.8	27.4
Total dissolved solids (TDS)	mg/L	4840	31.00
Electrical conductivity	µS/cm	9680	62.00
Total hydrocarbon content	mg/L	354.78	142.04
Total suspended solids (TSS)	mg/L	36.751	12.062
Oil and grease	mg/L	0.30	0.22
Lead	mg/L	<0.01	<0.01
Copper	mg/L	0.013	<0.01
Chromium	mg/L	<0.01	<0.01
Iron	mg/L	8.236	3.386
Zinc	mg/L	0.312	0.287

➢ *Removal Efficiency*

Table 2 Removal Efficiencies Reported for the Measured Parameters. Lead and Chromium were Below the Detection Limit Before and After Treatment; Removal Efficiency was Reported as not Applicable.

Parameter	Before	After	Removal Efficiency
TDS (mg/L)	4840	31.00	99.36%
Electrical conductivity (µS/cm)	9680	62.00	99.36%
Total hydrocarbon content (mg/L)	354.78	142.04	59.96%
TSS (mg/L)	36.751	12.062	67.18%
Oil and grease (mg/L)	0.30	0.22	26.67%
Copper (mg/L)	0.013	<0.01	23.08%
Iron (mg/L)	8.236	3.386	58.89%
Zinc (mg/L)	0.312	0.287	8.01%

➢ *Comparison with NUPRC Disposal Limits*

Table 3 Comparison of Treated-Water Values with the NUPRC Limits Reported in the Project. The Project Lists no NUPRC Limit for Total Hydrocarbon Content.

Parameter	Reported NUPRC Limit	After Treatment	Status Based on Reported Limits
pH	6.5–8.5	7.93	Meets limit
Temperature	40°C maximum	27.4°C	Meets limit
TDS	2000 mg/L	31.00 mg/L	Meets limit
Electrical conductivity	1250–2000 µS/cm	62.00 µS/cm	Below reported range
TSS	50 mg/L	12.062 mg/L	Meets limit
Oil and grease	10.0 mg/L	0.22 mg/L	Meets limit
Lead	0.05 mg/L	<0.01 mg/L	Meets limit
Copper	1.0 mg/L	<0.01 mg/L	Meets limit
Chromium	0.03 mg/L	<0.01 mg/L	Meets limit
Iron	1.0 mg/L	3.386 mg/L	Does not meet limit
Zinc	5.0 mg/L	0.287 mg/L	Meets limit

➢ *Discussion*

The largest reductions were observed for TDS and electrical conductivity, both reported at 99.36%. TDS decreased from 4,840 mg/L to 31.00 mg/L, while electrical conductivity decreased from 9,680 µS/cm to 62.00 µS/cm. TSS decreased from 36.751 to 12.062 mg/L, corresponding to 67.18% removal. The project notes that the untreated TSS value was already below the reported NUPRC limit of 50 mg/L.

Total hydrocarbon content decreased from 354.78 to 142.04 mg/L, representing 59.96% removal. Oil and grease decreased from 0.30 to 0.22 mg/L (26.67%). Lead and chromium were below the reported detection limit of 0.01 mg/L in both samples. Copper decreased from 0.013 mg/L to below 0.01 mg/L, while zinc decreased from 0.312 to 0.287 mg/L (8.01%).

Iron decreased from 8.236 to 3.386 mg/L, corresponding to 58.89% removal, but remained above the project's stated NUPRC limit of 1.0 mg/L. Thus, although the treatment improved the measured quality, one treatment pass using 10 g/L of activated corncob and 45 minutes of contact time did not achieve compliance for all assessed parameters. The project recommends varying adsorbent dosage and contact time and considering combined treatment methods to identify conditions that can achieve full compliance.

IV. CONCLUSION

KOH-activated corncob reduced several physicochemical parameters in produced water collected from Egbaoma Field Flow Station, Umutu, Delta State. TDS and electrical conductivity each showed 99.36% reduction; TSS, total hydrocarbon content, iron, and oil and grease showed reductions of 67.18%, 59.96%, 58.89%, and 26.67%, respectively. Based on the limits reported in the project, the treated sample met the limits for most assessed parameters, but iron remained non-compliant at 3.386 mg/L against a stated limit of 1.0 mg/L. The findings support the use of activated corncob as a treatment stage, rather than a stand-alone process for achieving full compliance under the conditions tested.

RECOMMENDATIONS

Future studies should systematically vary adsorbent dosage and contact time. Combined treatment methods should also be employed to identify optimum conditions for achieving full NUPRC compliance.

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