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Original Research Article

Phytoremediation Potential of *Pennisetum purpureum* for Crude oil -Contaminated Soils in Ogale Community, Rivers State, Nigeria

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Abstract

This study evaluated the phytoremediation potential of *Pennisetum purpureum* (elephant grass) in petroleum-contaminated soils collected from Ogale, Eleme Local Government Area of Rivers State, Nigeria. The investigation focused on the reduction of Total Petroleum Hydrocarbons (TPHs) and Polycyclic Aromatic Hydrocarbons (PAHs) in the soil and the accumulation of these hydrocarbons in plant tissues after a three-month remediation period. Experimental setups included control and contaminated soil samples, with TPH and PAH concentrations monitored before and after remediation using gas chromatography. The results revealed a significant reduction in hydrocarbon concentrations in moderately contaminated soils. In Sample B, TPH and PAH removal efficiencies reached 33.19% and 78.07%, respectively, while Sample C, which was more heavily polluted, showed lower efficiencies of 3.85% for TPHs and 58.65% for PAHs. Accumulation analysis confirmed the uptake of hydrocarbons by *P. purpureum*, with a total of 13,004.60 ppm of TPHs and 33.98 ppm of PAHs detected in plant tissues. The uptake-to-removal ratios further supported the plant's role in phytoextraction, particularly for high-molecular-weight hydrocarbons. These findings underscore the effectiveness of *P. purpureum* as a low-cost and environmentally sustainable solution for remediating petroleum-contaminated soils, especially in moderately polluted environments. The study reinforces the relevance of plant-soil-microbe interactions and site-specific conditions in enhancing phytoremediation efficiency.

Keywords: phytoremediation, *Pennisetum purpureum*, Total Petroleum Hydrocarbons, Polycyclic Aromatic Hydrocarbons, phytoextraction, rhizodegradation, crude oil pollution.

INTRODUCTION

Soil contamination by petroleum hydrocarbons is an unrelenting environmental crisis especially in oil prone environment areas like the Niger Delta of Nigeria. Frequent oil spills caused by consequences of old infrastructure, breakdown of equipment, vandalization of pipelines and illicit refineries have grossly affected the land and water life. Such cases in regions such as Ogale in Eleme Local Government Area, Rivers State have caused people to experience lowered soil fertility, biodiversity loss, and wide-scale contamination of water resources. Total Petroleum Hydrocarbons (TPHs) and Polycyclic Aromatic Hydrocarbons (PAHs) are for the most part considered as some of the most toxic and recalcitrant parts of crude oil because they have great bioaccumulative inclination, carcinogenicity, and long-term ecological stability [1]. They do not only reduce the activity of microbes and the development of plants but also endanger human health as a result of the polluted food and water supply [2].

Socio-economically, the negative effect of hydrocarbon contamination is enormous agricultural productivity level, food scarcity, loss of livelihood, which further aggravates poverty and unemployment in the afflicted groups of people [3]. Conventional remediation technologies like soil digging, chemical oxidation, and thermal desorption are usually constrained by excessive cost of application, complexity in operation, and destructiveness to the environment. Such interventions have the capacity to affect soil structure, microbial diversity and cannot be readily accessed in low resource settings. By contrast, phytoremediation has offered an effective and environmentally safe substitute that is affordable. It uses plants to extract, degrade, or stabilize any harmful substances in the environment via phytoextraction, rhizodegradation, phytodegradation, and phytostabilization [4]. Such processes can provide in situ remediation and maintain the integrity of soil and promote recovery of the ecosystem [5].

Pennisetum purpureum (elephant grass) has been a strong candidate in phytoremediation as it has a large root system and biomass production, adapts very well to marginal soils, and can tolerate hydrocarbon stress. It has been shown that the species stimulates the activity of microbes in the rhizosphere with the help of root exudates which favor the breaking down of hydrocarbons [6]. In particular, P. purpureum decreased the concentrations of total hydrocarbons in contaminated soils to 38 and 46 mg/kg after 40 days compared to 320 and 590 mg/kg, this was also the case with concentrations of 38 to 320 mg/kg and 46 to 590 mg/kg [6]. It also is demonstrated to be up to 27.67 percent effective in TPH decrease during early phases of growth in oil-based drill cuttings [7]. The capability of the plant to accumulate hydrocarbons in itself in addition to facilitating the rhizosphere microbial population adds further credence to its contribution not only to phytoextraction but also to rhizodegradation. It also contains a lot of lignocellulosic content which has a possible use as a bio energy resource which involves a zero-waste remediation method [8].

This paper will evaluate phytoremediation potential of *Pennisetum purpureum* to polluted soil that contain petroleum product in petroleum impacted soil at Ogale and community. To be precise, it aims to quantify pre- and post-phytoremediation TPHs and PAHs level, assess hydrocarbons accumulation in plant tissues, estimate the proportional overall remediation effectiveness, and introduce the uptake-to-removal ratio as the new parameter of assessing phytoextraction efficacy. These findings are pertinent to expanding research on sustainable remediation and provide an avenue of practical application on the application of *P. purpureum* on reversing the polluted oil-based environment especially the economically challenged as well as ecologically damaged regions.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in Ogale community, located in Eleme Local Government Area (LGA) of Rivers State, Nigeria. The area is intersected by the Trans-Niger Pipeline, which conveys Bonny Light crude oil and has experienced multiple spillage incidents over the years. A recent crude oil spill occurred in March 2025 due to the vandalism of aging, above-ground pipeline infrastructure. The spill persisted for several days, resulting in severe contamination of the surrounding soil and vegetation.

The dominant soil type in the area is loamy soil, which is moderately fertile and supports native plant species, including *Pennisetum purpureum* (elephant grass). Ogale is a fast-developing peri-urban settlement that faces continuous environmental and health challenges due to recurring petroleum pollution. For control purposes, soil samples were also collected from an uncontaminated site within the same geographical zone, sharing similar soil texture and vegetation but with no history of hydrocarbon contamination.

Sample Collection

Soil and plant samples were collected from both contaminated and uncontaminated areas in Ogale community. A hand soil auger was used to collect soil samples at a depth of 30 cm. Samples were collected in triplicates and bulked to form representative composites. Each composite sample was placed into sterilized, airtight polyethylene bags, properly labeled, and stored at 4°C prior to analysis. Control soil samples were obtained in triplicate from a proximal location within the same region but with no documented crude oil pollution. The control soil was taxonomically classified as loamy sand. In addition, *Pennisetum purpureum* were harvested from the experimental uncontainers at the end of the study period. The plant samples were placed in sterilized polyethylene bags, labeled accordingly, and stored at 4°C. Taxonomic identification and authentication of the plant were performed at the Department of Plant Science and Biotechnology, University of Port Harcourt.

Experimental Design and Methodology

The experiment was conducted under controlled conditions using contaminated and uncontaminated soils collected from the study site. Three 5-liter containers were used for the setup. Container A was filled with uncontaminated soil and served as the control, while Containers B and C were filled with contaminated soil samples collected from three different points within the polluted area. Prior to planting, 150 grams of soil from each treatment group were collected for baseline hydrocarbon analysis. Seedlings of *Pennisetum purpureum* were transplanted into all containers.

Preparation of Samples

Soil samples were air-dried at room temperature to constant weight. The dried soils were homogenized and sieved through a 2 mm polyethylene sieve to remove debris and standardize particle size for laboratory analysis. Plant samples were washed under running tap water to remove attached soil and then sectioned using a clean stainless-steel knife. The samples were oven-dried at 60°C for 24 hours, after which they were ground to a uniform particle size suitable for chemical analysis.

Sample Digestion and Analysis

PAH and TPH Extraction

Ten grams of each dried soil sample were weighed into solvent-rinsed beakers. Thirty milliliters of dichloromethane (DCM) was added to each sample as the extracting solvent. Ortho-terphenyl was used as an internal standard. Each mixture was vortexed for five minutes and then agitated in an orbital shaker for 30 minutes. The extracts were filtered using a glass funnel lined with glass wool and anhydrous sodium sulfate to remove particulate matter and residual moisture. The filtrate was transferred into Teflon-lined screw-cap vials,

sealed, and stored for hydrocarbon analysis. Quantification of Total Petroleum Hydrocarbons (TPHs) and Polycyclic Aromatic Hydrocarbons (PAHs) was carried out using Gas Chromatography (GC) following standard operating procedures.

Phytoremediation Efficiency Evaluation

The effectiveness of *Pennisetum purpureum* in remediating petroleum-contaminated soil was determined by comparing the concentrations of TPHs and PAHs before and after the three-month planting period. Remediation efficiency was calculated using the following expressions:

Amount Remediated (AR) = Initial Concentration (Ic) − Final Concentration (Fc)

$$\textbf{Percentage Remediation (\%)} = \frac{AR}{Ic} \times 100 \qquad (1)$$

Hydrocarbon Accumulation in Plant Tissues

To evaluate phytoaccumulation potential, the harvested plant tissues were analyzed for residual concentrations of TPHs and PAHs. This analysis provided insight into the degree of contaminant uptake and translocation within the plant biomass.

Determination of Hydrocarbon Accumulation in *Pennisetum purpureum* Tissues

The Uptake-to-Removal Ratio (URR) was calculated to quantify the proportion of hydrocarbons accumulated in plant tissues relative to the amount remediated from the soil, using the formula:

$$\textbf{URR (\%)} = \frac{\text{Total hydrocarbon in plant (ppm)}}{\text{Amount remediated from soil (ppm)}} \times 100 \qquad (2)$$

RESULTS AND DISCUSSION

Total Petroleum Hydrocarbon (TPH) Concentration Before and After Phytoremediation

The concentration of Total Petroleum Hydrocarbons (TPHs) in soil samples prior to phytoremediation is presented in Table 1. Sample A, the uncontaminated control, showed a baseline TPH level of 57.70 ppm. In contrast, Samples B and C recorded significantly higher concentrations of 7438.24 ppm and 8214.66 ppm, respectively, indicating substantial contamination at the study site.

Table 1: Total Petroleum Hydrocarbon (TPH) Concentrations in Soil Samples Before and After Phytoremediation

S/No	Component	Sample A Before (ppm)	Sample A After (ppm)	Sample B Before (ppm)	Sample B After (ppm)	Sample C Before (ppm)	Sample C After (ppm)
1	n-Octane (n-C_8)	–	–	–	–	–	–
2	n-Nonane (n-C_9)	–	–	–	–	–	–
3	n-Decane (n-C_{10})	–	–	–	–	–	2.29
4	n-Undecane (n-C_{11})	–	–	–	2.52	–	4.80
5	n-Dodecane (n-C_{12})	–	–	17.17	2.73	21.83	3.74
6	n-Tridecane (n-C_{13})	–	–	–	3.03	–	3.69
7	n-Tetradecane (n-C_{14})	–	–	–	3.67	–	4.28
8	n-Pentadecane (n-C_{15})	–	–	8.91	–	13.56	97.42
9	n-Hexadecane (n-C_{16})	–	3.35	286.47	311.58	321.5	618.92
10	n-Heptadecane (n-C_{17})	–	3.93	560.55	421.86	761.82	1325.70
11	Pristane	–	5.37	560.55	1056.27	761.82	1265.66
12	n-Octadecane (n-C_{18})	–	7.16	495.46	80.32	653.79	169.91
13	Phytane	–	–	495.46	1253.69	653.79	1677.59
14	n-Nonadecane (n-C_{19})	–	4.80	354.75	41.43	466.26	266.97
15	n-Eicosane (n-C_{20})	2.52	4.42	811.85	281.74	1051.2	221.15
16	n-Heneicosane (n-C_{21})	3.33	–	440.88	291.10	297.56	377.77
17	n-Docosane (n-C_{22})	4.27	2.574	146.97	338.43	436.32	537.12
18	n-Tricosane (n-C_{23})	3.36	–	353.73	509.26	195.89	71.05
19	n-Tetracosane (n-C_{24})	–	2.61	444.00	100.94	501.91	390.93
20	n-Pentacosane (n-C_{25})	31.11	–	378.08	79.41	231.88	124.80
21	n-Hexacosane (n-C_{26})	2.46	1.2401	500.07	11.25	528.56	79.21
22	n-Heptacosane (n-C_{27})	4.71	–	211.92	4.42	290.41	129.01
23	n-Octacosane (n-C_{28})	0	–	511.36	14.48	415.70	63.17
24	n-Nonacosane (n-C_{29})	–	18.50	387.35	20.92	406.50	214.35
25	n-Triacontane (n-C_{30})	2.83	–	511.38	68.47	572.89	52.21
26	n-Hentriacontane (n-C_{31})	–	–	316.42	29.20	305.14	90.29
27	n-Dotriacontane (n-C_{32})	–	–	142.09	7.54	324.91	85.48
28	n-Tritriacontane (n-C_{33})	–	3.46	169.36	18.48	213.92	6.20
29	n-Tetratriacontane (n-C_{34})	–	–	255.32	3.32	124.02	6.77
30	n-Pentatriacontane (n-C_{35})	3.13	–	89.69	–	55.91	4.00

S/No	Component	Sample A Before (ppm)	Sample A After (ppm)	Sample B Before (ppm)	Sample B After (ppm)	Sample C Before (ppm)	Sample C After (ppm)
31	n-Hexatriacontane (n-C_{36})	–	–	33.57	–	6.81	3.56
32	n-Heptatriacontane (n-C_{37})	–	–	6.71	–	9.39	–
33	n-Octatriacontane (n-C_{38})	–	–	4.20	–	6.98	–
34	n-Nonatriacontane (n-C_{39})	–	–	–	–	–	–
	Total (ppm)	**57.70**	**57.40**	**7438.24**	**4956.06**	**8214.66**	**7898.03**

Following the three-month phytoremediation period with *Pennisetum purpureum*, TPH concentrations were re-evaluated (Table 1). In Sample A, the TPH level slightly decreased to 57.40 ppm, with a remediation efficiency of 0.51%. However, a substantial reduction was observed in Sample B, where TPH concentration declined from 7438.24 ppm to 4956.06 ppm, corresponding to a remediation amount of 2462.17 ppm and a removal efficiency of 33.19%. Sample C exhibited a less pronounced reduction, from 8214.66 ppm to 7898.03 ppm, representing a remediation efficiency of 3.85%.

Specific hydrocarbon components also varied significantly post-treatment. in Sample B, n-eicosane (C_{20}) decreased from 811.85 ppm to 281.74 ppm, while n-heptadecane (C_{17}) declined from 560.55 ppm to 421.86 ppm. n-Hentriacontane (C_{31}) showed a marked reduction from 316.42 ppm to 29.20 ppm. Conversely, phytane increased from 495.46 ppm to 1253.69 ppm, possibly due to the breakdown of longer-chain hydrocarbons or analytical variability.

These findings are summarized visually in figure 1, which compares total TPH concentrations before and after phytoremediation across all samples. The results indicate the effectiveness of *P. purpureum* in remediating petroleum-contaminated soils, especially in moderately polluted scenarios (Sample B).

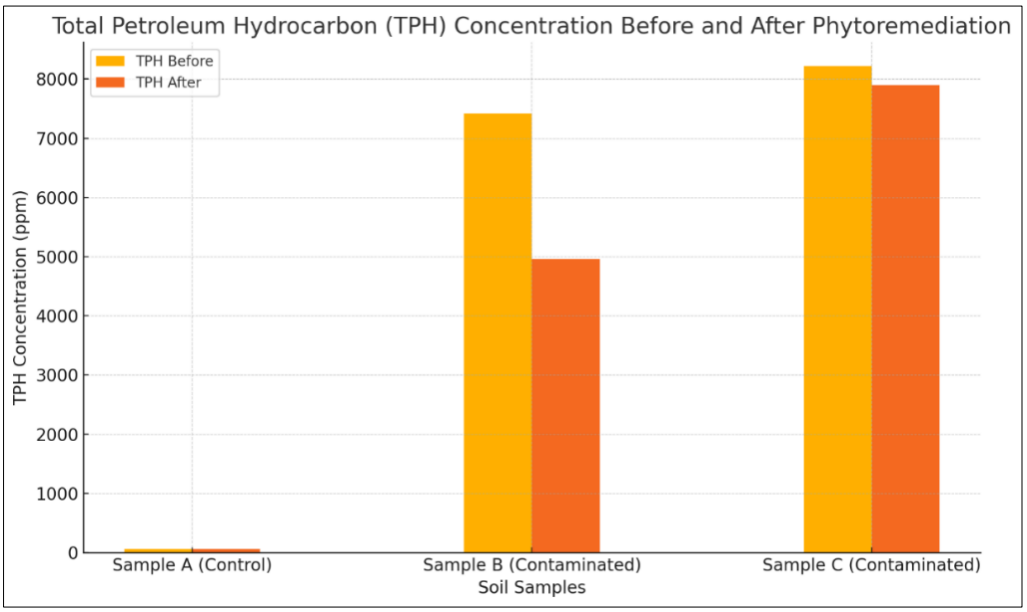

Figure 1: Total Petroleum Hydrocarbon (TPH) Concentration in Soil Samples Before and After Phytoremediation

The observed patterns are consistent with previous findings. Onwuka *et al.* [9] reported up to 86.2% TPH removal using *Cynodon dactylon*, while Cheng *et al.* [10] observed over 90% remediation using *Vetiveria zizanioides* under optimized conditions. The relatively lower efficiency in Sample C may reflect differences in soil conditions or root establishment. According to Udom *et al.* [11], high contamination levels tend to suppress plant growth and microbial activity, both critical for effective phytoremediation.

Polycyclic Aromatic Hydrocarbon (PAH) Concentration Before and After Phytoremediation

Baseline concentrations of Polycyclic Aromatic Hydrocarbons (PAHs) in soil samples before phytoremediation are shown in Table 2. Samples B and C recorded total PAH levels of 172.99 ppm and 185.83 ppm, respectively, whereas Sample A had a minor presence of 0.74 ppm.

Table 2: Polycyclic Aromatic Hydrocarbon (PAH) Concentration in Soil Before and After Phytoremediation

PAH Component	Sample A Before (ppm)	Sample A After (ppm)	Sample B Before (ppm)	Sample B After (ppm)	Sample C Before (ppm)	Sample C After (ppm)
Acenaphthene	–	–	2.08	–	3.15	–
Acenaphthylene	–	–	0.59	–	0.81	–
Anthracene	–	–	15.61	–	13.62	–
Benz(a)anthracene	–	–	12.30	8.40	16.47	11.26
Benz[a]pyrene	–	–	10.74	–	10.37	–
Benzo(b)fluoranthene	–	–	18.71	–	22.14	–
Benzo(g,h,i)perylene	–	–	2.43	–	0.30	–
Benzo(k)fluoranthene	–	–	13.12	–	11.45	–
Chrysene	0.74	–	24.10	–	20.36	7.30
Dibenz(a,h)anthracene	–	–	3.89	–	1.00	–
Fluoranthene	–	–	10.81	18.49	15.56	31.46
Fluorene	–	–	26.57	–	40.11	–
Indeno(1,2,3-cd)pyrene	–	–	1.02	–	1.07	–
Naphthalene	–	–	1.13	–	1.36	–
Phenanthrene	–	–	22.35	–	19.25	4.78
Pyrene	–	–	7.54	11.03	8.82	22.04
Total PAHs	0.74	0.00	172.99	37.93	185.83	76.84

After phytoremediation, residual PAH concentrations are presented in Table 2. In Sample A, PAHs became undetectable (0.00 ppm), while in Samples B and C, concentrations reduced to 37.93 ppm and 76.84 ppm, translating to remediation efficiencies of 78.07% and 58.65%, respectively.

Reductions in individual PAH compounds such as benz(a)anthracene, chrysene, and phenanthrene were particularly notable. However, in Sample C, some residual components, such as fluoranthene (31.46 ppm), remained elevated, suggesting incomplete remediation under high contamination loads. Figure 2 graphically illustrates the PAH concentrations before and after remediation. These results confirm that *P. purpureum* can effectively remove PAHs, especially in moderately contaminated soils, by supporting microbial communities that degrade aromatic hydrocarbons in the rhizosphere (Guang-jun, 2011).

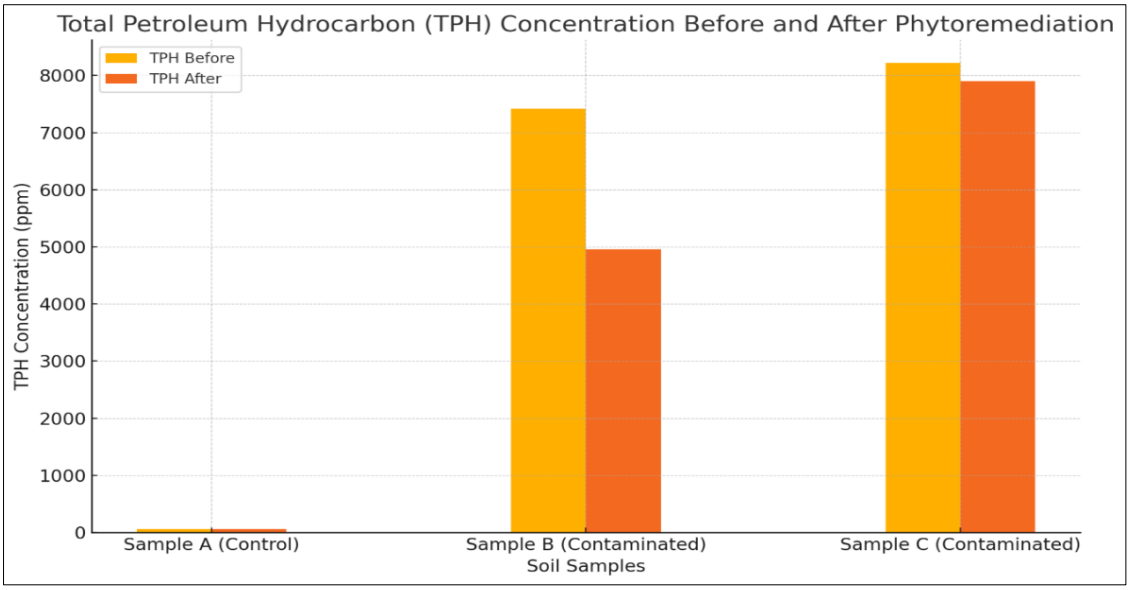

Figure 2: Total Petroleum Hydrocarbon (TPH) Concentration in Soil Samples Before and After Phytoremediation

The trends observed are corroborated by Xu *et al.* (2018) [12] and Boer & Wagelmans (2016) [13], who demonstrated near-complete PAH removal using similar phytoremediation approaches. Variability in degradation efficiency is linked to compound molecular weight and solubility, as higher-mass PAHs generally exhibit lower bioavailability (D'Souza *et al.,* 2015) [14].

TPH Accumulation in Plant Tissues

The accumulation of total petroleum hydrocarbons (TPHs) in *Pennisetum purpureum* tissues (Table 3) revealed marked differences between the control plant (Plant A) and the plant grown in contaminated soil (Plant B). In the control plant (Plant A), only 136.93 ppm of hydrocarbons were detected, with relatively low concentrations of medium- and long-chain hydrocarbons such as n-heptadecane (12.30 ppm), n-octadecane (10.56 ppm), and n-nonacosane (13.72 ppm). This low hydrocarbon content suggests background or minimal uptake under uncontaminated conditions.

In contrast, the plant grown in contaminated soil (Plant B) accumulated a remarkably high total of 13,004.60 ppm TPHs, nearly 95-fold higher than in the control. The hydrocarbon profile of Plant B was dominated by long-chain alkanes, particularly n-hentriacontane (2527.10 ppm), n-tritriacontane (1704.60 ppm), n-eicosane (1406.24 ppm), and n-tetratriacontane (1391.27 ppm), alongside branched isoprenoids such as phytane (414.03 ppm) and pristane (118.16 ppm). The predominance of high-molecular-weight hydrocarbons in Plant B underscores the strong capacity of *P. purpureum* to absorb and sequester persistent petroleum fractions, which are typically resistant to microbial degradation.

Table 3: Total Petroleum Hydrocarbon (TPH) Accumulation in Pennisetum *purpureum* (Plant Tissues) After Phytoremediation

S/No	Component	Plant A (ppm)	Plant B (ppm)
1	n-Octane (n-C_8)	–	–
2	n-Nonane (n-C_9)	–	–
3	n-Decane (n-C_{10})	–	6.62
4	n-Undecane (n-C_{11})	–	2.12
5	n-Dodecane (n-C_{12})	–	6.23
6	n-Tridecane (n-C_{13})	–	2.17
7	n-Tetradecane (n-C_{14})	2.55	7.29
8	n-Pentadecane (n-C_{15})	–	184.67
9	n-Hexadecane (n-C_{16})	3.11	207.66
10	n-Heptadecane (n-C_{17})	12.30	693.15
11	Pristane	8.80	118.16
12	n-Octadecane (n-C_{18})	10.56	158.97
13	Phytane	4.19	414.03
14	n-Nonadecane (n-C_{19})	6.66	216.40
15	n-Eicosane (n-C_{20})	7.26	1406.24
16	n-Heneicosane (n-C_{21})	4.17	164.79
17	n-Docosane (n-C_{22})	5.63	481.60
18	n-Tricosane (n-C_{23})	3.47	159.35
19	n-Tetracosane (n-C_{24})	4.11	209.42
20	n-Pentacosane (n-C_{25})	9.25	457.31
21	n-Hexacosane (n-C_{26})	2.73	299.43
22	n-Heptacosane (n-C_{27})	4.49	397.17
23	n-Octacosane (n-C_{28})	3.20	191.02
24	n-Nonacosane (n-C_{29})	13.72	437.35
25	n-Triacontane (n-C_{30})	1.87	209.35
26	n-Hentriacontane (n-C_{31})	3.21	2527.10
27	n-Dotriacontane (n-C_{32})	4.00	672.61
28	n-Tritriacontane (n-C_{33})	4.05	1704.60
29	n-Tetratriacontane (n-C_{34})	9.82	1391.27
30	n-Pentatriacontane (n-C_{35})	7.78	261.88
	Total TPH	136.93	13004.60

PAH Accumulation in Plant Tissues

Table 4 and figure 3 displays PAH accumulation in the same plant tissues. While none were detected in Plant A, Plant B accumulated 33.98 ppm of PAHs, including fluoranthene (6.99 ppm), phenanthrene (5.36 ppm), and pyrene (21.63 ppm). These results suggest selective uptake of PAHs based on molecular characteristics and solubility.

Table 4: Polycyclic Aromatic Hydrocarbon (PAH) Accumulation in *Pennisetum purpureum* (Plant Tissues) After Phytoremediation

PAH Component	Plant A (ppm)	Plant B (ppm)
Naphthalene	–	–
Acenaphthylene	–	–
Acenaphthene	–	–
Fluorene	–	–
Phenanthrene	–	5.36
Anthracene	–	–
Fluoranthene	–	6.99
Pyrene	–	21.63
Benz(a)anthracene	–	–
Chrysene	–	–
Benzo(b)fluoranthene	–	–
Benzo(k)fluoranthene	–	–
Benz[a]pyrene	–	–
Indeno(1,2,3-cd)pyrene	–	–
Dibenz(a,h)anthracene	–	–
Benzo(g,h,i)perylene	–	–
Total PAHs	**0.00**	**33.98**

The uptake-to-removal ratios, summarized in Table 5**,** indicate that *P. purpureum* accumulated hydrocarbons equivalent to 528.19% of the amount remediated from the soil for TPHs, and 25.16% for PAHs. These values affirm the plant's potential for phytoextraction and storage of petroleum hydrocarbons, as supported by Schwab & Dermody, [15] and Shirdam *et al.* [16].

Table 5: Hydrocarbon Remediation in Soil and Uptake by *Pennisetum purpureum*

Hydrocarbon Type	Soil Remediation (ppm)	Plant Accumulation (ppm)	Uptake-to-Removal Ratio (%)
Total Petroleum Hydrocarbons (TPH)	2462.17	13004.60	528.19%
Polycyclic Aromatic Hydrocarbons (PAH)	135.06	33.98	25.16%

Remediation Efficiency of *Pennisetum purpureum*

The overall efficiency of *P. purpureum* in remediating hydrocarbons is summarized in **Table 6** for TPHs and **Table 7** for PAHs. The plant achieved the highest remediation efficiency in moderately contaminated soil (Sample B), with 33.19% TPH and 78.07% PAH removal. In more heavily polluted soil (Sample C), efficiencies dropped to 3.85% and 58.65%, respectively.

Table 6: TPH Remediation Efficiency in Soil

Sample	TPH Before (ppm)	TPH After (ppm)	Amount Remediated (ppm)	Remediation Efficiency (%)
A (Control)	57.70	57.40	0.30	0.51%
B (Contaminated)	7418.24	4956.06	2462.17	33.19%
C (Contaminated)	8214.66	7898.03	316.63	3.85%

Table 7: PAH Remediation Efficiency in Soil

Sample	PAH Before (ppm)	PAH After (ppm)	Amount Remediated (ppm)	Remediation Efficiency (%)
A (Control)	0.74	0.00	0.74	100.00%
B (Contaminated)	172.99	37.93	135.06	78.07%
C (Contaminated)	185.83	76.84	108.98	58.65%

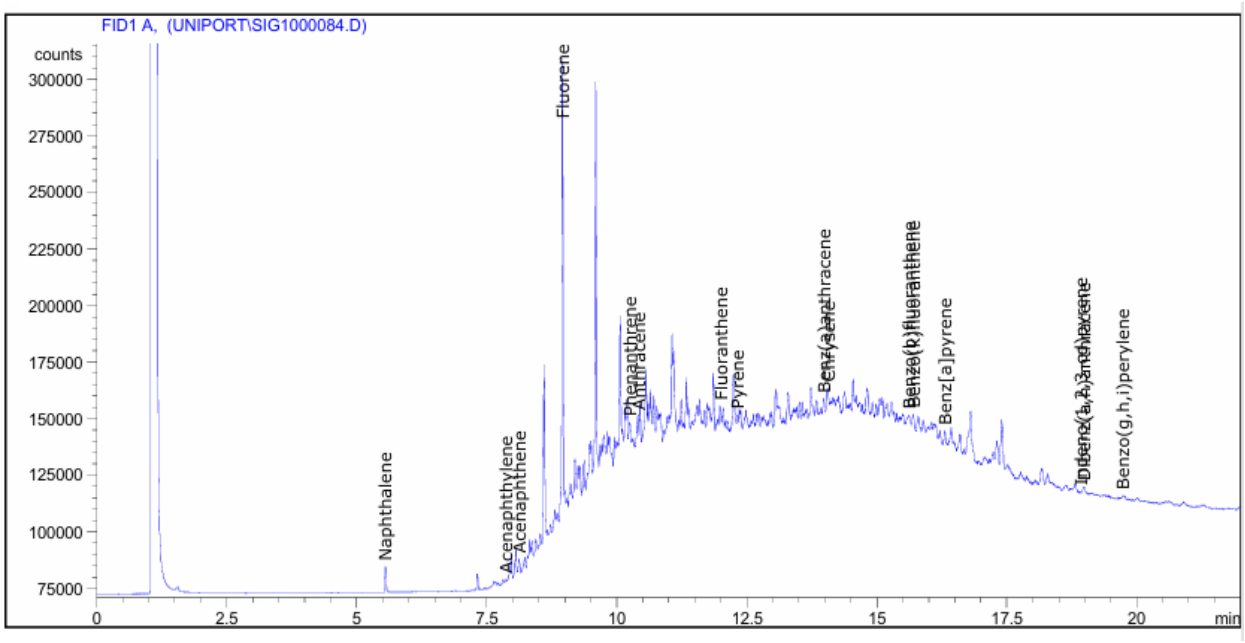

Figure 3: Representative chromatogram of PAH components in contaminated soil samples

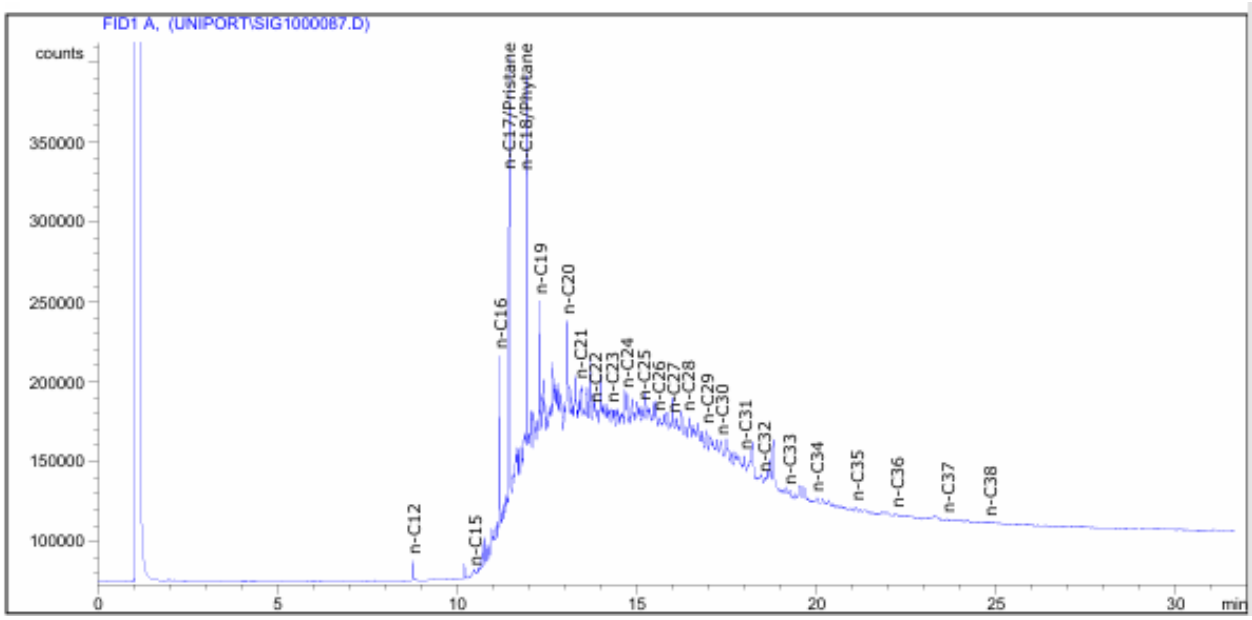

Figure 4: Representative chromatogram of TPH components in contaminated soil samples

These outcomes underscore the influence of contamination levels, soil conditions, and plant establishment on phytoremediation success. As demonstrated in previous studies [11,17], phytoremediation is most effective under moderate contamination and adequate nutrient availability.

CONCLUSION

The research evaluated the ability of *Pennisetum purpureum* (elephant grass) to phytoremediate crude oil-contaminated soils at Ogale township within River's state, Eleme Local Government Area in the state. The study targeted the extent of decrease of Total Petroleum Hydrocarbons (TPHs) and Polycyclic Aromatic Hydrocarbons (PAHs) in the soil as well as concentrations of these pollutants that will be collected in the plant tissues within a specified remedian period.

The results showed that *Pennisetum purpureum* treated petroleum hydrocarbon contaminated soils efficiently and there was phytoremediation which was evident in reducing PC levels as a result of applications like phytoextraction and rhizodegradation. The plant also showed that hydrocarbons were significantly localized in the tissues of plants showing that the plants had potential to take in even the contaminants and retain them. Such findings confirm the soil-root-shoot pathway as an essential process of phytoremediation using *P. purpureum*.

In addition, tolerance of the plant to hydrocarbon stress, adaptation to marginal soils and activation of microbial activity in the rhizosphere add to the remediation effectiveness of this plant. The differences that were traced in different contaminated sites also underline the relevance of site-specific factors to the phytoremediation performance, concentrating on the relevance of both the levels of contamination and the plant growth.

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