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ECO-PHYSIOLOGICAL PERFORMANCE OF *Picralima nitida* IN FRAGILE ECOSYSTEM

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Abstract
This study evaluated the eco-physiological responses of Picralima nitida seedlings grown in soils contaminated with different concentrations of spent lubricating oil (SLO). Morphological, physiological, and biochemical parameters were assessed across five treatments (T1-T5) vis 0L/ha, 3736.67L/ha, 7473.33 L/ha, 11210L/ha, 14946.67L/ha of spent lubricating oil in soil (uncontaminated, low, average, high and very high contamination) respectively. One year old seedlings of Picralima nitida were transplanted into soils treated with varying volumes of spent lubricating oil SLO: two weeks after the introduction of spent lubricating oil. Results indicated numerical differences in seedling height, collar diameter, leaf area, and chlorophyll content, with the control (T1) generally showing superior performance. However, analysis of variance (ANOVA) revealed no statistically significant differences across treatments. Despite this, trends indicate that increased SLO contamination negatively impacted photosynthesis and biomass allocation, with higher root-to-shoot ratios and reduced chlorophyll content observed at higher pollution levels. The findings suggest moderate tolerance of P. nitida at low SLO concentrations, but limited phytoremediation potential under severe contamination.

Keywords: *Picralima nitida, Eco-physiologcal performance, Chlorophyll content, Phytoremediation, Petroleum pollution*

Introduction

Rapid industrialization and modernization around the world have produced the unfortunate consequence of releasing toxic wastes to the environment thereby making it fragile. pollutants are derived mainly from industrial and agricultural activities. The former includes activities such as waste disposal, chemical manufacturing, and metal pollutants from vehicle lubricating oil and exhaust. The latter involves activities such as the use of agrochemicals, long-term application of sewage sludge, and wastewater to agricultural soils. Such releases have adversely affected human health and have produced toxic effects on plants and the soil microorganisms associated with them (Onwuka, 2005). Toxic contaminants from wastes or other products accumulate in the agricultural soils to which they are applied, threaten food security, and pose health risks to living organisms by their transfer within the food chain. Once heavy pollutants reach the soil, they are absorbed by plants and may be taken up by animals and humans through consumption of contaminated food or drinking water. They may even be inhaled as particulate contaminants, and due to their persistent nature, they may accumulate in both plants and animals over time.

As population increases, there is also increase in the level of Urbanization, Industrialization and commercial activities in a fixed land supply. This leads to contamination of soils and water by atmospheric deposition or disposal of sewage sludge inhibits growth of plants. Water and soils in hazardous waste sites are contaminated with heavy metals (Etim and Adie, 2012). Environmental impact of the oil and gas industry essentially results from the activities and processes necessary for the successful operations of the oil and gas industry by the multinational oil companies. This had caused a lot of distortions in the soil, flora and fauna, traditional economies (such as farming, fishing, livestock and wildlife production), and social practices of the people of the area (Orta-Martinez and Finer, 2010; Huang *et al*., 2011). It has also engendered poverty, food contamination and lack of security of human life (Ajibade and Awomuti, 2009).

Spent lubricating oil (SLO) is a major environmental pollutant, especially in urban and peri-urban soils. Its improper disposal contaminates soil ecosystems, affecting microbial activity, plant health, and biodiversity. In tropical ecosystems, where native species such as *Picralima nitida* contribute to ecological balance and medicinal value, contamination poses significant risks. Understanding the response of *P. nitida* to SLO is crucial for conservation and potential phytoremediation applications.

Wild plants serve not only as indispensable constituents of human diet but also as important medicinal tools for the treatment of various disease conditions (Aguwu *et al*., 2010). *Picralima nitida* (Stapf.) T. Durand and H. Durand is a valuable NTFPs native to Nigeria and widely distributed in the high forest zones of West Tropical Africa countries such as Ivory Coast, Nigeria, Uganda, and Gabon, and it is popularly known as Abeere in the Southwestern part of Nigeria among the Yoruba people (Amaeze *et al*., 2018). The species belongs to apocynaceae family and it grows to a height of 4 - 35 m as an understorey tree with a dense crown and bole diameter of about 60 cm. *Picralima nitida* is highly valued for its wide medicinal properties throughout its distribution areas. All the plant parts; roots, leaves, fruits, seeds and stem bark are utilised extensively for treatment of pneumonia, malaria, stomach disorder, pain relief and intestinal worms. In Ghana and Nigeria, the fruit shell is infused with palm wine and taken as fever remedy while the seed decoction and oral ingestion is used as an enema, pneumonia and gastrointestinal disorder treatment respectively (Olaniyi *et al*., 2021).

Picralima nitida has great usefulness in African traditional medicine especially in Nigeria. Although few studies have shown the medicinal benefit of *Picralima nitida*, there is, however, a paucity of information on the scientific validation of the potential of this plant against medicinal benefits and the usage. In addition to its medicinal virtue, *P. nitida* is a source of cash income for rural and urban households, thus contributing to drastic reduction of poverty among some sellers. Though, little information about the resource management, medicinal properties and socioeconomic contribution of *P. nitida* to household welfare is available. However, it faces erosion due to deforestation and pollution. There's need to study its tolerance in contaminated soil and investigate the effects of degraded soil on the growth performance of *Picralima nitida* in fragile ecosystem.

Presently, in many oil producing countries, oil spills regularly occur in the oil producing areas, while gases are continually flared in these areas (Abii and Nwosu, 2009; Idodo – Umeh and Ogbeibu, 2010). These pose a great danger to ecosystem, animal and plants life alike. Contaminants are among the significant sort of soil degradation. Most methods used to clean up the environment from these kinds of contaminants are costly and difficult to get optimum results. Plants have been recognized as a means of remediating oil contaminated soil. Hence there is need to study the performance of *Picralima nitida* in fragile ecosystem.

Materials and Methods

Study Area

The experiment was carried out at Tree Physiology nursery, Sustainable Forest Management Department, Forestry Research Institute of Nigeria (FRIN), Ibadan, Nigeria. FRIN is located on the longitude 07^{0}23'18"N to 07^{0}23'43"N and latitude 03^{0}51'20"E to 03^{0}51'43"E. The rainfall distribution pattern is bimodal with peak in June and July. The dry season occurs between November and March while the wet season is usually between April and September. The mean minimum and maximum temperatures are 19.5°C and 34.9°C while relative humidity was between 50% and 86.7%. The soil is lateritic alluvial soil (FRIN, 2015).

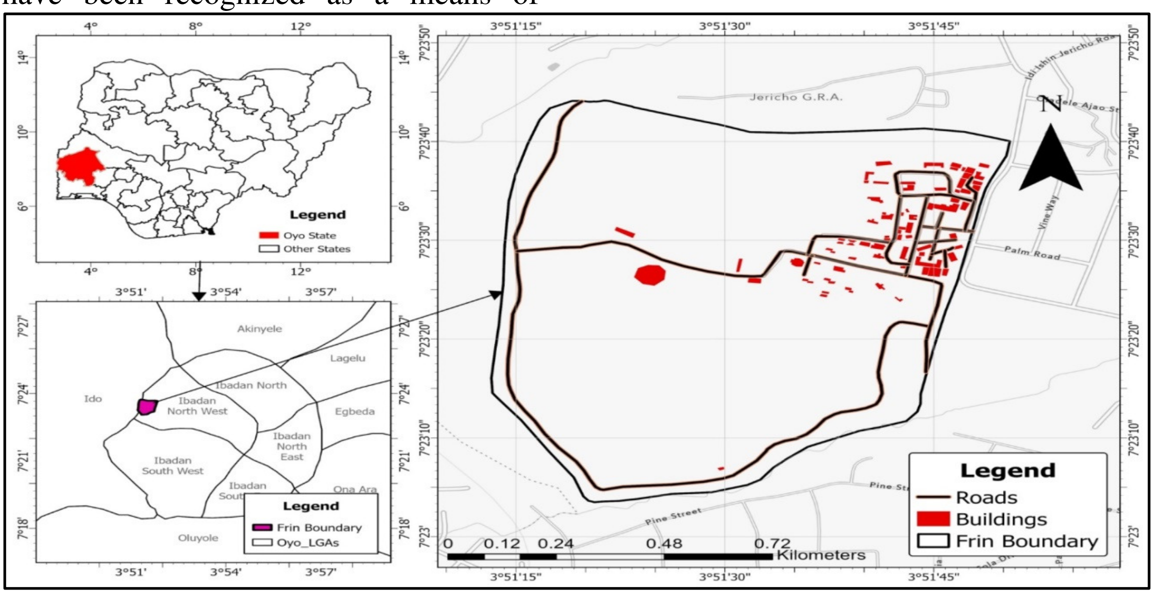

Fig. 1: Map of the study area

The Pot Experiment

The pot experiment was conducted in the greenhouse of the Forestry Research Institute of Nigeria, Ibadan. Uniformly growing one year old seedlings were used for the experiment. The pots with the 3kg capacity were filled with topsoil. Before transplanting, the soil was contaminated with four different doses of spent engine oil in (T_1, T_2, T_3, T_4 and T_5) 0L/ha, 3736.67L/ha, 7473.33 L/ha, 11210L/ha, 14946.67L/ha of oil in soil represents the treatments (uncontaminated, low, average, high and very high contamination) respectively. One year old seedlings of *Picralima nitida* were transplanted into soils treated with varying volumes of SLO: T1 (control), T2 (low), T3 (moderate), T4 (moderate-high), and T5 (high) two weeks after the introduction of spent engine oil into the 3kg soil in polythene pots. The experiment was carried out in ten replicates. Water was applied daily. The experiment was laid in Completely Randomized Design under the controlled environment.

The seedlings were assessed every two-week for twenty-four weeks. The morphological variables measured included seedling height (meter rule), collar diameter (veneer caliper), leaf area (leaf area meter) number of leaf (counting). Leaf, stem and root biomass were determined at the end of the experiment with sensitive weighing balance. The fresh weights of the different seedling components were determined for each seedling using sensitive weighing balance. The dry weights were determined by drying the roots, stems and leaves in an oven at 70ºC until constant weight is attained. Data collected on growth variables were analyzed using descriptive statistics and Analysis of Variance (ANOVA).

Physiological Parameters

Data collected were also used to determine Physiological traits such as Relative Growth Rate (RGR), Absolute Growth Rate (AGR), LAR, NAR, and Root – Shoot Ratio (RSR), leaf turgidity and Relative Water Content (RWC) were estimated from the data collected with the formula below:

Relative Growth Rate (RGR) = $\frac{\text{loge H2} - \text{Loge H1}}{\text{T2} - \text{T1}}$ ($\text{gg}^{-1}\ \text{day}^{-1}$)

Absolute Growth Rate (AGR) = $\frac{\text{H2} - \text{H1}}{\text{T2} - \text{T1}}$ (cm day^{-1})

Net Assimilation Rate (NAR) = $\frac{\text{RGR}}{\text{LAR}}$ ($\text{gcm}^{-2}\ \text{day}^{-1}$)

LAR (mm^2g^{-1}) = $\frac{A}{W}$

Where:
H = Plant Height (cm)
T = Time (days)
A = Plant Leaf Area (mm^2)
W = Plant Dry Weight (g)

Leaf turgidity = $\frac{\text{Leaf weight in water} - \text{Initial fresh weight}}{Initial\ Fresh\ Weight}\ X\ 100$

Relative Water Content (RWC) = $\frac{Fresh\ weight - Dry\ weight}{Turgid\ weight - Dry\ weight}$ x 100 (Pieczynski *et al*. 2013)

Leaf Chlorophyll Content, Temperature and Area

Leaf chlorophyll and temperature were measured using chlorophyll meter (TYS-B) and leaf area was measured with the use of portable leaf area meter (YMJ-B).

Results

Table 1: Morphological characteristics of *Picralima nitida* grown on different concentration of spent lubricating oil

Treatment	Seedling height (cm)	Collar diameter (mm)	Number of leaves	Leaf area (mm^2)	Total folia weight (g)
T1	52.36±11.06	5.51±0. 82	18.25±4.87	62.86	11.23
T2	46.54±18.34	5.06±0.73	15.92±3.76	44.71	7.98
T3	41.68±7.79	5.06±0.95	15.97±2.86	92.22	14.08
T4	45.76±8.99	5.63±1.02	15.71±3.09	46.58	11.18
T5	46.55±7.46	5.29±0.72	16.72±2.97	45.79	11.08

The highest seedling height (52.36±11.06cm) was observed in T1, followed by (46.55±7.46cm) in T5. The least (41.68±7.79cm) was found in T3. The highest collar diameter (5.63±1.02mm) was observed in T4, followed by (5.51±0. 82mm) in T1. The least (5.06±0.73mm & 5.06±0.95mm) was found in T2&3 respectively. The highest number of leaves (18.25±4.87) was observed in T1, followed by (16.72±2.97) in T5. The least (15.71±3.09) was found in T4. The highest leaf area (92.22mm^2) was observed in T3, followed by (62.86mm^2) in T1. The least (44.71mm^2) was found in T2. The highest total folia weight (14.08g) was observed in T3, followed by (11.23g) in T1. The least (7.98g) was found in T2 (Table 1). Despite these variations, ANOVA results showed no significant differences ($p > 0.05$) among treatments in all the variables assessed via seedling height, collar diameter, number of leaves, leaf area. These values indicate a general decline in vertical and radial growth under contaminated conditions, a phenomenon previously linked to the toxic effects of petroleum hydrocarbons on plant metabolism and nutrient assimilation. Despite the slight peak in collar diameter in T4, the variation could be due to random growth plasticity, rather than a positive response to pollution, as no significant differences were confirmed statistically (Table 2).

The absence of statistical significance in seedling height and collar diameter (Table 2) suggests a uniform growth suppression across all levels of contamination, pointing to a threshold effect where even low SLO concentrations begin to impair seedling development. The number of leaves and total foliar weight showed similar trends. The maximum number of leaves (18.25) and highest foliar weight (14.08 g) were observed in T1 and T3 respectively. While T3 had the lowest seedling height, it had the highest leaf area (92.22 mm^2) and foliar weight, suggesting an adaptive reallocation of resources toward photosynthetic organs-possibly a compensatory strategy under stress to maintain carbon assimilation. However, the reduction in leaf area and leaf number in T2 and T4 indicates the inhibitory effects of hydrocarbons on leaf initiation and expansion, consistent with findings that SLO in soil clogs root pores, reduces oxygen availability, and limits water uptake.

Table 2: Analysis of variance for variables measured

Variables	source of variation	Sum of Squares	Df	Mean Square	F	Sig.
	Treatment	2.68	4	0.67	0.92	0.46ns
Collar diameter	Error	33.00	45	0.73		
	Total	35.69	49			
	Treatment	43.51	4	10.88	0.85	0.50ns
No of leaf	Error	579.63	45	12.88		
	Total	623.14	49			
	Treatment	580.64	4	145.16	1.11	0.37ns
Seedlings height	Error	5901.28	45	131.14		
	Total	6481.92	49			
Leaf area	Treatment	577.99	4	144.50	4.00	0.50ns
	Error	1627.82	45	36.17		
	Total	2205.81	49			
Root/shoot ratio	Error	0.166	45	0.00		
	Total	0.219	49			

ns – not significant
* - significant

Table 3: Physiological characteristics of *Picralima nitida* grown on different concentration of spent lubricating oil

Treatment	**RWC (%)**	**Leaf Turgidity**	**LAR (mm^2g^{-1})**	**NAR ($g/cm^2/day$)**	**RGR ($gg^{-1}day^{-1}$)**	**AGR (cm day^{-1})**	**R/S ratio**
T1	4.33	440	5.60	0.0002	0.0011	0.1425	0.17±0.04
T2	6.94	129.67	5.60	0.0002	0.0011	0.1434	0.20±0.07
T3	62.26	42.222	6.55	0.0002	0.0011	0.1410	0.23±0.06
T4	81.84	30.23	4.17	0.0003	0.0012	0.1501	0.23±0.06
T5	59.78	35.42	4.13	0.0003	0.0011	0.1363	0.27±0.07

Relative water content (RWC) increased in polluted treatments, from 4.33% (T1) to 81.84% (T4), possibly due to reduced transpiration or osmotic adjustments. Leaf turgidity declined sharply under contamination. LAR peaked at T3, correlating with its higher leaf area. NAR and RGR remained relatively constant across treatments. The root-to-shoot ratio increased progressively with contamination (Table 3). Net assimilation rate (NAR) and relative growth rate (RGR) were relatively stable across treatments, suggesting that photosynthetic activity was not completely suppressed. However, leaf area ratio (LAR) increased at T3 (6.55 $mm^2\ g^{-1}$), aligning with its higher foliar biomass. This suggests a high surface area per unit biomass, a known trait in plants adjusting to light or stress compensation.

The Root-to-Shoot (R/S) ratio increased from 0.17 in the control to 0.27 in T5, a strong indicator of resource reallocation towards root development. In stress conditions, especially with hydrocarbon pollution, plants often increase root investment to enhance nutrient and water foraging capacity. However, if sustained, this shift could reduce shoot vigor and reproductive potential, compromising long-term survival. T3 once again emerged with comparatively higher biomass accumulation across all components (leaf, stem, and root, indicating that *P. nitida* may possess intermediate tolerance to certain SLO levels. However, T2 and T5, which had the lowest biomass and chlorophyll levels, clearly illustrate the detrimental effects of SLO on carbon fixation and growth performance.

The results show that while *Picralima nitida* demonstrates moderate adaptive traits (such as biomass redistribution and stable NAR), its overall eco-physiological performance declines with increasing SLO contamination. The species' sensitivity in terms of chlorophyll degradation, decreased turgor, and reduced foliar development indicates that it is not highly tolerant to petroleum-polluted soils, particularly at higher contamination levels. Nonetheless, the relatively stable RGR and high foliar biomass in T3 suggest a possible phytoremediation role at low to moderate SLO levels. For heavily polluted soils, however, *P. nitida* would likely require soil pre-treatment or biostimulation before successful establishment. The most dramatic physiological shifts were observed in RWC and leaf turgidity. Surprisingly, RWC increased with contamination, from 4.33% in T1 to 81.84% in T4. Normally, low RWC indicates water stress, but in this case, the control had the lowest RWC (Table 3). The leaf turgidity, however, dropped from 440 (T1) to 30.23 (T4), confirming a functional water imbalance. This physiological disconnection between RWC and turgidity might be due to cellular or structural damage that prevents effective use of retained water. It also hints at osmotic dysfunction or cell wall rigidity, conditions exacerbated by the presence of hydrocarbons.

Table 4: Biomass accumulation and chlorophyll content of *Picralima nitida* grown on different concentration of spent lubricating oil

Treatment	**Leaf biomass (g)**	**Stem biomass (g)**	**Root biomass (g)**	**Chlorophyll content** (µg g−1)	**Leaf temperature (°C)**
T1	4.09	3.96	2.58	13.5	32.75
T2	2.47	3.42	2.09	2.1	32.68
T3	5.79	4.60	3.69	7.7	32.75
T4	3.01	4.03	4.14	11.8	32.68
T5	2.67	2.90	5.51	2.6	32.68

Chlorophyll content declined significantly with increased SLO, from 13.5 µg g^{-1} in T1 to 2.1 µg g^{-1} in T2. A critical impact of SLO contamination is observed in the chlorophyll content (Table 4). The control (T1) had the highest chlorophyll concentration (13.5 µg g^{-1}), while T2 and T5 showed severe declines (2.1 and 2.6 µg g^{-1} respectively). Chlorophyll degradation is a primary indicator of oxidative stress, often triggered by pollutants that generate reactive oxygen species (ROS) damaging chloroplast membranes. These results confirm that SLO pollution severely hampers photosynthetic efficiency, even at relatively low concentrations, and corroborate earlier findings in related studies where hydrocarbon contamination caused chlorosis and pigment breakdown in seedlings. T3 recorded the highest biomass across all organs, while T5 had the lowest stem biomass but the highest root mass, suggesting adaptive reallocation. Interestingly, leaf temperature (Table 4) remained relatively unchanged across treatments, suggesting that transpirational cooling **was** not significantly affected, or that the duration of stress was not sufficient to cause measurable stomata closure effects on leaf temperature.

Discussion

The eco-physiological response of *Picralima nitida* seedlings to spent lubricating oil (SLO) contamination revealed varying levels of morphological, physiological, and biochemical adjustments, indicating species-level sensitivity to hydrocarbon-induced soil stress. This confirmed the submission of Oyedeji and Oyedeji, (2022).

Morphological Performance

The lack of significant differences in growth parameters may mask underlying physiological stress. The observed trends—such as decreased chlorophyll content and altered biomass partitioning—suggest that *P. nitida* experiences oxidative and water stress under SLO contamination. These results align with previous findings (Adam and Duncan, 2002; Okonokhua *et al*., 2007; Njoku *et al*., 2009 and Oyedeji *et al*, 2021) showing that hydrocarbons interfere with root respiration and chloroplast function. The growth pattern suggests a general decline in vertical growth under SLO stress, consistent with hydrocarbon-induced interference in root respiration and water uptake (Okonokhua *et al*., 2007). It also indicates the inhibitory effects of hydrocarbons on leaf initiation and expansion**,** consistent with findings that SLO in soil clogs root pores, reduces oxygen availability, and limits water uptake (Okonokhua *et al*., 2007).

Interestingly, leaf area and foliar weight were highest in T3, despite T3 not having the highest seedling height. This might indicate a stress-induced morphological reallocation, where the plant invests in leaf expansion and biomass to enhance photosynthesis in compromised soil conditions—a phenomenon observed in tolerant species (Agbogidi *et al*., 2007). These results confirm that SLO pollution severely hampers photosynthetic efficiency, even at relatively low concentrations, and corroborate earlier findings in related studies where hydrocarbon contamination caused chlorosis and pigment breakdown in seedlings (Eze and Nwankwo, 2014). However, the differences in these morphological traits were not statistically significant ($p > 0.05$). This suggests that while numerical variation exists, it may not be strong enough to infer differential performance under the tested SLO concentrations. High standard deviations in the data (especially for height and number of leaves) further support this.

Physiological Characteristics

The Relative Water Content (RWC) and leaf turgidity (Table 3) showed dramatic variability. The inverse pattern—higher RWC under polluted conditions—might be due to osmotic adjustments or reduced transpiration caused by stomata closure, a known response to petroleum-induced stress (Njoku *et al*., 2009). However, leaf turgidity was highest in T1 and sharply declined with contamination, confirming a physiological compromise in water balance. This counterintuitive result could suggest reduced transpiration rates due to stomata closure or cuticle thickening in response to hydrocarbon stress, leading to temporary water retention in leaf tissues (Farid *et al*., 2013). Growth rate indicators like Relative Growth Rate (RGR) and Net Assimilation Rate (NAR) were relatively stable across treatments, with minor numerical differences. Leaf Area Ratio (LAR) peaked at T3, possibly aligning with its high foliar weight and leaf area. The Root-to-Shoot (R/S) ratio increased with pollution, suggesting allocation shift to root systems for nutrient scavenging and anchorage under stress (Adam and Duncan, 2002). The increased R/S ratio reflects typical stress adaptation mechanisms, promoting root development to enhance water and nutrient uptake. In stress conditions, especially with hydrocarbon pollution, plants often increase root investment to enhance nutrient and water foraging capacity (Agbogidi *et al*, 2007 and Farid, *et al*, 2013). However, if sustained, this shift could reduce shoot vigor and reproductive potential, compromising long-term survival.

Biomass and Chlorophyll Content

T3 consistently had the highest total biomass (leaf, stem, root), suggesting some level of adaptation or physiological resilience. However, chlorophyll content dropped sharply in contaminated treatments, especially in T2 and T5, compared to T1. This trend is a strong indicator of photosynthetic suppression under SLO stress, which may be due to oxidative degradation of chlorophyll molecules or impaired chloroplast function. This confirmed that leaf chlorophyll content is an indication of stress in plant environment (Li *et al*., 2006; Mehta *et al*., 2010; Ueda *et al*., 2003; Chaves *et al*. 2009). Chlorophyll degradation is a primary indicator of oxidative stress, often triggered by pollutants that generate reactive oxygen species (ROS) damaging chloroplast membranes (Njoku *et al*., 2009). The near-uniform leaf temperature across treatments suggests that transpirational cooling was not markedly affected, although long-term stress could still manifest in stomata regulation rather than thermal indicators.

Conclusion

P. nitida exhibited morphological plasticity and some physiological resilience, the overall performance declined under SLO contamination. The species demonstrated moderate tolerance at certain pollutant levels, but consistent reductions in chlorophyll content, turgidity, and biomass under high contamination levels suggest that *P. nitida* may not be suitable for heavily polluted sites without remediation support. The study concludes that *Picralima nitida* exhibits moderate tolerance to SLO at low concentrations, with partial physiological adjustments. However, at higher contamination levels, the species shows signs of biochemical and structural stress, reducing its suitability for direct phytoremediation use in severely polluted soils.

Recommendations

P. nitida can be used in phytoremediation of moderately contaminated soils with proper soil amendments. Pre-remediation strategies such as composting or microbial inoculation are advised for heavily polluted areas. Future research should focus on long-term exposure effects and molecular stress markers. Combining *P. nitida* with more tolerant pioneer species may improve restoration outcomes.

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