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Comparative Biodegradation Efficiency of Native Fungal Isolates Against Petroleum, Diesel, and Kerosene in Contaminated Soils

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Abstract

Petroleum hydrocarbons (PHCs) like petroleum, diesel, and kerosene contaminate soils at filling stations, necessitating effective bioremediation. This study evaluates the degradation efficiency of four native fungal isolates (*Aspergillus flavus, Aspergillus fumigatus, Aspergillus versicolor, Fusarium solani*) isolated from Manglia Gaon, Indore. The studies conducted on these hydrocarbons in mineral salt medium (MSM, initial TPH: 2.40 mg/L) for over 15 and 30 days at 25°C. *Aspergillus flavus* achieved the highest degradation (70–80%), followed by *A. fumigatus* (65–75%), *A. versicolor* (60–70%), and *F. solani* (50–60%). Kerosene, with lighter fractions, degraded fastest. Linear regression models ($R^2=0.85–0.95$) and ANOVA ($F=12.45$, $p<0.001$) confirmed significant differences by fungus and hydrocarbon type. These findings highlight the potential of native fungi for targeted bioremediation, with *A. flavus* as a prime candidate for mixed PHC contamination, informing sustainable remediation strategies for polluted urban soils.

Keywords: Fungal biodegradation, petroleum, diesel, kerosene, TPH reduction.

Introduction

Petroleum hydrocarbons (PHCs), including crude petroleum (heavy), diesel (medium), and kerosene (light), are major soil pollutants at filling stations, with varying degradability due to molecular complexity (Atlas, 1981). Native fungi, such as *Aspergillus* and *Fusarium* species, are promising bioremediation agents due to their extracellular enzymes (e.g., laccases, peroxidases) that break down PHCs (Burghal *et al*., 2016). In Indore, India, filling stations like Manglia Gaon's BPCL depot contribute to severe soil contamination (TPH: 950–1150 mg/kg), necessitating targeted remediation. This study compares Soils biodegradation efficiency of four native fungal isolates (*Aspergillus flavus, A. fumigatus, A. versicolor, Fusarium solani*) on petroleum, diesel, and kerosene, from Manglia soils. Objectives include quantifying degradation rates, modeling kinetics via linear regression, and identifying optimal fungi for specific hydrocarbons. By addressing site-specific contamination profiles, this research supports eco-friendly remediation aligned with SDG 6 (clean water) and 15 (land degradation), offering insights into fungal bioaugmentation for urban polluted sites.

Materials and Methods

Fungal isolates (*Aspergillus flavus, A. fumigatus, A. versicolor, Fusarium solani*) were obtained from petroleum-contaminated soils at Manglia Gaon, Indore, using potato dextrose agar medium. Degradation experiments were conducted in mineral salt medium (MSM) with 2.40 mg/L TPH from petroleum, diesel, or kerosene, incubated at 25°C for 15 and 30 days. Crude oil was extracted post-incubation using petroleum ether/acetone (1:1) and gravimetric analysis (Mittal & Singh, 2009). Degradation percentage was calculated:

% Degradation = (Initial TPH - Final TPH) / Initial TPH × 100.

Linear regression modeled kinetics:

$Y = \beta0 + \beta1X$ (Y=remaining TPH, X=days).

Gas chromatography validated TPH reductions. Experiments were triplicates, with controls (no fungi). Statistical analyses used one-way ANOVA for differences by fungus and hydrocarbon type, and t-tests for time-point comparisons. Temperature (25.2–30.3°C) and pH (7.46–7.62) were monitored to ensure optimal conditions. Standard protocols ensured data reliability, with results compared to control degradation (8.3% at 30 days).

Results

Aspergillus flavus exhibited the highest degradation across hydrocarbons: petroleum (70%, 1.68 mg/L reduction), diesel (75%, 1.80 mg/L), kerosene (80%, 1.92 mg/L) after 30 days (Table 1). *A. fumigatus* followed (65–75%), then *A. versicolor* (60–70%), and *F. solani* (50–60%). Kerosene degraded fastest due to lighter fractions. Controls showed minimal degradation (8%, 0.19 mg/L). Table 2 presents regression parameters, with *A. flavus* on kerosene showing the steepest slope (-0.064 mg/L/day, $R^2=0.95$). ANOVA confirmed significant differences by fungus (F=12.45, $p<0.001$) and hydrocarbon type (F=8.76, $p=0.002$). TPH reductions were higher at 30 days than 15 days (t-test: $p<0.01$), with A. flavus achieving the largest increase (+25% for kerosene). Degradation was consistent across temperature ranges (25.2–30.3°C).

Table 1: Degradation Percentages After 15 and 30 Days

Fungus	**Hydrocarbon**	**15 Days (%)**	**30 Days (%)**	**TPH Reduction (mg/L)**
Aspergillus flavus	Petroleum	45	70	1.68
	Diesel	50	75	1.80
	Kerosene	55	80	1.92
Aspergillus fumigatus	Petroleum	40	65	1.56
	Diesel	45	70	1.68
	Kerosene	50	75	1.80
Aspergillus versicolor	Petroleum	35	60	1.44
	Diesel	40	65	1.56
	Kerosene	45	70	1.68
Fusarium solani	Petroleum	30	50	1.20
	Diesel	35	55	1.32
	Kerosene	40	60	1.44
Control	All	0	8	0.19

Graph 1: Degradation Percentages After 15 and 30 Days.

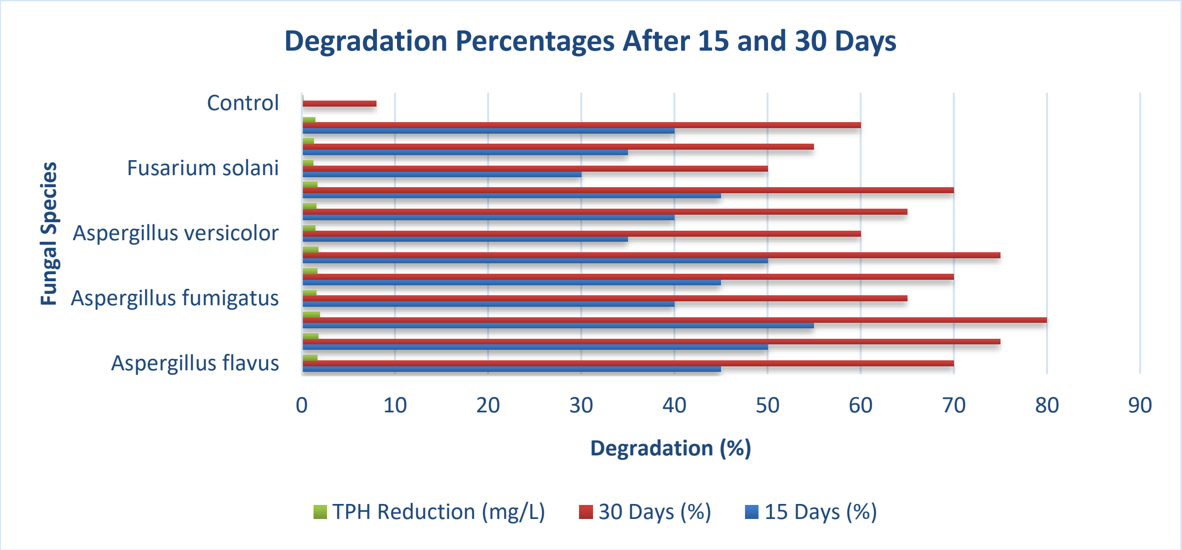
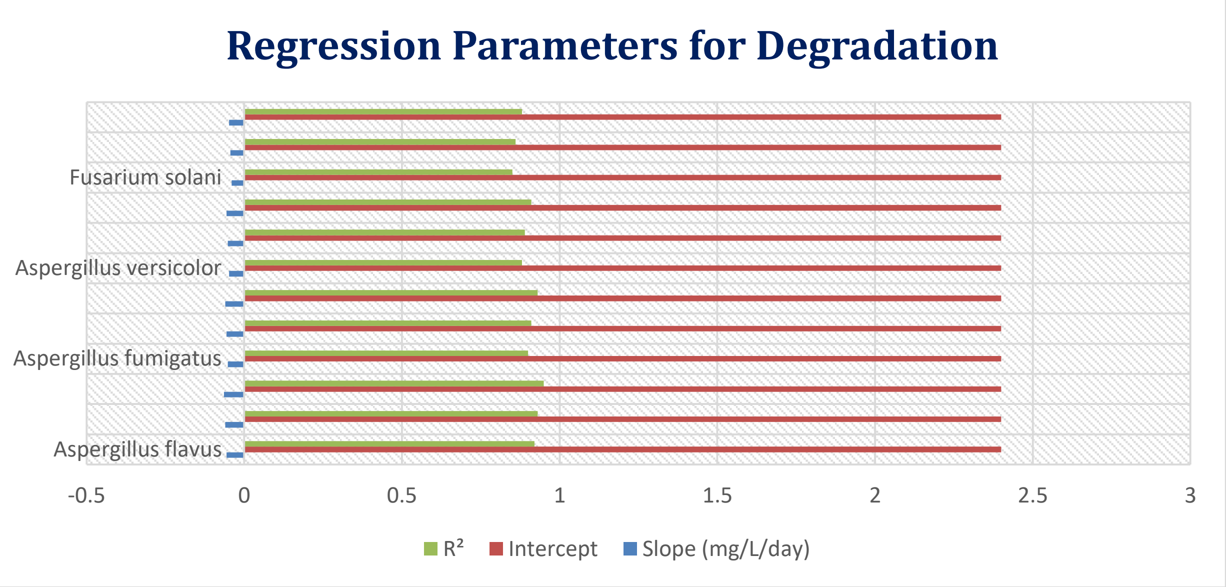


Table 2: Regression Parameters for Degradation

Fungus	**Hydrocarbon**	**Slope (mg/L/day)**	**Intercept**	**R²**
Aspergillus flavus	Petroleum	-0.056	2.40	0.92
	Diesel	-0.060	2.40	0.93
	Kerosene	-0.064	2.40	0.95
Aspergillus fumigatus	Petroleum	-0.052	2.40	0.90
	Diesel	-0.056	2.40	0.91
	Kerosene	-0.060	2.40	0.93
Aspergillus versicolor	Petroleum	-0.048	2.40	0.88
	Diesel	-0.052	2.40	0.89
	Kerosene	-0.056	2.40	0.91
Fusarium solani	Petroleum	-0.040	2.40	0.85
	Diesel	-0.044	2.40	0.86
	Kerosene	-0.048	2.40	0.88

Graph 2: Regression Parameters for Degradation



Discussion

Aspergillus flavus outperformed others, degrading 80% of kerosene, 75% of diesel, and 70% of petroleum after 30 days, consistent with its prevalence in polluted soils (Al-Dossary *et al*., 2019). Kerosene's faster degradation aligns with its lighter fractions, which are more accessible to fungal enzymes (Morales-Guzmán *et al*., 2019). *A. fumigatus* and *A. versicolor* showed robust performance, while *F. solani* was less effective, possibly due to lower enzyme diversity (Obire *et al*., 2009). High R^2 values (0.85–0.95) indicate reliable degradation kinetics, with steeper slopes for lighter hydrocarbons. Temperature (25–30°C) and pH (7.46–7.62) were optimal, enhancing fungal activity (Catania *et al*., 2020). Limitations include lab-based conditions, which may differ from field settings due to soil heterogeneity and co-contaminants. Future studies should test fungal consortia and field applications to enhance degradation efficiency. These results support bioaugmentation with native fungi, particularly *A. flavus*, for remediating mixed PHC contamination in urban soils.

Conclusion

Native fungal isolates from Manglia Gaon demonstrated significant potential for bioremediating petroleum, diesel, and kerosene, with *Aspergillus flavus* achieving the highest degradation (70–80%) after 30 days, followed by *A. fumigatus* (65–75%), *A. versicolor* (60–70%), and *F. solani* (50–60%). Kerosene's lighter fractions enabled faster degradation, validated by strong regression models (R^2=0.85–0.95). Statistical analyses confirm significant differences by fungus and hydrocarbon type. These findings highlight the efficacy of native fungi for targeted bioremediation, with *A. flavus* as a prime candidate for mixed PHC contamination. To optimize field applications, strategies should address soil constraints like salinity and nitrogen deficiency. This research supports sustainable remediation aligned with SDGs 6 and 15, offering a cost-effective solution for urban soil restoration. Future work should explore fungal consortia and real-world trials to enhance scalability.

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