Impact of Moringa and Elephant Grass Treatments on Soil Total Nitrogen and Hydrocarbon Degradation in Contaminated Swampy and Clay Soils

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Abstract- This study investigates the influence of treatment with moringa and elephant grass on total nitrogen levels in swampy and clay soils, focusing on their effects on bioremediation processes. Results indicate that total nitrogen in both soil types increased over time and with higher treatment weights. In swampy soil, total nitrogen rose steadily up to the 56th day, stabilizing in samples with 40g or more of either treatment. For moringa-treated swampy soil, nitrogen levels increased from 0.094% post-contamination to 0.941% with 100g of treatment at 84 days. Elephant grass also demonstrated a similar trend, with nitrogen rising from 0.094% to 0.963% under the same conditions. In clay soil, the pattern was comparable. Moringa treatment led to an increase in nitrogen from 0.113% after contamination to 0.813% with 100g of treatment at 84 days. Elephant grass treatment resulted in a rise from 0.113% to 0.826%. The data suggest that both moringa and elephant grass enhance nitrogen levels, which supports the growth of hydrocarbon-degrading bacteria, crucial for effective bioremediation of polluted soils.

Indexed Terms- Remediation, Loamy Soil, Elephant Grass, Moringa Seed, Soil Purity

I. INTRODUCTION

Soil health and its ability to remediate contaminants are significantly influenced by nutrient dynamics, particularly nitrogen, which plays a crucial role in microbial activity and pollutant degradation ;1]. This study investigates the impact of moringa and elephant grass treatments on total nitrogen levels in both swampy and clay soils contaminated with Total Petroleum Hydrocarbons (TPH). A section in this research illustrates that in swampy soil treated with moringa, total nitrogen content increased progressively up to day 56, stabilizing at higher treatment weights [2-4]. This rise in nitrogen is linked to enhanced microbial growth, which utilizes nitrogen to degrade TPH more efficiently. Similarly, elephant grass treatment, also increased nitrogen levels, with a comparable trend of steady growth followed by stabilization [5].

In clay soil, the application of moringa and elephant grass resulted in a significant increase in total nitrogen, though the total nitrogen levels remained lower compared to swampy soil. Both treatments led to a progressive rise in nitrogen content up to day 56, after which levels stabilized. This suggests that both plant materials contribute to soil nitrogen enrichment, supporting the growth of hydrocarbon-degrading bacteria essential for bioremediation [6-9].

This findings underscore the effectiveness of plant-based amendments in enhancing soil nitrogen levels, which in turn promotes microbial activity and accelerates the degradation of TPHs. Moringa and elephant grass proved to be valuable in improving soil health and bioremediation processes, with elephant grass demonstrating a greater capacity for nitrogen enrichment across both soil types [10].

II. METHODOLOGY

The results from various treatment options were compared with the control sample using analysis of variance (ANOVA) in Microsoft Excel, with a significance level set at 95% (Alpha = 0.05). A treatment option was considered significant if the F-calculated value (F) exceeded the F-tabulated value (Fcrit) in the ANOVA table. In such cases, it was concluded that there was a significant difference between the treatment and the control sample.

Conversely, if F-calculated was not greater than F-tabulated, the treatment performance in reducing TPH content was not significantly different from that of the control sample. The theoretical formula for calculating sample variance is as follows:

$$S^2 = \frac{1}{n-1}\Sigma(y_i - \bar{y})^2 \qquad (1)$$

In this context, the divisor is referred to as the degrees of freedom (df), the summation is known as the sum of squares (SS), the resulting value is called the mean square (MS), and the squared terms represent deviations from the sample mean. The core method involves partitioning the total sum of squares (SS) into components that correspond to the effects specified in the model. For instance, in a simplified ANOVA model with a single treatment factor at various levels, this partitioning process helps in understanding the impact of the treatment on the overall variability.

$$SS_{TOTAL} = SS_{ERROR} + SS_{TREATMENT} \qquad (2)$$

The degrees of freedom can also be partitioned in a similar manner. One component, known as the error term, follows a chi-squared distribution that describes the associated sum of squares. Similarly, if no treatment effect is present, the degrees of freedom for treatments will also follow a chi-squared distribution.

$$DF_{TOTAL} = DF_{ERROR} + DF_{TREATMENTS} \qquad (3)$$

The F-test is employed to compare the factors contributing to the total deviation. In a one-way or single-factor ANOVA, statistical significance is assessed by comparing the F-test statistic across different models. This test is used to evaluate hypotheses about groups of coefficients.

$$F = \frac{Variance\ \ between\ treatment}{\mathrm{var}\,iance\ \ within\ treatment} \qquad (4)$$

$$F = \frac{MS_{treatment}}{MS_{error}} = \frac{SS_{treatments/(1-1)}}{SS_{Error/(n-1)}} \qquad (5)$$

III. RESULTS AND DISCUSSION

Influence of Treatment on the Soil Total Nitrogen

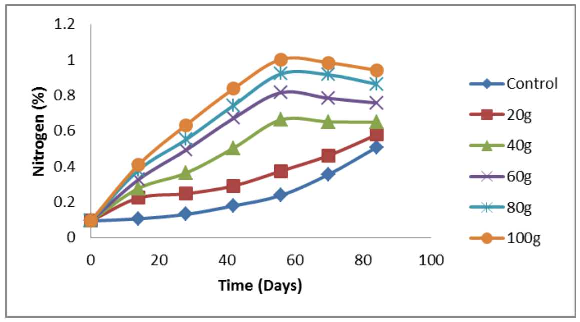

Figure 1: Variation of Total Nitrogen in Swampy Soil with Moringa

Figure 1 illustrates the variation in total nitrogen levels in swampy soil treated with moringa. The data indicate that treatment addition led to notable changes in soil nitrogen content. While natural attenuation also occurred, moringa treatment significantly enhanced the degradation rate of Total Petroleum Hydrocarbons (TPH) over time, primarily due to the increased nitrogen supply. Total nitrogen levels rose consistently up to the 56th day and then stabilized for samples with 40g of treatment weight or more. This suggests that the added nitrogen supported the growth of hydrocarbon-degrading bacteria, which utilized the nitrogen to effectively break down TPH.

Previous research has shown that nitrogen enrichment, through the use of lipophilic fertilizers, biosurfactants, and molasses, can boost microorganism activity in crude oil bioremediation. Similarly, the presence of oxygen was found to accelerate nitrogen consumption and enhance TPH degradation compared to non-oxygenated conditions.

In comparison, swampy soil exhibited higher total nitrogen levels than clay soil. Elephant grass was more effective than moringa in increasing nitrogen content in both soil types. Before contamination, total nitrogen in swampy soil was 1.032%, which dropped to 0.094% after pollution. By the 84th day, nitrogen levels in swampy soil had risen to 0.507%, 0.578%, 0.649%, 0.757%, 0.863%, and 0.941% for control, 20g, 40g, 60g, 80g, and 100g treatment weights, respectively.

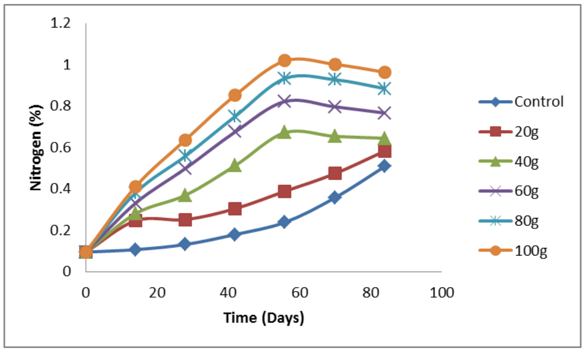

Figure 2: Variation of Total Nitrogen in Swampy Soil with Elephant Grass

Figure 2 presents the variation in total nitrogen levels in swampy soil treated with elephant grass. Total nitrogen increased with both the duration of treatment and the amount of elephant grass applied. The nitrogen levels rose steadily up to the 56th day and then stabilized for samples with 40g of treatment weight or more. This suggests that the added elephant grass contributed additional nitrogen to the soil, which was utilized by hydrocarbon-degrading bacteria to break down TPH content.

Initially, total nitrogen in swampy soil was 1.032%, but it dropped to 0.094% after contamination. By the end of the treatment period, total nitrogen levels had increased to 0.582%, 0.644%, 0.766%, 0.884%, and 0.963% for the control (0g elephant grass) and the 20g, 40g, 60g, 80g, and 100g treatment weights, respectively.

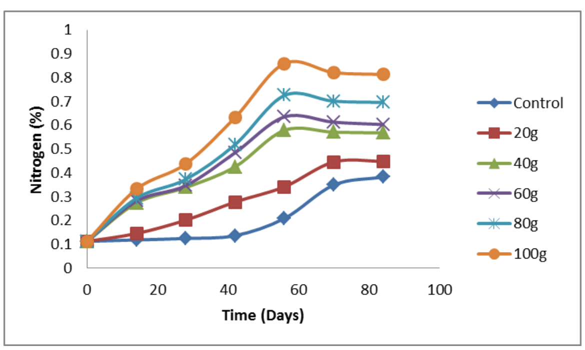

Figure 3: Variation of Total Nitrogen in Clay Soil with Moringa

Figure 3 illustrates the variation in total nitrogen levels in clay soil treated with moringa. Total nitrogen content increased with both the duration of treatment and the amount of moringa applied. The nitrogen levels rose steadily up to the 56th day and then stabilized for samples with 40g of moringa or more. Initially, total nitrogen in clay soil was 0.981%, but it decreased to 0.113% after contamination. By the end of the treatment period (84th day), total nitrogen levels had risen to 0.383%, 0.449%, 0.568%, 0.603%, 0.696%, and 0.813% for the control (0g moringa) and the 20g, 40g, 60g, 80g, and 100g moringa treatments, respectively.

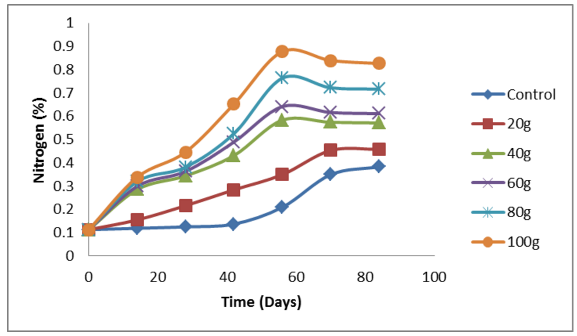

Figure 4: Variation of Total Nitrogen in Clay Soil with Elephant Grass

Figure 4 depicts the variation in total nitrogen levels in clay soil treated with elephant grass. Total nitrogen content increased with both the duration of treatment and the amount of elephant grass applied. The nitrogen levels rose steadily up to the 56th day and then stabilized for samples with 40g of elephant grass or more. Initially, total nitrogen in clay soil was 0.981%, but this decreased to 0.113% following contamination. By the end of the treatment period (84th day), total nitrogen levels had increased to 0.383%, 0.458%, 0.571%, 0.611%, 0.716%, and 0.826% for the control (0g elephant grass), and the 20g, 40g, 60g, 80g, and 100g treatment weights, respectively.

CONCLUSION

This study evaluated the effects of moringa and elephant grass treatments on total nitrogen levels and hydrocarbon degradation in both swampy and clay soils. The results indicate that both plant materials significantly enhance soil nitrogen content, which supports the growth of hydrocarbon-degrading bacteria essential for effective bioremediation.

In swampy soil, total nitrogen increased steadily with time and treatment weight for both moringa and elephant grass. Nitrogen levels stabilized at 56 days for treatments of 40g or more, with elephant grass showing slightly higher nitrogen enrichment than moringa. For moringa, nitrogen increased from 0.094% post-contamination to 0.941% with 100g of treatment, while elephant grass resulted in an increase from 0.094% to 0.963%.

In clay soil, similar trends were observed. Moringa treatment raised nitrogen from 0.113% to 0.813%, and elephant grass treatment resulted in an increase from 0.113% to 0.826%. Both treatments improved soil nitrogen levels, albeit to a lesser extent compared to swampy soil.

The findings underscore the effectiveness of both moringa and elephant grass in enhancing soil nitrogen, thereby supporting microbial activity and accelerating TPH degradation. Elephant grass demonstrated a slightly greater capacity for nitrogen enrichment across both soil types, making it a potentially more effective option for bioremediation efforts.

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