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Comparison of Percentage Removal of Petroleum Hydrocarbon on the Effect of Biostimulant in Polluted Soil Environment Using *Chromolaena odorata*

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Abstract

The investigation on the comparison of percentage reduction on polluted soil environment using chromolaena odorata as a bio-stimulant upon the effect of contact time revealed increase in percentage removal of total petroleum hydrocarbon (TPH). The rate of total petroleum hydrocarbon (TPH) removal was discovered to have been influenced y the mas of bio-stimulant dosage immersed or introduced into each of the bioreactor. However, as the mass of the bio-stimulant dosage increases the more the percentage reduction also increases in the each of the bioreactor. The rate of TPH reduction in terms of percentage reduction in the control samples was low and this was attributed to lack of available nutrients for the microorganism to makes up as to catalyzed the reaction mechanism of the process for optimum performance of the microbes. Indeed, the research revealed lack of inhibiting effect by the possible inhibiting factors such as pH, temperature, oxygen, contaminants concentration, and other physicochemical parameters. The result contained revealed that the amount of TPH removed by the application of the bio stimulant using sun dried sample is 42.34% for 25g dosage, 61.21% for 50g dosage, 78.37 for 75g dosage and 90.18% for 100g dosage whereas control sample is 10.22% without the application of the bio-stimulant for the period of 42 days sampling. In the case, of room-dried of the bio-stimulant the percentage reduction is 50.49% for 25g dosage, 71.57% for 50g dosage 83.77% for 75g dosage and 98.01% for 100g dosage for contact time of 42days. The research has shown that bio-stimulant subjected into room dried retained their potential nutrients which enhanced bioremediation process as well as facilitate the rate of TPH remediation or degradation of pollutant and indeed, enhanced environmental clean – up of a contaminated soil.

Keywords: Comparison, percentage, reduction, TPH, effect biostimulant, *Chromolaena odorata*

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INTRODUCTION

Hydrocarbon biodegradation in soil can be limited by numerous factors, including nutrient availability, pH, temperature, moisture, oxygen, soil properties, and contaminants [1]. Enhancing the environment to support bacteria capable of bioremediation is referred to as biostimulation. This approach involves the addition of electron acceptors and essential nutrients—such as carbon (e.g., in the form of molasses), nitrogen, phosphorus, or oxygen—that are otherwise present at limiting levels for microbial activity [2-4].

One primary advantage of biostimulation is that it relies on naturally occurring microorganisms already adapted to the subsurface environment and widely distributed throughout it [5, 6]. However, the delivery of these additives is challenging, as the subsurface geology dictates how accessible they will be to microorganisms. Tight, impermeable lithologies, such as clays or fine-grained materials, impede even distribution of additives across impacted areas [7, 8]. In these cases, subsurface fractures create preferential pathways, causing additives to flow unevenly. Moreover, nutrient addition can trigger competition among the local microflora, potentially promoting the growth of heterotrophic microbes that are not effective at degrading total petroleum hydrocarbons (TPH) [9].

Phytoremediation, another bioremediation approach, utilizes plants to remove, sequester, or detoxify contaminants in soil and water. This technique is both visually appealing and environmentally friendly, preserving soil structure [10]. Phytoremediation primarily addresses elemental and organic pollutants, including metals, herbicides, explosives, and oil. Plants play a crucial role by preventing the spread of contaminants to other locations via wind, rain, and groundwater [11]. This method is most effective in sites with low to moderate contamination levels, where plants can absorb harmful substances from soil, streams, and groundwater as their roots take up water and nutrients. Contaminants can be remediated to the depth at which roots reach, with deeper-rooted trees often used for pollutants found deeper underground. Within the plant, chemicals may be stored in roots, stems, or leaves, transformed into less toxic compounds, or converted into gases released into the atmosphere during transpiration [12].

Phytoremediation can occur even when contaminants are not directly absorbed by plant roots. Some chemicals adhere to or “sorb” onto plant roots, or nearby microbes may transform these chemicals into less toxic forms. Plants then grow, absorbing or accumulating these substances, which can later be harvested and disposed of. If the contaminants are metals, these may even be recycled. Trees, however, are generally left unharvested to continue remediation over time. In addition, phytoremediation plants can help prevent contaminant migration from polluted sites to surrounding areas, reducing the quantity of pollutants that may otherwise disperse via wind or water runoff [13].

MATERIALS AND METHODS

Materials

In this research the following materials were used: crude oil, plastic containers, Awolowo leaf (*Chloromolaema Odorata*), shovel, hand trowel.

Sample Collection

The loamy soil sample was collected from the Agricultural Farm at Rivers State University and transported to the Department of Chemical/Petrochemical Engineering Laboratory. A portion of the soil sample was analyzed in the Department of Soil Science, also at Rivers State University, Port Harcourt. The soil was then prepared for the experimental setup.

The crude oil sample was sourced from a soil site in Ogoni, owned by Shell Petroleum Development Company (SPDC). This sample was also taken to Rivers State University's Department of Chemical/Petrochemical Engineering Laboratory for examination. The crude oil, identified as Bonny Light Medium, was prepared for use in the experimental setup.

The Awolowo leaf (Chloromolaema odorata), used as a bioremediation agent, was collected from the Mgbuitanwo community in Emohua Local Government Area of Rivers State. The collected bioremediant was then transported to the same Department of Chemical/Petrochemical Engineering Laboratory, where it was prepared for the experimental setup.

Gas Chromatography: An Instrument Used for Crude Oil Analysis

This analytical tool quantifies the concentration of each component in a sample. The process, known as gas chromatography, is performed using a gas chromatograph. In gas chromatography, the sample solution is injected into the instrument and carried by a gas stream (typically nitrogen or helium) into a separation tube called a column. Within the column, the sample components are separated. As each component exits the column, a detector measures it. To determine the concentration of an unknown sample, a standard sample with a known concentration is first injected. The concentration is then calculated by comparing the peak retention time and area of the standard sample with those of the test sample.

RESULTS AND DISCUSSION

The result obtained from the computation is presented in Figures and Tables below and the percentage reduction in the total petroleum hydrocarbon increases with increase in the period of exposure.

Figure 1 shows the perfomance of Room dried bio-stimulant sample of *Chloromolaema Odorata* in the process of degradation of TPH in each reactor by percentages. The investigation shows the effectiveness in TPH remediation being dependent on the degree of dosage concentration in each reactor labelled R_{R1}, R_{R2}, R_{R3},R_{R4} and control. $R_{R4.}$ With a dosage of 100g of bio-stimulant sample of *Chloromolaema Odorata* for the 42nd Day, 93.01% degradation of TPH was recorded. The order of TPH percentage degradtion is expressed as R_{R4}(100g) > R_{R3}(75g) > R_{R2} (50g) > R_{R1} (25g) > Control.

Figure 2 shows the performance of Room dried bio-stimulant sample of *Chloromolaema Odorata* in the process of degradation of TPH in each reactor by percentages. The investigation shows the effectiveness in TPH remediation being dependent on the degree of dosage concentration in each reactor labelled R_1, R_{R2}, R_{R3},R_{R4} and control. $R_{R4.}$ With a dosage of 100g of bio-stimulant of *Chloromolaema Odorata* for the 42nd Day, 90.18% degradation of TPH was recorded. The order of TPH percentage degradtion is expressed as R_{S4}(100g) > R_{S3}(75g) > R_{S2} (50g) > R_{S1} (25g) > Control.

Table 1 showcases the percentage removal of the TPH content from each of the bioreactor set-up and the obtained result revealed increased in TPH removal with increase the concentration of bio-stimutant dosage.

Table 2 showcases the percentage removal of the TPH content from each of the bioreactor set-up and the obtained result revealed increased in TPH removal with increase the concentration of bio-stimulant dosage.

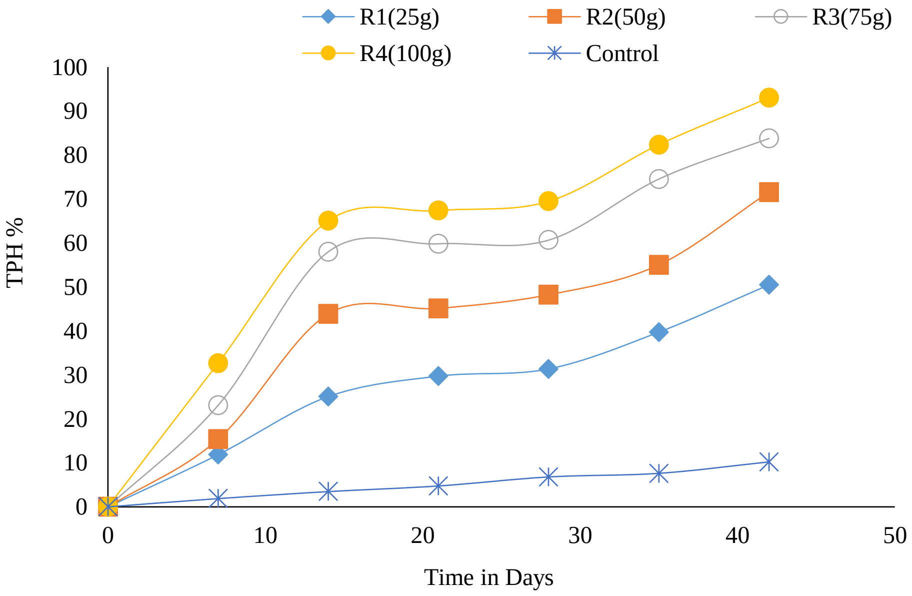

Figure 1. TPH Percentage Removal Versus Effect of Time on Remediant (*Chloromolaema Odorata)* for R_{R1}, R_{R2}, R_{R3}, R_{R4} and control for Room Dried.

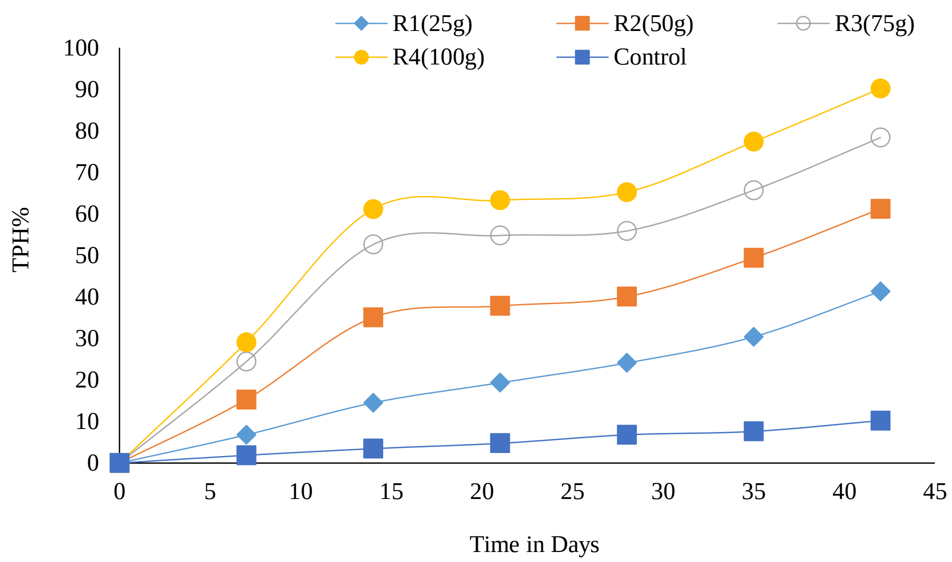

Figure 2. TPH percentage removal versus effect of time on remediant (*Chloromolaema Odorata)* for R_{R1}, R_{R2}, R_{R3}, R_{R4} and control for Room Dried.

Table 1. TPH percentage removal for *Chloromolaena Odorata* (Awolowo Leaf) on loamy soil in different bioreactor for room dried remediant.

Time (Days)	TPH(%) R_{RI}(25g)	TPH(%) R_{RI}(50g)	TPH(%) R_{RI}(75g)	TPH(%) R_{RI}(100g)	TPH(%) Control
0	0	0	0	0	0
7	11.86	15.36	23.08	32.66	1.87
14	25.07	43.86	57.996	65.03	3.47
21	29.73	45.13	59.82	67.37	4.75
28	31.36	48.23	60.65	69.47	6.8
35	39.72	55.02	74.53	82.35	7.62
42	50.49	71.57	83.77	93.01	10.22

Table 2. TPH percentage removal for *Chloromolaena Odorata* (Awolowo Leaf) on loamy soil in different bioreactor for sun dried remediant.

Time (Days)	TPH(%) R_{SI}(25g)	TPH(%) R_{S2}(50g)	TPH(%) R_{S3}(75g)	TPH(%) R_{S4}(100g)	TPH(%) Control
0	0	0	0	0	0
7	6.79	15.28	24.42	29.09	1.87
14	14.51	35.05	52.62	61.15	3.47
21	19.33	37.83	54.79	63.27	4.75
28	24.1	40.06	55.89	65.24	6.8
35	30.4	49.4	65.7	77.36	7.62
42	41.34	61.21	78.37	90.18	10.22

Table 3 shows the trend of the TPH degradation upon the action of microbes which is catalyzed by the bio-stimulant added to increase the available nutrients in each of the bioreactor set-up. Decrease in the TPH concentration was observed with increase in contact time and the rate of TPH in each bioreactor was influenced by the mass of bio-stimulant dosage in the system. The medium in which the bio-stimulant was prepared also influenced the efficiency of performance in the given process. The degradation of the TPH under the influence of nature, which its bioreactor does not received the application of bio-stimulant partially undergo remediation and the rate of TPH remediation occurrence was very slow due to lack of nutrient in the system.

Table 3. TPH Analysis on the effect of *Chloromolaena Odorata* (Awolowo Leaf) on loamy soil in different bioreactor for room dried remediant.

TPH Concentration (ppm) RD					
Time (Days)	*R_{R1}(25g)*	*R_{R2}(50g)*	*R_{R3}(75g)*	*R_{R4}(100g)*	*Control*
0	39847.71148	39847.71148	39847.71148	39847.71148	39847.71148
7	35118.5662	33728.61711	30649.74718	26833.1147	39101.36240
14	29859.42896	22372.36212	17135.99439	13936.75588	38463.71663
21	28001.35571	21863.37401	16011.29612	13000.61227	37955.33614
28	27349.81703	20629.85170	15681.49688	12165.35065	37139.55273
35	24022.10062	17924.88370	10147.41816	7035.27491	36812.99160
42	19728.37888	11328.14792	6467.89155	2786.56583	35775.40022

Table 4. THP Analysis on the effect of Chloromolaena Odorata (Awolowo Leaf) on loamy soil in different bioreactor for room dried remediant.

TPH Concentration (ppm) SD					
Time (Days)	*R_{S1}(25g)*	*R_{S2}(50g)*	*R_{S3}(75g)*	*R_{S4}(100g)*	*Control*
0	39847.71148	39847.71148	39847.71148	39847.71148	39847.71148
7	37141.22181	33757.5255	30117.3612	28255.94416	39101.36240
14	34065.60257	25881.49773	18880.91033	15480.72463	38463.71663
21	32144.07252	24773.61341	18013.5227	14636.13616	37955.33614
28	30245.56278	23885.03224	17578.24181	13850.67450	37139.55273
35	27733.99164	20161.27511	13666.14715	9022.69270	36812.9916
42	23374.79564	15458.12706	8619.23026	3911.18015	35775.40022

Table 4 shows the trend of the TPH degradation upon the action of microbes which is catalyzed by the bio-stimulant added to increase the available nutrients in each of the bioreactor set-up. Decrease in the TPH concentration was observed with increase in contact time and the rate of TPH in each bioreactor was influenced by the mass of bio-stimulant dosage in the system. The medium in which the bio-stimulant was prepared also influenced the efficiency of performance in the given process. The degradation of the TPH under the influence of nature, which its bioreactor does not received the application of bio-stimulant partially undergo remediation and the rate of TPH remediation occurrence was very slow due to lack of nutrient in the system.

CONCLUSION

The conclusion drawn from this research was based on the findings, such as:

- The percentage remediation of the TPH was within 95 and 98%.
- The obtained information revealed that the biostimulant is a good remediatant
- The biostimulant and microbial growth was not inhibited by the degree of pollutant concentration throughout the process
- Increase in microbial build-up was experienced

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