DEGRADATION EFFICIENCY OF SPENT MUSHROOM IN PETROLEUM CONTAMINATED SOIL

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Abstract

The Niger Delta Area of Nigeria is characterized by perennial pollution of soil and water environment due to sabotage or equipment failure. Based on this, experimental investigation was carried out to examine the efficiency of spent mushroom on the degradation of Total Petroleum Hydrocarbon (TPH) in soil. The investigation was monitored for a period of 70 days in bioreactor. As time was increased, the degradation rate of TPH in soil equally increased. Though, the spent mushroom amendment showed high efficiency in the degradation of TPH in soil, the different concentrations do not vary significantly across the different reactors as the percentage degradation after 70 days were approximately within 92-93%. This showed that between 800 and 1000g (or 160g/kg soil and 200g/kg soil) concentration of the spent mushroom can be effective for remediation of TPH in soil environment.

Keywords*: Degradation, Bioreactor, Spent Mushroom, Crude Oil*

I. INTRODUCTION

Crude oil exploration and exploitation has significantly deteriorated the Niger Delta environment in Nigeria. In fact, the persistent release of crude and its products into the environment is depleting sources of livelihood of people. Oil pollution in rivers, streams, lakes and swamps has reduced the production of fish in these water bodies, and fishing is the main occupation characterizing the coastline dwellers. Also, the people living on upland are not left out of the aftermath effect of oil pollution, as agricultural yield has significantly reduced occasioned by poor harvest especially in soils polluted by crude oil.

As noted by some researchers, pollution by crude oil changes the properties of natural vegetation [1-4]. In another study, it was reported that hydraulic conductivity, porosity, and bulk density of soil were affected by oil pollution [5].

Beside the changes in soil properties, crude oil with toxic compounds, radioactive materials, or disease-causing agents may have adverse effects on plant growth and animal health [1, 5-6]. The destruction or alteration of nutrient source in soil affects the overall growth of plants. Thus, effect of oil spillage on plants' nutrient source such as manganese and ferrous elements has been reported [2].

Studies are seriously ongoing to reduce the impact of crude oil on the environment through finding alternative and cost effective mechanisms for proper remediation of crude oil polluted soil. One of such mechanisms is the bioremediation technology, where agricultural wastes, microorganism or biological material is used for amendment of contaminated soils.

Of course, many amendments for remediation of crude oil contaminated soil have been investigated such as poultry manure, cow dung, pig dung, cassava peels, beans, melon and groundnut shells [7-9]. In this study, spent mushroom was used as remediating agent for TPH polluted soil. Mushroom has useful nutrient source for biodegrading organisms which can be utilized to degrade diverse of environmental pollutants [10-12].

II. MATERIALS AND METHODS

The crude oil used for this experiment was obtained from Nigeria National Petroleum Company (NNPC) in Port Harcourt, Rivers State. The spent mushrooms were collected from Dilomat Farm, Rivers State University, Port Harcourt.

A. Experimental procedure

The soil was divided into six treatment sample cells (reactors) coded: WF-0 to WF-5. Cell WF-0 was used as control sample (no treatment); while cells WF-1, WF-2, WF-3, WF-4, and WF-5 received 1000, 950, 900, 850 and 800g of spent mushroom respectively. 5kg of soil and 340ml of crude oil were added into each of the cell, and then mixed properly.

After the mixing process, the cells were left undisturbed for three days. This was done to allow degradation to commence [13]. At the end of three days, measured weights of 800, 850, 900, 950 and 1000g spent mushrooms were added to the labeled cell WF-1, WF-2, WF-3, WF-4 and WF-5 respectively, and then followed by addition of 750ml of distilled water.

B. Laboratory analysis

Soil physiochemical properties such as moisture content, organic carbon, total nitrogen, electrical conductivity, nitrate content (NO_3), phosphate content PO_4 and soil pH were determined using standard methods described in literature [14]. The Total Heterotrophic Bacteria (THB) counts were determined according to the method described in literature [8].

ACU TPH standard of 500mg/l dichromethane was used to determine the TPH concentration. Three days after pollution, baseline analysis for TPH was conducted before addition of the spent mushroom and water. 10g of each sample was taken into sample bottles. 80ml of chloroform was measured and added to each sample. The sample was tightly closed and then shaken for proper mixing of content. The mixture was left to stand for 2 days to allow for extraction of the crude oil by the chloroform. On the 4th day, each of the samples was decanted and the clear liquid transferred to fresh sample bottles, and the volume made up to 60ml using chloroform. The UV-VIS spectrophotometer was standardized using chloroform for the blank, with wavelength set at 290nm. This procedure was done every two weeks until (10) weeks. TPH percentage degradation was calculated using the expression:

$$TPH(\%) = \frac{TPH_o - TPH_t}{TPH_o} \times 100\% \quad (1)$$

Where: TPH_o and TPH_t are the TPH concentrations initially in the soil and that measured at any given time.

III. RESULTS AND DISCUSSION

Physicochemical analysis of the soil sample before the application of Spent mushroom amendments shown in Table 1.

Table 1: Physicochemical analysis of the soil before treatment

Parameter	Value
Moisture Content (%)	14.00 ± 1.00
pH	4.65 ± 0.10
EC (µ/cm)	29.00 ± 2.00
Organic carbon (%)	0.18 ± 0.02
Total nitrogen content (%)	0.62 ± 0.02
Total phosphorus content (%)	0.73± 0.02
C/N	0.4 0± 0.01

*Results are in three replicates

The initial assessment of the soil parameters indicates that the soil is acidic with a mean pH value of 4.65±0.10, electrical conductivity, EC of 29.00±0.10, C/N of 0.40±0.01 and moisture content of 14±1.00%. Again, as shown in Table 1, the soil organic carbon is 0.18±0.02%, total nitrogen content is 0.62±0.02% and total phosphorus content is 0.73±0.02%. The low contents of organic carbon, total nitrogen and total phosphorus is an indication that remediation would not be favourable naturally without an amendment agent [15]. Similar observation had been reported in previous studies [16-17].

A. TPH degradation over the period

The biweekly analysis of TPH degradation in soil for all the treatment cells is shown in Figure 1. After 3 days, the baseline analysis showed slight decline in TPH in the soil. However, on addition of treatment, there was increased rate of degradation across the cells, except for the controlled sample. From initial 4500g/kg TPH in the soils, the percentage degradation of TPH in the respective cells from 3rd day to the 70th day (10th week) were found to have increased to 53.67, 92.84, 92.41, 92.63, 92.03 and 92.18% for WF-0, WF-1, WF-2, WF-3, WF-4 and WF-5 cells respectively. Thus, from the percentage degradation, there is no significant different between various weights of spent mushroom (800 to 1000g). Thus, any of weight could be used. However, there was slow degradation of TPH without amendment, as only 53.67% after 10 weeks was degraded.

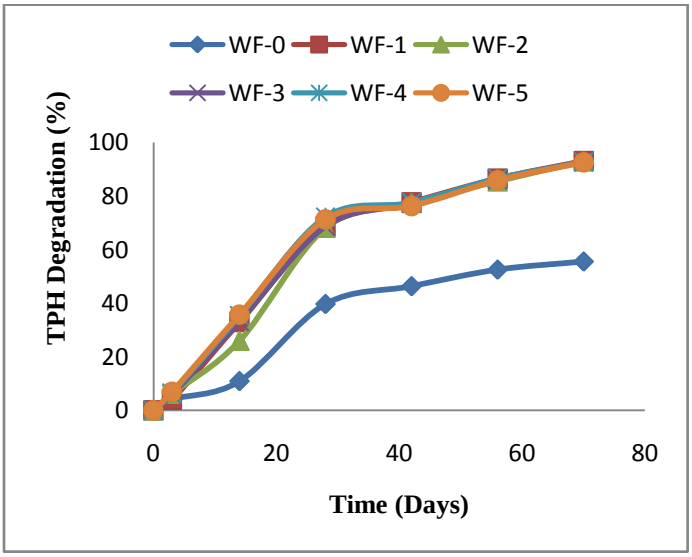

Figure 1: Effect of Amendment Content on TPH Reduction with Time

B. Total heterotrophic Bacteria (THB) growth

The increased degradation rate of TPH is attributed to increase in population of microorganism, arising from the nutrient supplied by the spent mushroom. The growth of micro-organism over the period across the cells is shown in Figure 2. The profiles showed that there was significant growth of microbes in the cells injected with spent mushroom than the naturally

degrading soil (control: indicated by WF-0). Although, the highest growth of microbes was observed in the cell labeled WF-2 containing 950g of the spent mushroom, there was no remarkable difference in the growth of microbes in the cells. However, microbial growth declined after 42 days in the cells, whereas, gradual growth of microbes was still observed in the control sample.

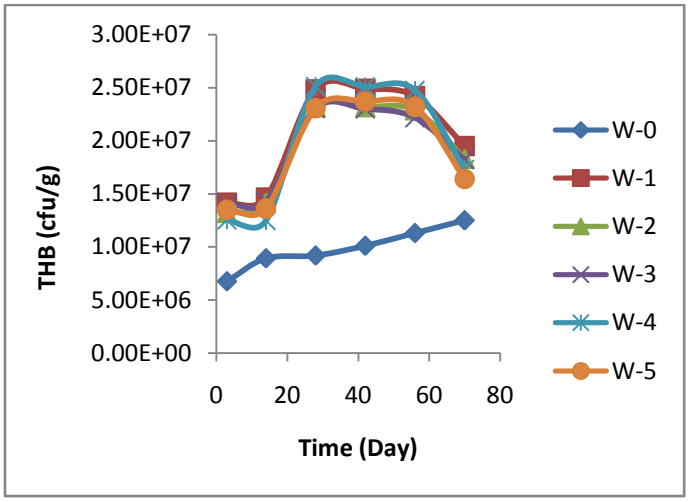

Figure 2: Effect of Spent Mushroom on THB

IV. CONCLUSION

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