Efficiency of *Pluerotus ostreatus* in bioremoval of total petroleum hydrocarbon from refinery effluent

Abstract

The contamination level of Total Petroleum Hydrocarbons (TPH) in effluent discharged from Port Harcourt refinery was evaluated and removed using *Pluerotus ostreatus* in this study. Concentrations of TPH in the effluent were monitored in a soil microcosm study with *Pluerotus ostreatus*, sawdust and rice bran amendment. Five treatment options were used (i.e. positive control to monitor natural attenuation, filtered sample, which is the negative control, effluent seeded with spawn, effluent seeded with spawn and sawdust and effluent seeded with spawn, sawdust and rice bran. Sawdust mixed with rice bran colonized with *Pluerotus ostreatus* spawn was efficient in removing 95.29% of TPH. Hence, this treatment option could be utilized as an excellent bioadsorbent. This study demonstrates that *Pleurotus ostreatus* has bioadsorbent potential that can be exploited in the treatment of environments polluted with effluent containing significant levels of Total Petroleum Hydrocarbon.

Key words: Total Petroleum Hydrocarbon, *Pleurotus ostreatus*, bioadsorption, effluent.

INTRODUCTION

Total Petroleum Hydrocarbons (TPH) is a term used to describe a broad family of several hundred chemical compounds that originally come from crude oil. They are called hydrocarbons because almost all of them are made entirely from hydrogen and carbon. Crude oils can vary in how much of each chemical they contain, and so can the petroleum products that are made from crude oils. Because modern society uses so many petroleum-based products (for example, gasoline, kerosene, fuel oil, mineral oil, and asphalt), contamination of the environment by them is potentially widespread. Contamination may originate from a variety of sources: fossil fuels, pipeline vandalism, runoff, oil accidents, illegal discharges and shipping (lemponen *et. al.*, 2005).

Petroleum industry wastes pollute the environment when they are not properly treated before discharge. Effluents discharged into the environment is said to be a source of toxicity to aquatic and terrestrial organisms. Measurement of the total amount of TPH in a sample is important because there are so many different chemicals in crude oil and in other petroleum
products, and it is not practical to measure each one separately (Forrester et al., 2010). Petroleum hydrocarbons are monitored at various levels depending on the state and testing site.

The search for new technologies involving the removal of petroleum hydrocarbons from wastewaters has directed attention to bioremoval, based on metal binding capacities of various biological materials. Isikhuemhen et al. (2003) reported that white-rot fungi are increasingly being investigated and used in bioremediation because of their ability to degrade an extremely diverse range of very persistent or toxic environmental pollutants. White-rot fungi digest lignin in wood by the secretion of enzymes giving wood a bleached appearance (Kirk et al., 1992; Ogbo et al., 2011). They have also been found to be involved in mineralization, biodegradation, transformation and co-metabolism (Bennet et al., 2002). Although different potential fungal biosorbents have been investigated, very little is known of the ability of Pleurotus ostreatus in bioremoval of TPH in refinery effluent. The present study examined the efficiency of Pleurotus ostreatus in bioremoval of TPH in effluent obtained from Port Harcourt refinery Eleme, Rivers State, Nigeria.

MATERIALS AND METHODS

Sample collection

The white rot Fungi mushroom, Pleurotus ostreatus used was obtained from NDDC/RSUST/DIPLOMAT mushroom/spawn production and research centre of the Faculty of Agriculture Teaching and Research Campus, Rivers State University of Science and Technology, Nkpolu, Port Harcourt. A 10 liter container sterilized with 70% ethanol was used to collect the effluent from the refinery drains and taken to the laboratory for immediate analysis. The physiochemical parameters of the effluent were analysed to have an initial value on day zero. The substrates, sawdust and rice bran were fermented and pasteurized...
using heat at NDDC/RSUST/DILOMAT mushroom/spawn production and research centre of the faculty of Agriculture Teaching and Research Campus, Rivers State University of Science and Technology, Nkpolu, Port Harcourt.

Substrate for Spawn Preparation

Guinea corn was used for spawn preparation. The spawn was bought at NDDC/RSUST/DILOMAT mushroom/spawn production and research centre of the Faculty of Agriculture Teaching and Research Campus, Rivers State University of Science and Technology, Nkpolu, Port Harcourt.

Experimental Design

Five different treatment options were set up in and labeled A-E in a plastic container with cover. Flask A: Containing 1.6 liters of the original sample to monitor the natural process. It’s the positive control. Flask B: Containing 1.6 liters of the filtered sample. It’s the negative control. Flask C: Containing 1.6 liters of the effluent, seeded with spawn. Flask D: Containing 1.6 liters of the effluent seeded with spawn and fermented saw dust. Flask E: Containing 1.6 liters of the effluent, seeded with spawn, fermented saw dust and fermented rice bran. The samples were kept at room temperature for 60 days. Fifty milliliters (50mls) of each sample was used for analysis. The concentration of the TPH was measured every 15 days.

Baseline Physicochemical Characteristic of Effluent

pH

pH was measured using APHA 4500 H⁺ (Electrode Method).
Temperature
The temperature reading of the sample was taken at site of collection using a thermometer (Orion, USA).

Biochemical Oxygen Demand (BOD)
BOD was determined using the dilution method according to APHA 5210B (APHA, 2012).

Total organic carbon (TOC)
TOC was determined according to APHA 5310C.

Phosphate concentration
Phosphate concentration was determined by Ascorbic acid method.

Nitrate concentration
Nitrate concentration was determined using the ASTM D3867.

Total petroleum hydrocarbon (TPH)
TPH was determined using the ASTM D5765-95.

Statistical Analysis
Experimental data were subjected to one way analysis of variance (ANOVA) using SPSS 20.

RESULTS AND DISCUSSION
Baseline physicochemical parameters
The baseline physicochemical parameters of the effluent are shown in Table 1. It was observed that the initial temperature of the effluent was 27.0°C with pH at 6.87 and differed
from that of filtered effluent which was 26.90 at pH 7.05. There were variations in the physicochemical parameters, with filtered effluent showing lower levels. Concentrations of total organic carbon, nitrate and phosphate in the medium were able to sustain the growth of 

P. ostreatus in the effluent for the period of the study.

Table 1: Baseline physicochemical parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Effluent</th>
<th>Filtered Effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH</td>
<td>6.87</td>
<td>7.05</td>
</tr>
<tr>
<td>Temp. °C</td>
<td>27.10</td>
<td>26.90</td>
</tr>
<tr>
<td>Total Dissolved Solids, mg/l</td>
<td>231.28</td>
<td>208.88</td>
</tr>
<tr>
<td>Turbidity, NTU</td>
<td>29.60</td>
<td>19.50</td>
</tr>
<tr>
<td>TSS, mg/l</td>
<td>27.00</td>
<td>14.00</td>
</tr>
<tr>
<td>DO, mg/l</td>
<td>5.01</td>
<td>5.16</td>
</tr>
<tr>
<td>Nitrate, mg/l</td>
<td>4.22</td>
<td>4.14</td>
</tr>
<tr>
<td>Phosphate, mg/l</td>
<td>0.63</td>
<td>0.54</td>
</tr>
<tr>
<td>BOD, mg/l</td>
<td>6.25</td>
<td>6.01</td>
</tr>
<tr>
<td>COD, mg/l</td>
<td>10.05</td>
<td>8.88</td>
</tr>
<tr>
<td>TOC, mg/l</td>
<td>3.50</td>
<td>1.66</td>
</tr>
<tr>
<td>TPH, mg/l</td>
<td>5.09</td>
<td>2.97</td>
</tr>
</tbody>
</table>

Total Petroleum Hydrocarbon Removal

Total petroleum hydrocarbon concentrations with various treatments are presented in Figure 1. The TPH removal efficiency of the various treatments showed variations. Treatment option A (positive control) which is the natural process showed the presence of TPH. Treatment option B (negative control) which is the filtered sample showed presence of some of the TPH, an indication that not all the TPH were eliminated by filtration. The activities in treatment option E demonstrated an excellent performance with a seemingly constant percentage
removal for 60 days. The reduction may be due to the presence of sufficient nutrient in the effluent. Treatment option C and D also demonstrated good reduction performance due to less substrate compared to treatment option E. The decrease from day 15 may be as a result of the presence of some intermediate metabolic products that might have altered the condition of the medium. The production of appropriate enzyme system and increase in cell population may be responsible for increase as seen from day 30. Fungi have excellent biosorbent capability due to their fast growth rate, minimal nutrient requirement as well as large biomass production. The composition of the fungal cell wall and the filamentous morphology of fungi may be an added advantage.

![Figure 1: Changes in concentration of TPH](image)

**Figure 1: Changes in concentration of TPH**

Presence of TPH even in small amount can be injurious to health. Humans are exposed to TPH from many sources, like gasoline fumes at the pump, spilled crankcase oil on pavement, chemicals at home or work, or certain pesticides that contain TPH components as solvents.
Many occupations involve extracting and refining crude oil, manufacturing petroleum and other hydrocarbon products, or using these products. Through skin contact or by breathing contaminated air caused by leakage from underground storage tanks. Children may be exposed by playing in soil contaminated with TPH.

TPH can enter the body through drinking water, food, inhaled air, soil; or by touch. Other TPH compounds are slowly distributed by the blood to other parts of the body and do not readily break down. When you touch TPH compounds, they are absorbed more slowly and to a lesser extent than when you breathe or swallow them. Most TPH compounds leave the body through urine or exhaled air containing the compounds.

Information about health effects of TPH must be based on specific compounds or petroleum products that have been studied. However, exposure for a long time can cause permanent damage to the central nervous system. Swallowing of petroleum products causes irritation of the throat and stomach, central nervous system depression, difficulty in breathing, and pneumonia from breathing liquid into the lungs. The compounds in some TPH fractions can also affect the blood, immune system, liver, spleen, kidneys, developing foetus, and lungs.

Certain TPH compounds can be irritating to the skin and eyes. Other TPH compounds, such as some mineral oils, are not very toxic and are used in foods.

The mushrooms used for the remediation of effluent should be properly discarded. They can be incinerated and the ash not deposited in soils or water bodies but recycled to get back the petroleum hydrocarbons or removed to dump sites that are not used for agricultural purposes. Mushrooms harvested from crude oil contaminated sites should be analysed before consumption.

**CONCLUSION**
*Pleurotus ostreatus* can biodegrade and bind petroleum hydrocarbons and heavy metals in associated medium thereby aiding their removal. This is because white rot fungi produce extracellular enzymes with low substrate specificity that enables degradation of a wide array of aromatic compounds including petroleum hydrocarbons. This study showed that the use of *Pleurotus ostreatus* in biotreatment of effluent is an excellent possibility.

**REFERENCE**


Mirsadeghi SA, Zakaria MP, Yap CK, Shahbazi A (2011) Risk assessment for the daily intake of polycyclic aromatic hydrocarbons from the ingestion of cockle (*Anadara granosa)*
and exposure to contaminated water and sediments along the west coast of Peninsular Malaysia. J Environ Sci 23:336–345


