Application of Food Waste Composting Process for the Treatment of Diesel Contaminated Soil

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Abstract—Paradigm shifting from traditional food waste composting process to treat diesel oil-contaminated soil is an innovative, low cost and effective technology. However, according to the traditional bioremediation technologies, a key issue is that there is a maximum tolerated concentration. A test was then carried out to study whether there is a maximum tolerated concentration for the proposed method, and if yes, what is the operating value? The following diesel contaminations were tested: 0 mg/kg (without addition), 5000 mg/kg, 10000 mg/kg, 20000 mg/kg, 30000 mg/kg and 50000 mg/kg. The result showed that diesel decomposition efficiency and the bioactivity of decomposing bacteria in the food waste compost pile were not restricted as diesel concentration increased up to 50000 mg/kg, an expected high concentration in general oil contamination site. Observed results indicate the proposed thermophilic composting process may develop into a cost-effective novel green remediation technology with high efficiency, thus provides a potential alternative in bioremediation of oil contamination sites.

Keywords—food waste composting process; diesel oil; bioaugmentation; bioremediation efficiency)

I. INTRODUCTION

Contamination of soil or water with hydrocarbons is a major problem in many industrial sites dealing with production, processing and storage of oil and petrochemicals. Bioremediation is a feasible and economical way to remove petroleum pollutants from contaminated soil.¹⁻² Most of the approaches happen to the problems of pollution concentration, bioremediation efficiency, enhancement of bioaugmentation or biostimulation, and mesophilic or psychrophilic process.³⁻⁵ For examples, bioremediation process has the limit of pollution concentration, what the maximum of pollution concentration could be treated? and how was the bioremediation efficiency? For concerning of bioremediation efficiency, enhancement of bioaugmentation with external consortia or biostimulation of nutrient addition was necessary to be taken.³ Diesel fuel concentrations in contaminated soils typically range between 1000 and 10000 mg/kg with some hot spots containing 10000 to 50000 mg/kg. Therefore, during the composting process, key points are the tolerated concentration. A test was carried out to obtain the maximum tolerated concentration of diesel oil using food waste from the community, and the biodegradation efficacy of diesel oil without bioaugmentation or nutrient addition was estimated by the rate constant of kinetic characteristics.

II. METHOD AND MATERIAL

The compost mixture for testing the maximum tolerated concentration of diesel oil was used in this experiment, and the ratio of food waste: microbial seeding (matured compost): saw dust was 64 : 16 : 20 (by weight %). The initial compost mixture in this experiment contained 1.2% nitrogen, 0.5% phosphate, and 1.1% potassium with the C/N ratio of 32. The food waste from the community contained 1.1% nitrogen, 0.6% phosphate, and 1.2% potassium with the C/N ratio of 36. Maximum tolerated concentration of diesel oil will be tested by using following diesel oil concentrations: 0 mg/kg (without addition), 5000 mg/kg, 10000 mg/kg, 20000 mg/kg, 30000 mg/kg and 50000 mg/kg. During the test, the temperature, water content and pH values were monitored and the concentration of Total Petroleum Hydrocarbons (TPH) was analyzed.

III. RESULTS AND DISCUSSION

A. Enhancing effect of edible oil on biodegradation of diesel oil

As shown in Figure. 1, the initial TPH concentrations of composting soil piles being spiked with diesel were about 33770, 45081, 59819, 69041 and 88118 mg/kg, respectively. The edible oil of community food waste contributed to the concentration of 30000 mg/kg in average, and made it ease to decompose diesel possibly due to the effect of hydrocarbon cometabolism.⁶ Similar cometabolic effect resulted from synergic effects of diesel in the biodegradability was observed by Mudge and Pereira (1999)⁶. Because the cooked edible oil of community food waste was easier to decompose than raw diesel oil. On the other hand, community food waste was abundant bacterial diversity and adequate nutrient, which were benefit to the fast biodegradation of diesel oil. Therefore, the fast biodegradation of TPH were observed in initial 10 days below 30000 mg/kg concentration. After 10 days of the composting process, diesel concentration were degraded...
down to 9909, 12452, 22617, 46000, and 61756 mg/kg, respectively.

There were two biodegradation trends of TPH concentration curves as shown in Fig 1. There seems to be two different biodegradation mechanisms that might involve the concentration of TPH.[7] Two stages of biodegradation curves were observed when simulated concentration was lower than 30000 mg/kg, which the fast biodegradation of TPH were presented in initial 10 days. First stage of biodegradation curves was observed in 30000 mg/kg and 50000 mg/kg concentration, which the biodegradation of TPH slowly decreased in 30 days of composting process. Because the percentages of edible oil in the diesel concentration below 30000 mg/kg were higher than those in the diesel concentration of 30000 mg/kg and 50000 mg/kg, leading to fast biodegradation in the first stage of bioremediation. Therefore, it is reasonable to assume that the biodegradation efficiency was affected by the fraction of TPH components and concentration.[7] The similar experimental results were observed in the literature (Lin et al., 2010). After 30 days of the bioremediation process, diesel oil were degraded down to 2976, 6277, 8732, 18613, and 28205 mg/kg, respectively, and with the removal rate of 91%, 86%, 85%, 73% and 68%, respectively. Hence, community food waste composting was effective in enhancement on decomposing diesel oil below 30000 mg/kg concentration during initial composting process.

B. Analysis of kinetic characteristics

Kinetic characteristics of diesel biodegradation during composting process were shown in Table 1. Results revealed that all of k1 constant larger than k2 constant of various spiked diesel concentration with the exception of spiked 50000 mg/kg of diesel concentration, which reflected two distinct stages presented in the composting process. The k1 constant of various spiked diesel concentration decreased with the spiked diesel concentration. However, bacterial activity did not inhibit by spiked 50000 mg/kg of diesel concentration. The k1 constant of various spiked diesel concentration were measured in temperature-rising stage of ranged from 32°C to 75°C, which were responsible to the first stage of fast TPH biodegradation before 10 days of composting process. The k1 (0.0835) & k2 (0.0528) rate constant of spiked 20000 mg/kg diesel concentration well fitted curve with correlation coefficient of R1² (0.8431) & R2² (0.8497) as shown in Figure 2. Comparison of k1 (0.0149 ~0.1714) of all piles spiked with various diesel concentration, the difference of rate constants were very large, which ranged from 1.3 folds to 11.5 folds. Nevertheless, there were no lag biodegradation in all piles during composting process, even though that high spiked with 50000 mg/kg. Moreover, the change profiles of pH (3.8 to 8.5) and temperature (32°C to 75°C) were dramatically during first stage of composting process. It revealed that microbial biodegradation was fast and stable undergoing. Hence, the biodegradation efficiency of composting method using community food waste was high expected to commercial application.

<table>
<thead>
<tr>
<th>Diesel conc. (mg/kg)</th>
<th>Initial conc. (mg/kg)</th>
<th>Degradation removal rate</th>
<th>First stage</th>
<th>Second stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>k1 (day⁻¹)</td>
<td>k2 (day⁻¹)</td>
</tr>
<tr>
<td>5000</td>
<td>33770</td>
<td>91%</td>
<td>0.1714</td>
<td>0.056</td>
</tr>
<tr>
<td>10000</td>
<td>45081</td>
<td>86%</td>
<td>0.1283</td>
<td>0.4602</td>
</tr>
<tr>
<td>20000</td>
<td>59819</td>
<td>85%</td>
<td>0.0835</td>
<td>0.8431</td>
</tr>
<tr>
<td>30000</td>
<td>69041</td>
<td>73%</td>
<td>0.0512</td>
<td>0.676</td>
</tr>
<tr>
<td>50000</td>
<td>88118</td>
<td>68%</td>
<td>0.0149</td>
<td>0.481</td>
</tr>
</tbody>
</table>

Note: k1, first stage first-order rate constant; k2, second stage first order rate constant.

IV. CONCLUSION

The food waste composting method was developed into a cost-effective novel green remediation technology with high efficiency. Moreover, it could treat high concentration of diesel oil-pollution such as 50000 mg/kg, thus provided a potential alternative in bioremediation of oil pollution sites.

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REFERENCES


