CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The biopile experiment was conducted to soil contaminated oil from Fang Petroleum Refinery, Chiang Mai Province. From eight samples, two sites (site 3 and 7) were chosen to be representative. The samples were adjusted in order to get soil porosity higher than 25% by mixing soil from site 3 and site 7 with a ratio 40 : 60. Both samples showed a soil pH in the range for optimum condition for the bioremediation.

The samples were divided into two group. The first group was tank 1 as a control group, it was not amended with nutrients and addition air. The second group consisted of 5 tanks with different air flow rates (tank 2 through tank 6) which were amended with the same nutrients. The biopile experiment was done for 17 weeks.

The aeration system consisted of a plastic tube which was placed in a circular pattern at the base-middle of the tank and controlled by air flow rate regulator and pressure regulator. The air flow rate was varied and set to 2 hours intervals per day during experiment period and controlled by an automatic timer.

The amended nutrients were done by addition urea and diammonium phosphate as nitrogen and phosphorous source, respectively. This was done in order to reach the ratio C:N:P of 100:10:1. Since the bioremediation was aerobic, the addition of air flow rate based on the calculation of balancing the reduction-oxidation (redox) reaction between the main contamination of petroleum hydrocarbon and oxygen.

The nutrients were in powder form and the amended nutrients were conducted only one time which was at the beginning of treatment with no water being added.

The initial soil pH of all tanks was close to neutral. At the end of the biopile experiment, the soil pH of the control group (6.01 ± 0.04) had fallen to a level below that favorable for bioremediation. For the treated-soil group, all tanks showed a soil pH at (6.5-8.0) which was favorable for biodegradation.

At the end of the experiment, in the tank 1 or control group available nitrogen remained relatively unchanged. However, the organic carbon increased 3% and the ratio C:N was 470:10, which was far from favorable for bioremediation.

For the treated-soil both the available nitrogen decreased and organic carbon decreased gradually. Except for tank 6, the ratio C:N in the tank 2 through tank 5 increased and the highest ratio was in tank 3 followed by tank 4 and 5 for (140:10), (130:10), (120:10), respectively.

The removal of organic carbon was highest in tank 6 (24%) followed by tank 2 (17%) and tank 5 (16%).

During the experiment the water content in the all tanks decreased continuously and in the end of experiment their water content was below a level favorable for bioremediation. In the tank 1 or control group, the level of water content was below that favorable for bioremediation since 77 days and it was faster than the other tanks, at the end of experiment its water content was (2.4 ± 0.156)%.

For the treated-soil group, the loss of water content in tank 2, 5 and 6 had same period (95 days) and it was slowest than the other tanks. In the end of experiment the highest water content was in tank 6 (3.8 ± 0.198 %) followed by tank 5 (3.7 ± 0.184 %).

The enumeration of culturable heterotrophic microbial population was done by using peptone tryptone yeast extract glucose agar (PTYG) medium. The culturable heterotrophic microbial population in the control group was observed to increase by a two log cycle.

For the treated-soil group, the culturable heterotrophic microbial population remained unchanged, however tank 5 was higher than the other tanks.

The first-order kinetics of the bioremediation for removal of petroleum hydrocarbons from soil was performed both for the control group and treated-soil group. For treated soil group (tank 2 through 6) the choice of the optimum degradation rate was based on the goodness of fit (R^2) of linear line regression.

The degradation rate constant at the control group was observed at (0.007 $\pm$ 0.002) day^{-1} with 95% of confidence level.

For treated-soil group that received amended nutrient and addition air, it is interesting note that the tank 5 with air flow rate was 3.8 l/min had the lower biodegradation rate constant (0.0083 $\pm$ 0.0011) day^{-1} than tank 6 (0.0094 $\pm$ 0.0015) day^{-1} but the R^2 of the tank 5 (0.9524) was higher than tank 6 (0.9266) with 95% of confidence level.

Based on strength of R^2 the optimum condition of degradation rate was chosen in the tank 5 with degradation rate constant was (0.0083 $\pm$ 0.0011) day^{-1} and the amount of air flow rate was 3.8 l/min.

5.2 Recommendations

Since the presence of heavy metals in the soil may limit biodegradation, the compositional heterogeneity among different refined products influences the overall rate of biodegradation, both of the oil and of its component fractions. Enumeration of hydrocarbon degrading bacterial provide additional information on the hydrocarbon biodegradation potential by comparison to the total heterotrophic bacterial counts usually reflects the extent of microbial acclimation and hydrocarbon degradation activities in an oil-contaminated sites. So it is recommended to measure the concentration of heavy metals, PAHs content, and hydrocarbon degrading bacterial.