Chapter 5

Conclusion and Recommendations

5.1 Conclusion

It is possible to use *T.versicolor* BCC 8725 and *F. flavus* BCC 17421 fungi for leachate decolorization and removal of BOD and COD. *T.versicolor* showed better results as compared to *F. flavus*. In batch experiment, it was found that the optimum pH was found to be 4 for both immobilized *T. versicolor* BCC 8725 and *F. flavus* BCC 17421 indicating that fungi works better in acidic conditions. In terms of decolorization, co-substrates could be ranked as glucose>corn starch>cassava. The optimum co-substrate concentration of glucose was 3 g/L. It was essential to dose adequate carbon source, but the presence of excessive carbon source did not enhance or even inhibit the degradation. Fungi require co-substrate for growth and also give higher removal efficiency for color, BOD and COD as compared to when no co-substrate was added. As cassava is a cheap agricultural product, it could also be used as an effective co-substrate. Based on the assumption that the glucose was used for the growth of fungi and did not contribute to the BOD and COD of the leachate and the biomass of fungi is uniformly grown on PUF, mg removal of BOD and COD per mg of biomass was calculated and compared the removal efficiency in batch experiment with 3 g/L of glucose within 15 days. The mg removal of BOD and COD per mg of biomass for leachate from the stabilization pond (leachate 1) is 13.35 and 41.21, respectively which is the lowest efficiency among the leachate studied. The reason might be because leachate 1 is stabilized (pH 8.3) with very high ammonia concentration (BOD = 2,100 mg/L, COD = 4,870 mg/L, ammonia = 1,542 mg/L and low concentration of heavy metal). The mg removal of BOD and COD per mg of biomass for leachate as discharged from pipe to the pond (leachate 4) is 109.48 and 187.84, respectively which showed highest removal efficiency among all the leachate used in this study although it is very high strength leachate but it contains low ammonia and low concentration of heavy metal (BOD = 48,900 mg/L, COD = 96,512 mg/L, ammonia = 32 mg/L). Thus, the factors affecting the removal efficiency by *T.versicolor* BCC 8725 might be the ammonia concentration and the heavy metal concentration.

Laccase was the main enzyme which contributed to the decolorization of leachate by *T.versicolor* BCC 8725. In addition, MnP and LiP could also be detected and helped in decolorization and degradation of organic compounds. Although in absence of glucose, the enzymes were also detected but in the presence of glucose, enzyme activity was very high. Immobilized fungi gave better removal efficiency compared to mobilized fungi. When immobilized *T.versicolor* BCC 8725 on PUF was subjected to repeated used in garbage truck leachate (leachate 3) in batch experiment, the decolorization efficiency decreased from about 50% to 10-30% over the course of 3 cycles under similar conditions. Along with the fungal biomass growth in PDB, leachate could also be used to grow the fungi. Fungi are good in degradation of complex organic compounds that are not readily biodegradable as high COD removal was observed compared to BOD.

In column experiment, it was found that the removal efficiency was influenced by the organic loading, co-substrate addition as well as the degree of immobilization. From this study, the same immobilized fungi on PUF can be reused for at least 4 cycles (1 cycle of 5 days each). The maximum color, BOD and COD removal of 63%, 52%, and 42% was achieved in column studies using concentrated leachate 4 with glucose 3 g/L, whereas

31%, 25% and 23% were obtained when there was no glucose addition (4-day immobilization). Dilution of leachate did not significantly increase the removal efficiency when glucose was not added. About 8% and 15% higher color removal was obtained without and with glucose when the leachate was diluted for 5-time (600 mg/L of glucose) with 4-day immobilization. About 1-6% higher color removal efficiency was obtained on day 20 when immobilization of fungi on PUF for 15days was used compared with 4 days immobilization. However, when removal efficiency was calculated in terms of mg removal per mg of biomass, it was found that concentrated leachate with 4 day immobilization and 3 g/l glucose gave the highest removal of 0.6 mg COD per mg of biomass and 0.45 mg BOD per mg of biomass. Although the removal of color increased to some extent after dilution, however, mg removal per mg of biomass is lower indicating that efficiency per unit mass does not increase with dilution. The color removal increased from 40% to 81% when glucose was added and the leachate was diluted for 5-time with the immobilization of fungi on PUF initially for 15 days. The mg BOD and COD removed per mg of biomass in batch (day 15) and continuous experiment (day 20) in leachate 4 was compared. The mg BOD and COD per mg of biomass was 109.48 and 187.84 in batch experiment whereas 0.45 and 0.6 was observed in continuous experiment. This can be indicated that batch experiment works more efficient than in continuous experiment. However, if the time is extended longer than 20 days, the removal efficiency may be higher as the graph showed that it still tends to increase.

Fungi used in this study cannot remove completely color, BOD and COD from leachate but could remove to a large extent. Thus, this treatment should be coupled with other treatment system. It was found that fungi is not capable of removing heavy metals present in the leachate. Thus, the heavy metals presented in the leachate still exceeded the recommended BMA standard. Finally, it can be concluded that this study demonstrated a novel process which provides an alternative way of managing leachate since it is a natural biological process and can also be used for treatment of high strength leachate when ammonia concentration is low.

5.2 Recommendations for future study

Based on the results of the study, the following recommendations for future research are made:

- In this study, Nonthaburi landfill leachates are used, it is suggested to use leachate from other places or other types of industrial wastewater to assess the applicability of the fungi *T.versicolor* BCC 8725. Moreover, variability of results should be observed as the effect of leachate age and the source of leachate.
- The present study use *T.versicolor* BCC 8725, it is suggested to use other types of fungi such as *P.chrysosporium.*
- Although various parameters have already been analyzed in leachate characterization, a more detailed analysis would be useful to assist in determining the lignin and metal removal.
- As high ammonia is shown to be toxic to the fungi, for future works, it is suggested that the sample should be pretreated by removing ammonia nitrogen to some extent for better removal efficiency.
- In this study, the fungi was immobilized on PUF, it is suggested to use other natural support, such as pine wood, corn cob, barley bran, because an immobilization

material that mimics the natural habitat of the fungi can provide them with additional nutrients and stimulate the production of enzymes.

- Reuse of the PUF immobilized with fungi should be investigated for filtration system in the fish tank.
- Economic evaluation of the fungal treatment may be investigated.