CHAPTER VII
CONCLUSION AND RECOMMENDATION

7.1 Conclusion

Municipal solid wastes landfills contain a mixture of many chemical compounds such as batteries, paints, dyes and ink on paper, pesticides and fertilizers. Landfill accordingly contains somewhat amount of heavy metals acting as the toxic substances which are possibly contained in the landfill leachate and released into the environment. In order to understand the heavy metal behavior in the environment, the study on sorption and transportation of heavy metals in landfill leachate being influenced by physical and chemical characteristics of soil had been carried out at Kham Bon landfill site. The study research was consisted of landfill site characterization, analysis of sorption and transportation of heavy metals in soil, and the development of environmental models simulation.

Landfill site characterization included analysis of leachate, soil, groundwater and surface water. The characteristics of leachate both influent and effluent of the treatment system were determined. COD concentration of influent varied between 18,360 and 27,160 mg kg^{-1} while BOD concentrations were 8,933-12,500 mg/l. COD concentration of effluent varied between 1,800 and 2,800 mg L^{-1} while BOD concentration were in the range of 150 to 250 mg L^{-1}. For mineral contents, chloride content was noted that it was relatively high as presented by 2,700-5,200 mg L^{-1} and 1,600-3,800 mg L^{-1} for influent and effluent, respectively. Even though the studied heavy metals concentration (Pb, Zn, Cr, Cd, Cu) did not exceed the standard limit, it is interesting to know their behavior in the environment.

With references to the physico-chemical properties, soils at Kham Bon Landfill site could be classified as clay loam, silty clay loam, sandy loam, loamy sand and sand while pH, organic matter content and cation exchange capacity were 6 to 8.4, 0.05 to 2.5%, and 0.7 to 10.7 respectively. Concentration of Cr, Cd, Pb, Cu and Zn in soil varied in the range of 0.1-5.6 mg kg^{-1} Cr, 1.8-3.0 mg kg^{-1} Cd, 5-23 mg kg^{-1} Pb, 0.9-55.0 mg kg^{-1} Zn and 0.9-12.7 mg kg^{-1} Cu, respectively. The highest concentration of heavy metals was recorded close to the landfill site with a radius of

500 meters, decreasing with distance from the site. Focusing on parameters influencing the heavy metals deposition, it is depicted that a high heavy metals accumulation at a higher clay content, cation exchange capacity, oxides of Fe and Mn, and humic substance associated with natural organic matter.

Groundwater study includes soil profile study and groundwater analysis. There are two mains aquifers, shallow and unconfined as well as deep and confined, in this study area. The groundwater flows very well corresponding to the flow direction of surface runoff which flowing northeast and southeast downward to the Pong River. Groundwater samples were taken from 11 monitoring wells and analyzed for physical as well as chemical properties and heavy metals. The parameters related to leachate study was chloride, of which the concentration varied from 5-880 mg L^{-1} in the eastern part of the landfill site. This chloride phenomenon was interpreted that the leachate possibly infiltrate into the groundwater. Due to a large fluctuation of heavy metal concentration during the entire monitoring period, it was hardly to express evidently of heavy metal contamination.

Considering about chloride content and heavy metals in surface water near the landfill site, the concentration of chloride was low as 80 mg L^{-1} and most of heavy metals concentrations were within the standard allowable limit, likely indicate that surface water quality not yet being impacted by leachate.

In addition, the VISAUL HELP model was used to simulate impact of leachate to groundwater. It indicated that the leachate generation rate was 0.12-0.38 $m^3/m^2/yr$. Moreover, the water balance was also simulated for the additional of HDPE as a liner material. It illustrate that the HDPE could be used as an effective liner to manage the leachate.

Result from the study of Kham Bon landfill site characterization revealed that heavy metals were more adsorbed by Kham Bon soil rather than percolate into groundwater. Therefore, batch and column experiments were conducted to study behaviors of heavy metals including adsorbed, released and transported through Kham Bon landfill soil.

For batch experiments, the sorption of heavy metals (Cd, Cr, Pb, Cu, and Zn) from monometal and competitive metals were investigated to compare the sorption efficiency of the actual and the synthetic leachate. The results were fitted to linear,

Freundlich and Langmuir isotherms. They presented the same trend of heavy metals adsorption for either monometal or mixed heavy metals of synthetic and actual leachate. Affinity of heavy metals to KBS-1 (silty clay loam) was higher than KBS-3 (loamy sand) and KBS-2 (sand) soil. Sequence of heavy metals adsorption was Zn > Pb > Cr > Cd > Cu for KBS-1 soil, and the same trend of KSB 2 and KSB 3 as Pb > Zn > Cr > Cd > Cu. However, the amount of heavy adsorption of monometal solution was higher than the mixed solution, and the synthetic leachate was higher than actual leachate.

Desorption batch experiment was also conducted to study desorption behavior of contaminants in soil systems. The experimental results revealed that the amount of heavy metals desorbed from the soil was very small. Desorption tests were resulted the same trend as adsorption. Pb and Zn were rather retarded on soil than Cr, Cd and Cu as shown by the sequence of Pb> Zn>Cr>Cd>Cu.

Selective sequential extraction study was performed to study chemical forms of heavy metals associated with particulates or colloids of soil. It was observed that Cd was easier extracted than other heavy metals in this study. Beside, Cr was also easy to release. While releasing of Cu and Zn were similar. Pb was difficult to be released. These results presented the similar trend stated above.

Column study may provide information that is not obtained from the batch experiments, and they are generally considered to be a more realized simulation of field condition. Column test results were similar to the batch experiments. The affinity sequence of heavy metals was in the order of Pb > Zn > Cd > Cr > Cu. The higher retention of heavy metals was observed in soil treated with synthetic leachate tha treated with actual leachate.

Both batch and column experiments yielded the same trend of adsorption behavior of the studied heavy metals. It was noted that the factors controlling adsorption in this study are soil property (Fe-Mn oxide, CEC, organic matters and clay content), organic content in leachate (synthetic and actual leachate), high pH and alkalinity in the leachate induce precipitation of heavy metals occurred in parallel with adsorption. The studies reveal that Pb and Zn were likely accumulated in soil, while Cr, Cd and Cu potentially released to groundwater and surface water.

7.2 Recommendation

1. Keeping monitoring of environmental receptors including soil, groundwater and surface water in order to have the data base for studying the fate and transport behavior of the contaminants at the landfill site and its vicinity.

2. Studying sorption and transportation of other heavy metals contaminated in landfill leachate particularly Hg.

3. There is a potential of heavy metal accumulation in soil and is possibly percolated to groundwater and surface water caused by landfill leachate. The further study should be carried out for site remediation.