CHAPTER 5

CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

5.1 Conclusions

From our study, WWTS could reduce the movement of endosulfan in soil by sorption process. The sorption coefficient of tangerine orchard soil and WWTSs; from pig farm WWTP, municipal WWTP, and food industrial (sweet corn canning) WWTP were 47.5, 1,755.5, 466.9, and 707.7 mL g^{-1}, respectively. High organic content in WWTS was probably the major factor influencing endosulfan sorption. Meanwhile, we cannot exclude the effects of other physical and chemical properties of WWTS such as size, shape, configuration, molecular structure, chemical functions, solubility, polarity, polarizability and charge distribution of interacting species on endosulfan sorption behavior. Further study should be carried out to provide basic knowledge on this sorption phenomena.

In the soil column experiment, WWTS from pig farm were used. This WWTS had the highest value of sorption coefficient and low desorption efficiency. We found that WWTS as soil cover material could sorp endosulfan and retard its movement through the soil column. In addition, 2-cm sludge layer reduced endosulfan movement more effectively than 1-cm sludge layer. The recommended amount of sludge for further application was 5 Ton rai^{-1}. The sorption of endosulfan was also affected by the pattern of pesticide application. Single application and weekly application of endosulfan were conducted to study the effect of repeated pesticide application. The results showed the larger amounts of endosulfan were retarded in sludge and soil layers after weekly application. On the other hand, the movement of endosulfan after single endosulfan application was faster than in repeated application. Although, WWTS layer will provide protection against pollution from the pesticide application, the risk remains that WWTS layer will store pesticide and may cause future leaching. Consequently, long-term field trials are required to substantiate this study.

5.2 Suggestions for future work

Wastewater treatment sludge cover application is one of many techniques to prevent pesticide accumulation problems. The sludge amended soil was generally used in many countries. In Thailand, the accumulation of pesticides was detected not only from tangerine orchards but also from other agriculture activities such as rice fields, para-rubber plantations, and other fruit orchards. In these activities, a large number of insecticides, herbicides, and fungicides are used to enhance quality and quantity of products. Consequently, wastewater treatment sludge should be applied to those agricultural areas to reduce the contamination of pesticides in soil and groundwater.

Beside pig farm WWTS, other WWTSs that available in the agriculture area and have high organic content may be used to reduce pesticide contamination in soil as well. Meanwhile, the factors that should be considered before sludge application are background of toxic substances in WWTS such as amount of pesticide and metals.

In addition to WWTS, liquid waste (i.e. wastewater) may be applied to attenuate the leaching of pesticide. Cox *et al.* (1997), showed that olive mill wastewater increased soil organic carbon content and reduce soil porosity, which produced an increase in the residence time of clopyralid and metamitron herbicides by enhancing diffusion, sorption and degradation processes, and consequently retarding mobility.

Although, wastewater treatment sludge layer will provide protection against pollution from the pesticide application, we should concern about the long-term effects of wastewater treatment sludge applications on the accumulation of toxic metals, fate and transport of bound pesticide residues, changes of soil properties, and qualities of agricultural produces. Long-term field trials are therefore required to ensure the safety and efficiency of this technique.

According to this study, the sorption behavior are not only influenced by the organic content, but there are also the other parameters that effect on this pheomena such as size, shape, configuration, molecular structure, chemical functions, solubility, polarity, polarizability and charge distribution of interacting species. The experiment should be conducted to describe these factors. In addition, remediation technique such as microbial degradation should be studied to reduce the amount of endosulfan contamination in soil or sludge layer.

Biodegradation is an enzymatic method to detoxify endosulfan (Awasthi *et al.*, 2003). Under aerobic condition, endosulfan is degraded by bacterial enzymes to form endosulfan diol, endosulfan ether, endosulfan lactone, and endosulfan sulfate (Kwon *et al.*, 2002, Siddique *et al.*, 2003). From a study in cotton fields, indigenous plants or soil microorganisms were suggested to responsible for the degradation of 20-30% soil endosulfan residues (Kennedy *et al.*, 2001).

The degradation of endosulfan in contaminated soil is enhanced by the addition of endosulfan degraders that isolated from another contaminated site (Awasthi *et al.*, 2000). On the other hand, soil amended with organic matter showed a reduction of endosulfan biodegradation (Sethunathan *et al.* 2002). Organic matter is the main sorbent for hydrophobic pesticides in soil. Although, sorption reduces the transport of pesticides from the application sites, it decreases the amount of bioavailable molecule (aqueous form) for degrading bacteria. Meanwhile, Guo *et al.* (1999) suggested that sorption might increase biodegradation as a whole by increasing the residence time of pesticides in the soil where most microbial activity occurs. The study of endosulfan biodegradation process in soil combined with sludges would help in the development of post application approach to mitigate endosulfan contamination problem in the future.