CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Oil contaminated in wastewater from gas station is not only present in free oil form, but also in oil-in-water emulsion formed by admixture of automotive oil such as lubricant oil with emulsifier and water. The conventional treatment method can remove only free oil and settled solid. These techniques cannot remove the oil-in-water emulsion. Hence, the removal of oil-in-water emulsion from wastewater effluent becomes environmentally important problem. This study investigated the oil-in-water emulsion removal efficiency of sorption by chitosan, degradation by the isolated bacteria, and sorption and degradation by chitosan-immobilized bacteria treatment. Three forms of chitosan used in this study were powder chitosan, flake shrimp shell chitosan, and flake squid pen chitosan.Oil-in-water emulsion was prepared by mixing lubricating oil, nonionic emulsifier (Tween 80), and distilled water. Powder chitosan had the highest water and oil sorption capacity that were 10.13±0.48 g water/g chitosan and 0.48±0.04 g oil/g chitosan, respectively. For the sorption by chitosan, the research specifically focused on the determination of optimum condition for oil-in-water emulsion removal by powder chitosan. Powder chitosan 1.0 g/L and mixing time 60 min were the optimum oil-in-water emulsion sorption condition that provided the highest oil-in-water emulsion removal. For the degradation by the isolated bacteria, the study evaluated the lubricating oil degradation ability of five oil-degrading bacteria isolated from soil. The highest lubricating oil and oil-in-water emulsion degradation was obtained by strain Ch2. Then, powder chitosan, flake shrimp shell chitosan, and flake squid pen chitosan was used to immobilize bacteria Ch2 and evaluated the potential for removal of oil-in-water emulsion. Flake shrimp shell and flake squid pen chitosan-immobilized cells provided the lowest amounts of remaining oil in water. Moreover, some bacteria were outgrowth and detached from chitosan. Hence, not only the immobilized bacteria degrade oil sorped by chitosan but the outgrowth bacteria also degraded oil presented in the aqueous phase.

The last section of the study focused on the comparison between the potential of sorption by chitosan, degradation by the isolated bacteria, and sorption and degradation by chitosan-immobilized bacteria treatment for treating oil-in-water emulsion. All of these treatment techniques were applied to remove oil-in-water emulsion that added 200 mg/L lubricating oil everyday until finish the study. The effectiveness of each treatment was determined from the oil remaining in water at day 4^{th}. This research found that the treatment of oil-in-water emulsion by chitosan-immobilized cells showed 91% oil removal efficiency, which higher than the treatments by chitosan and bacteria alone.

Treatment of oil-in-water emulsion by chitosan and bacteria alone has its own limitation in long term application. Oil-in-water emulsion treatment by chitosan was limited by maximum oil sorption capacity of chitosan. When the concentration of oil remaining in water was higher than maximum oil sorption capacity of chitosan, chitosan have no capability to sorp more oil. On the other hand, the oil-in-water emulsion degradation activity of bacteria was limited by the toxicity of high oil concentration to bacteria. Here, sorption and degradation by chitosan-immobilized cells treatment could solve these problems. The sorped-oil was rapidly degraded by the immobilized bacteria, thereby preventing the oil accumulation on chitosan surface. Moreover, the immobilization of bacteria on chitosan provided a protective niche to the bacterial strain and resulted in a high oil degrading activity over long term application.

5.2 Recommendations for future work

Based on the this study, some recommendations for further study are proposed as follows; first of all, many types of the materials for oil sorption and immobilized cells are available. Thus, this should be studied in the future as the alternatives of chitosan. The media may be the natural materials, inorganic materials or synthetic materials. Moreover, the regenerative of each immobilized cells also needs to address. Secondly, the new isolated bacteria used for further study should be isolated from real oily wastewater from gas station which may provide higher lubricating oil and oil-in-water emulsion degradation efficiency. Thirdly, the chitosan-immobilized bacteria should be studied for its shelf life. The suitable storage condition of chitosan-immobilized cells, such as temperature, should be investigated. Finally, the experiment should be scale-up in order to apply for real wastewater. The experiment may require through bench scale and pilot plant investigation.

In application aspect, the chitosan-immobilized bacteria can be applied for clean-up oily wastewater from gas station. For example, the chitosan-immobilized cells may be applied into the submerged biological aerated filter treatment system. The Biological Aerated Filter (BAF) is a type of immobilization reactor that can maintain high hydraulic loading rates and retain a high biomass concentration to reduce environmental shock, resulting in less sludge formation, and promoting microorganisms grow (Zhao *et al.*, 2006). In real condition, oil-in-water emulsion removal involves and depends on many factors, thus trial-and-error experimentation is essential. Furthermore, the cost of the entire treatment process should be estimated.