

## CHAPTER 5

### CONCLUSION AND RECOMMENDATION

#### 5.1 Conclusions

The results of this work can be summarized as follows:

1. The pH  $5.0 \pm 0.2$  unit was suitable for all four heavy metals in the range of concentration less than 100 mg/l were still dissolved but not precipitated.
2. The largest amount element observed in *Caulerpa lentillifera* was aluminum, and the interested heavy metals for this work (Cu, Cd, Pb, and Zn) were found to exist in very low quantities.
3. The adsorption equilibrium followed both Langmuir and Freundlich isotherms. Adsorption capacity of Cd was found to be the lowest.
4. The possible functional groups in this algae that were responsible for the metals binding were O-H Bending, N-H Bending, N-H stretching, C-N stretching, C-O, S-O stretching, and S=O stretching.
5. There were competition between heavy metals to the binding site of algae, as the metal sorption capacities in multi component systems were always less than those in single component systems.
6. There were a difference in binding site responsible for metal binding, as the total sorption capacities in multi component system were always more than those in single component systems.
7. Heavy metal affinities to the binding site of this alga could be order from high to low as:  $Pb > Cu > Cd > Zn$  at low concentration range and  $Pb > Cu > Zn > Cd$  at high concentration range.

## 5.2 Contribution of this work

This work demonstrated the potential in using *Caulerpa lentillifera* as a biosorbent in the wastewater containing low concentration of heavy metal (lower than 100 mg/l). This algal biomass was found to be particularly suitable for the sorption of Pb. Details on multi component sorption of heavy metal e.g. binary sorption, ternary sorption, and four-component sorption were provided in this report. Findings from this work contribute greatly to the research in the field of competitive sorption by using biomass and also provide the insight information for the future development of biosorption process to apply with treatment of actual wastewater that containing multi-component heavy metals.

## 5.3 Recommendations for future work

The adsorption examined in this work was limited to the metal concentration range from 0 – 100 mg/l. This was initially thought to be appropriate for biosorption as its actual application would be in this low concentration range. However, for the sake of completion of the work, experiment should be extended to include the high concentration range. This will make the discussion of the mechanism of the biosorption for these heavy metals.

Moreover, further studies should be conducted in a larger scale system such as column experiment, with a real wastewater to examine the performance of the actual adsorption/treatment technique in terms of trouble-shooting or operational difficulties.