CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The investigation in this work led to the following conclusions:

1. An increase in pH could lead to a greater dissolution of CO_2 resulting in a greater TIC concentration trend and %CO_2 dissolution efficiency.
2. High %efficiency was found in the early stage of experiment and later was decreased with time due to the concentration difference between gas phase and liquid phase.
3. Adding gas-liquid contact area and gas hold up (ε_g) caused a slightly greater dissolution of CO_2 due to the slower slip velocity by path blockage and bubble was coalescence resulting in large bubble diameter of gas and decreased mass transfer rate.
4. A triple increase in height in packed column gave the better overall %efficiency but not in direct proportional in triple times. Furthermore, concentration in gas decreased along the axial position resulting in low TIC concentration in higher position.
5. A greater gas flowrate fed into the system displayed a higher TIC concentration due to an accelerating bubble velocity which enhanced the gas-liquid mass transfer. However, a greater quantity of CO_2 did not have enough contact time with the solution and wastefully released to the atmosphere causing low %efficiency.

6. Higher degree of salinity gave the lower TIC dissolved in the water. Fresh water exhibited the higher TIC trend and %efficiency at any time than salt water.
7. The optimal combined effects from previous findings led to the system design of better CO_2 dissolution called "Circulating Counterflow Contactor- C.C.C". It allowed liquid and gas to contact in transverse direction. This would provide the longer dissolution period and gas bubbles did not show coalescing behaviour in this system. As a result, C.C.C. offered the steadily high %efficiency not only in early stage but also later stage in range 34-56% in the case where 2 LPM optimal flowrate was employed.
8. The most suitable initial pH for cultivating fresh water microalgae *Chlorella vulgaris* with $NaHCO_3$ were 6 and 7 in which maximum cell concentration and specific growth rate were slightly different. On the contrary, pH 8 and 9 did not suit the C. vulgaris cultivation.
9. An increase in $NaHCO_3$ concentration in the cultivation system from 30 to 80 and 200 ppm did not particularly give the different in growth characteristic. Besides, CO_2 dissolution water from C.C.C. (around 80 ppm TIC concentration) provided a slightly higher in growth curve, maximum cell concentration and specific growth rate. This proved that CO_2 dissolved water from CO_2 dissolution system could be implemented for the microalgal cultivation.

5.2 Contributions

To mitigate greenhouse effect, many CO_2 capture and storage technologies are employed in a wide range of industries. Sequestration of CO_2 into a biomass form is considered to be the potentially sustainable method. Microalgae have the capability of conducting highly effective photosynthetic activity in which CO_2 is turned into the form of microalgal biomass but this transformation rate is much too low when compared with the rate at which CO_2 is being released to the atmosphere. This work introduces the transformation of CO_2 into the other forms, e.g. bicarbonate and carbonate compounds which could later be used as carbon source for the microalgae. This system will act like a buffer zone where CO_2 is being captured prior to feeding to the algal culture. CO_2 dissolution water was proved in accelerating *C. vulgaris* growth (compared with the no addition of inorganic carbon). These preliminary results provide an encouraging indication to the future development of CO_2 capturing technology where the two step approach could be treated as a potential direction.

5.3 Recommendations / Future works

This work only presents the beginning of CO_2 sequestration by capturing CO_2 and prior storage for the microalgal uptake instead of feeding CO_2 directly into the cultivation system. Many fundamental effects were studied in this work e.g. pH, gas-liquid contact, salinity and column height. Moreover, the captured CO_2 in the liquid form was proved to be applicable as a carbon source for the cultivation of microalgae *C. vulgaris*. The next step towards the implementation of such technology is to upscale the CO_2 dissolution system as a pilot study along with the actual size microalgal cultivating system. The use of actual CO_2 from the flue gas should also be investigated.