CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 GENERAL CONCLUSION

It was found that the water quality of Paya Indah from December 2006 to February 2007 was considered as polluted, especially at the major lakes (Visitor Lake, Lotus Lake, Petaling Tin Lake and Main Lake). These could be seen through the WQI values calculated from the data obtained from the field survey. From the analysis of WQI done on 15 sampling stations within Paya Indah vicinity, only the average WQI values of Station W6, Station W7 and Station W11 stood within slightly polluted range. The rest was in the polluted range. However, the WQI values were dynamic and could change from time to time as the weekly WQI values at all the 15 stations had shown fluctuations. Five (5) stations showed significant fluctuation on the weekly WQI values as the percentages of standard deviations against average WQI were greater than 20%. Comparative analysis on the average WQI values at major the lakes (Main Lake, Visitor Lake, Petaling Tin Lake and Lotus Lake) and canals (Canal C2 and Canal C4) between 1996 and 2006, shows that the average WQI values at all these locations stood at polluted range, despite Canal C2 and Canal C4 recording WQI values in 2006 better than 10 years before.

The critical parameters that had been identified for lowering the WQI values were pH, Dissolved Oxygen and Chemical Oxygen Demand. The pH, Dissolved Oxygen and

Chemical Oxygen Demand could highly influence the WQI reading as they are sub-index parameters. Thus, these sub-index parameter values are obviously affecting the WQI value of the water body. Any changes in one of the sub-index parameters could influence the WQI values.

The average pH values of Paya Indah were observed to be relatively low at all the 15 sampling stations, with most of the sampling stations recording pH values below Class III of INWQS (minimum 5.0). However the weekly data of each station occasionally recorded pH value of more than 7. CTI and OYO (2001) denoted that low pH values indicating acidic water were caused by inflow streams going through peat swamp containing tannins and organic acids; and sulphuric acid which originated from exposure of pyrite-rich sediments to the air (as high as 24% of the total contents of sediment) as a result of former mining activities. The condition of the adjacent Kuala Langat Peat Swamp Forest is acidic in nature because peat swamp water contains acidic substances such as tannin and lignin from the waterlogged decomposition process without the presence of microbes. This acidic water flows through the drainage system of Paya Indah. Low pH of Paya Indah may also be related to the rainfall as CETEC (1996) denoted that rainfall was one of the factors influencing pH at Paya Indah. The pH of uncontaminated rainwater, according to Wolff et al. (1988), was between 4.5 and 7.4.

From the 15 sampling stations within Paya Indah, only 5 stations recorded average DO concentrations well within Class III of INWQS (minimum limit is 3.0 mg/l). The remaining stations recorded average DO concentrations standing at Class V of INWQS. The low DO concentrations at Paya Indah may be mainly caused by the decomposition process on organic materials in the peat swamp which produces tannin causing

colouration which in turn prevent light penetration into the water body. Lack of sunlight penetration caused by excessive tannin colouration may restrict submerged aquatic plants from performing photosynthesis. Besides, oxidation of pyrite was mediated by a kind of microbe, namely *Acidithiobacillus ferrooxidans*, which consumes high amount of DO.

BOD values of Paya Indah were relatively low within acceptable levels, as most stations recorded BOD values well below Class III of INWQS (6.00 mg/l). This is because the presence of microbial activities is minimal as decomposition of the organic matter is fully in acidic condition (UNDP, 2006). However, the COD values were observed to be high. Seven (7), out of the 15 sampling stations recorded average COD values exceeding Class III of INWQS (50.0 mg/l). The high COD values were due to the oxidation process of Pyrite (FeS_2), which also produces sulphuric acid (H_2SO_4).The FeS_2 originated from the former mining activities. Besides, landfill leachate, untreated POME and downfalls from the nearest sewage treatment plant and industrial estates, which are within 5 km radius of Paya Indah vicinity, could have increased both BOD and COD values through infiltration into Paya Indah groundwater systems.

For TSS and NH_3-N, most of the 15 sampling stations show values of both TSS and NH_3-N well below Class III of INWQS (150 mg/l and 0.9 mg/l respectively). Thus the colouration of water at the major lakes of Paya Indah near the peat swamp was due to the tannin content, not high TSS. However, TSS values also depend on the weather conditions, being higher during bad weather, especially during heavy downpour. The presence of NH_3-N was minimal as very few of the 15 stations having values exceeding Class III of INWQS. Moreover NH_3-N occasionally recorded values below detection limit (<0.1 mg/l).

From the analysis on data obtained from the two (2) baseline studies, contamination of Fe, Mn and *E. coli* were observed at Paya Indah. Contamination of Fe was the most obvious because almost all 15 stations recorded Fe concentrations exceeding Class III of INWQS (1.0 mg/l) in both baseline studies, and most of the stations exhibit significant increase between first baseline and second baseline periods. The presence of pyrite (FeS_2) had been identified as the main cause of high Fe content. Previous mining activities, especially tin mining have left tin residues that contains FeS_2. The FeS_2 is the major cause of the condition of Paya Indah being acidic, low in oxygen, thus high oxygen demands condition of Paya Indah and high in iron concentration. This is because pyrite is oxidized by oxygen to form Sulphuric Acid and Ferric Sulphate.

The presence of Mn was due to former mining activities, including clay mining. Most of the 15 stations recorded Mn concentrations well below Class III of INWQS (1.0 mg/l), despite Mn concentrations were considerably high in the first baseline. However, in the second baseline, some stations recorded Mn concentrations below detection limit.

It was also observed that Paya Indah contains high *E. coli*, as 8 out of 15 stations show E. coli counts higher than 5000. Presence of *E. coli* may be attributed to either internal or external sources. Internal sources may include the animals inside Paya Indah such as crocodiles, hippos and buffaloes, while external sources may include the landfill leachate, sewage treatment plant or rearing farms, which could encroach Paya Indah through seepage into the groundwater system.

To conclude, the occurrences of low WQI at the major lakes of Paya Indah and the inflowing canals were highly influenced by low pH, low DO concentration and high

COD values. These parameters are sub-indices in the WQI calculation, therefore the changes occurring in these parameters values could cause changes in the WQI values. Low water quality of Paya Indah is also caused by the presence of FeS_2 at the major lakes, which in turn caused high COD values and Fe content. From the field survey, the water circulations at all major lakes of Paya Indah were observed to be visually stagnant. These indicated that internal water circulations among the major lakes of Paya Indah were very minimal. Therefore, the poor water circulation could also be a factor contributing to the poor water quality.

As mentioned earlier, the above water quality conditions were observed to be as described during the three month study period. It should be noted that the quality of a water body has been found to be very dynamic and change frequently. Thus this study could serve as a reference for further studies on the water quality of Paya Indah.

6.2 RECOMMENDATIONS

In order to improve Paya Indah water quality, serious attention should be given to the areas where the water quality had been seriously degraded, as indicated by low WQI, low pH, low DO, high COD and high Fe contents,. Priority should be given to the Visitor Lake, Lotus Lake, Main Lake and Petaling Tin Lake, and also the two canals, as these areas recorded low WQI values with pH values lower than 5.0, low average DO concentrations (less than 3.0 mg/l) and high average COD values (51 mg/l – 100 mg/l). Moreover, the water quality at these lakes had worsened since 1996 through reduction of WQI values from 1996 to 2006/2007. Improvement was only observed at those two canals, but very minimal.

Several recommendations are suggested to curb futher degradation of the water quality at these areas. One of the recommendations is to improve water circulation among the lakes and to enhance regulation of water inflow and outflow from the surrounding areas into Paya Indah and vice versa. By improving the water circulation among the lakes, the water quality at these major lakes could be improved. This is because when the water is minimally moving or stagnant, the water quality would deteriorate due to lower pH values in the peat swamp environment, reduction of DO concentrations as the DO is unlikely to be replenished in stagnant water, all leading to an increase in Oxygen Demands. Besides, chemical reactions between the existing chemical substances in the water could cause an increase of new dangerous chemicals such as suphuric acid and ferric sulphate. Moving water could maintain pH values within acceptable level and at the same time replenish DO and reduce chemical reactions that potentially produce dangerous substances.

The water cycle within Paya Indah vicinity could also be improved by proper regulation of Paya Indah water inlet and outlet. Properly regulated inflow and outflow into and out of Paya Indah could also improve water quality as the water with poor quality would be flushed out from Paya Indah, and replenished with fresher water from the adjacent drainage system at the north. However, a specific study on hydrology of Paya Indah should be carried out to facilitate an improvement program for the water circulation and drainage regulations.

Another recommendation suggested to improve Paya Indah water quality is to reduce the content of pyrite (FeS_2) in Paya Indah. This is because FeS_2 is the major factor causing the high Fe content and one of the causes of the low pH. Suitable methods in

reducing FeS_2 from Paya Indah should be studied to prevent the occurrence of adverse impact on Paya Indah.

Monitoring on the outfalls from existing industrial areas and agricultural farms near Paya Indah is also suggested, as to ensure that the quality of the outfalls comply with Environmental Quality (Sewage and Industrial Effluent) Regulations, 1979 and other relevant regulations. Moreover, enforcement by the relevant authorities against non-compliance should be more stringent to prevent water pollution at Paya Indah.

Any development within Paya Indah vicinity is recommended to be controlled and to be ensured that the impacts from the development against Paya Indah are minimal. Thus, it is strongly recommended that any development within Paya Indah vicinity should be required to pass detailed environmental impact assessment (EIA). Besides maintaining the status quo of Kuala Langat Peat Swamp Forest, an area within 5 km radius from Paya Indah should be demarcated as buffer zone. This means that any new development within this area should be prohibited, including development of new premises for industrial, residential, agricultural and wastes disposal ground, as well as expansion of existing palm oil estates. Furthermore, awareness program on the importance of wetland conservations is suggested to be carried out more aggressively and expanded as to enhance the awareness level among the people, especially the locals.

Responsibility in conserving and rehabilitating Paya Indah wetlands should be not only at the hand of the relevant authorities, but also by everyone. Commitment and cooperation from the public is required to ensure that the aim of rehabilitating Paya Indah is achieved. This is because if there is no action to prevent degradation of Paya Indah, this wetland will become as a wasteland, no more migratory birds coming to the

place and it will lose its attraction. Thus Paya Indah must be rehabilitated not only to attract birdwatchers, but also for the next generations.