# CHAPTER 6

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As the Putrajaya wetlands system is the first constructed wetlands in Malaysia, data generated from this study is very important and gives an insight into the constructed wetlands system. The study recorded the trend of water quality changes before, during and after the construction of the wetland cells. Water quality monitoring of 41 months was carried out to assess the trend of water quality index and water quality parameters, the classification of the water quality data with Class IIB water stipulated in the Interim National Water Quality Standard for Malaysia (INWQSM) and the effects of season on water quality. In this study, statistical analysis such the simple correlation, ANOVA and Principal Component Analysis (PCA) were used to assess the trend of water quality data.

During the study, all the water quality parameters were compared with Class IIB water (recreational use with body contact) stipulated in the Interim National Water Quality Standard for Malaysia (INWQSM) as this is one of the objectives of Putrajaya constructed wetlands so as to guarantee a high quality of lake water that complies with the standard set by the local authority and permits for body contact recreation. Overall, both mean DO and COD concentrations for the three sites were well within the Class IIB limits of 5 – 7 mg $L^{-1}$ and 25 mg $L^{-1}$ throughout the study period. As for pH, mean pH concentrations were well within the Class IIB limits for the three sites at pre-construction and during construction of wetland cells. However, mean pH recorded was lower in UN and CW after construction of wetland cells. Mean BOD, AN and TSS concentrations for the three sites were high at pre-construction of wetland cells. However, mean BOD, AN and TSS concentrations were well within the Class IIB limits of 3 mg $L^{-1}$, 0.3 mg $L^{-1}$ and 25 mg $L^{-1}$ during and after the wetlands construction. However, mean AN and TSS concentrations exceeded the Class IIB levels at PL during construction of wetland cells.

Overall, data presented in this study showed that there were significant temporal, spatial and seasonal differences of water quality parameters monitored before, during and after the construction of wetland cells. All the mean water quality parameters such as pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen (AN) and total suspended solids (TSS) concentrations were significantly different between phases of construction ($p < 0.05$). This was clearly revealed by the PCA where relatively high BOD, AN, pH and TSS concentrations was observed at pre-construction of wetland cells and otherwise. However, not all water quality parameters exhibited significant spatial differences. Only mean pH, DO and AN concentrations showed significant differences among the three sites, which is the Upper North wetland cells (UN), central wetland cell (CW) and Primary Lake (PL). Water quality of the constructed wetlands was significantly different between dry and wet seasons during the whole study period except for the water quality parameters of pH and TSS.

The water quality parameters above were used to calculate the Water Quality Index (WQI) based on the Department of Environment (DOE) of Malaysia Water Quality

Index. There was significant difference of WQI between the phases of construction of wetland cells. Mean WQI at pre-construction of UN (74.7 ± 4.2), CW (76.4 ± 2.2) and PL (73.3 ± 2.9) was slightly polluted as compared to WQI obtained during and after construction of wetland cells. All the mean WQI during and after construction of wetland cells for the three sites were classified as clean water with WQI $\geq 80$. During the study, the WQI was significant correlated with pH ($r = 0.21$), DO ( $r = 0.44$) and negatively correlated with BOD ($r = -0.64$), COD ($r = - 0.67$) AN ($r = -0.56$) and TSS ($r = -0.30$).

The performance of Putrajaya constructed wetlands in removing pollutants was compared between the inflow (UN) and outflow (PL) during the maintenance period. Results obtained showed that the plants in the constructed wetlands had successfully retained the suspended solids before discharge into the main river of Sg. Langat. A 61.1% removal was obtained with the mean TSS of inflow (21.1 ± 11.6 mg $L^{-1}$) reduced to 8.2 ± 3.9 mg $L^{-1}$ at the outflow. At the same time, the pH and DO concentrations showed an increase of 8.3% and 10.5% respectively. This was similar for WQI as a 5.1% increase was obtained. As for mean COD concentrations, mean COD concentrations was higher at the outflow (7.5 ± 5.4 mg $L^{-1}$) compared with the inflow of 7.1 ± 5.4 mg $L^{-1}$. However, no changes of BOD and AN were obtained between inflow and outflow. This was probably due to low concentrations of organic and sewerage pollutant from the inflow water that resulted in the low loadings of BOD and AN.

Experience in the Putrajaya constructed wetlands demonstrates the benefits and versatility of constructed wetlands. High quality outflow produced by the constructed wetlands is envisaged to create and support diverse wildlife habitats and public parks. The incorporation of constructed wetlands into large-scale watershed plans can improve the biological, physical and chemical integrity of our watersheds.

The construction of wetland systems would have a long-term positive impact on the water quality at the Putrajaya wetlands system. Further research should be carried out on the biological and ecological aspects, metal removal and microbiological aspects to enhance the knowledge on the constructed wetlands system and its efficiency in cleaning the urban runoff.

Significant observations:

1. The constructed wetlands have a positive effect on water quality of the area.
2. pH, BOD, COD, AN and TSS values after construction fall within the Class IIB limits (recreational use with body contact).
3. There is a seasonal effect on water quality parameters except for pH and TSS.
4. WQI $\geq$ 80 was obtained for all three sites during and after construction of wetland cells.
5. WQI was positively correlated with pH ($r = 0.21$), DO ($r = 0.44$) and negatively correlated with BOD ($r = -0.64$), COD ($r = -0.67$), AN ($r = -0.56$) and TSS ($r = -0.30$).
6. 61.1% of TSS removal was achieved by the wetlands.