USE OF CONSTRUCTED WETLANDS FOR WATER QUALITY MANAGEMENT IN PUTRAJAYA, MALAYSIA

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ABSTRACT

Water quality monitoring was carried out in Malaysia's first constructed wetlands at Putrajaya, a new government administrative centre or a new garden city, from March 1997 to July 2000. The constructed wetlands represent an environmental showpiece and living demonstration on wetlands. The main objective of the wetlands is to create a self-sustaining and balanced lake ecosystem. Other multi-functional purposes include provision for flood control, stormwater quality treatment, habitat, recreation, asthetic amenity, a focus for scientific, biological and environmental education centre for the nation. The design process involves assessment of surface run-off water quantity and quality, with emphasis on pollutant loads generated from this new development administration centre and downstream river system. The construction of wetlands also incorporates an innovative multi-cell and cascading weir system to maximise stormwater run-off treatment and retention times. Water quality data of 41 months was obtained to study the trend of the water quality from three wetland cells; the Upper North (UN) wetland cells, central wetlands (CW) and the primary lake (PL). All the data obtained has been classified into three phases, which is the pre-construction (March 1997 – April 1998), during construction (May 1998 – September 1999) and after construction of wetland cells (October 1999 – July 2000). This study was aimed at evaluating the trend of water quality during the different periods of the establishment of the wetlands, to assess the water quality index (WQI) and water quality parameters, to classify the water quality data with Class IIB water standards stipulated in the Interim National Water Quality Standards for Malaysia (INWQSM) and to assess the effects of season on water quality. WQI is based on six water quality parameters which include pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen (AN) and total suspended solids (TSS). There was significant difference in WQI observed among the three phases ($p < 0.05$). WQI was high before any commencement of civil works (March – May 1997). It deteriorated during the period of heavy civil works on the construction of wetland cells (Jun 1997 – April 1998). WQI recovered after the formation of wetland cells with WQI ≥ 80. There were significant temporal differences in means of pH, DO, BOD, COD, AN and TSS among the three phases. This was clearly revealed by the Principal Component Analysis (PCA) where temporal variability were observed (high mean BOD, AN, pH and TSS were obtained at pre-construction of wetland cells). Significant differences between dry and wet seasons were also observed for all the water quality parameters except pH and TSS. Among the water quality parameters analysed, only 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} through out the study period. Mean BOD, AN, TSS concentrations were well within the Class IIB limits of 3 mg L^{-1}, 0.3 mg L^{-1} and 25 mg L^{-1} after the construction of wetland cells. Mean pH recorded was lower than the Class IIB limits of 6.5 – 9.0 in UN and CW after construction of wetland cells. An increase of 5.1%, 8.3% and 10.5% of WQI, pH and DO was observed for Putrajaya constructed wetlands system throughout the study period. The results also indicated a 61% reduction in mean TSS from inflow (21.1 ± 11.6 mg L^{-1}) to 8.2 ± 3.9 mg L^{-1} at the outflow. All these significant observations suggest that the constructed wetlands will have a long-term positive impact on the water quality at the Putrajaya wetlands system.

ABSTRAK

Pengawasan kualiti air telah dilakukan ke atas tanah lembab buatan yang pertama di Putrajaya, Malaysia, sebuah pusat pentadbiran yang baru atau sebuah bandaraya bertaman yang baru bermula pada Mac 1997 hingga Julai 2000. Tanah lembab buatan telah mewakili contoh alam sekitar dan kehidupan wetland. Objektif utama tanah lembab buatan tersebut adalah untuk mewujudkan ekosistem yang boleh mempertahankan diri dan seimbang. Peranan yang lain termasuk mengawal banjir, merawat kualiti air daripada ribut taufan, menyediakan habitat, rekreasi, kemudahan estetika, fokus sebagai pusat sains, biologi dan pendidikan alam sekitar demi masyarakat. Proses rekabentuk merangkumi penilaian kuantiti dan kualiti larian permukaan air, dengan mengutamakan muatan bahan-bahan pencemaran yang dijanakan oleh pembangunan pusat pentadbiran yang baru ini dan sistem aliran hilir sungai. Tanah lembab buatan juga mempunyai sistem berbagai bahagian dan sistem penambakan bertingkat untuk meningkatkan rawatan larian permukaan air semasa ribut taufan dan juga masa penambakan air. Data-data kualiti air untuk 41 bulan telah diperolehi untuk mengkaji aliran kualiti air daripada tiga bahagian tanah lembab: Tanah lembab utara bahagian atas (UN), pusat tanah lembab (CW) dan tasik utama (PL). Kesemua data yang diperolehi boleh dikelaskan kepada tiga fasa iaitu sebelum pembinaan (Mac 1997 – April 1998), semasa pembinaan (Mei 1998 – September 1999) dan selepas pembinaan bahagian-bahagian tanah lembab (Oktober 1999 – Julai 2000). Ini adalah bertujuan untuk menilai aliran kualiti air pada peringkat masa yang berlainan sepanjang masa pembinaan, untuk menilai Indek Kualiti Air (IKA) dan parameter-parameter kualiti air, untuk mengkelaskan data-data kualiti air dengan Kelas IIB seperti yang ditetapkan dalam Piawaian Interim Kualiti Air Kebangsaan untuk Malaysia dan juga untuk menilai kesan musim ke atas kualiti air. Perbezaan signifikan IKA telah diperhatikan di antara ketiga-tiga fasa ($p < 0.05$). IKA adalah tinggi sebelum sebarang kerja-kerja pembinaan. IKA merosot semasa kerja-kerja pembinaan yang berat dijalankan (Jun 1997 – April 1998). IKA pulih setelah pembentukan bahagian-bahagian tanah lembab buatan dengan IKA $\geq$ 80. Terdapat juga perbezaan masa untuk min pH, oksigen terlarut, permintaan oksigen biologi, permintaan oksigen kimia, ammoniakal nitrogen and pepejal terampai di antara ketiga-tiga fasa. Ini jelas diperhatikan oleh Analisis Komponen Utama (PCA) di mana keragaman masa telah diperhatikan (min permintaan oksigen biologi, ammoniakal nitrogen, pH dan pepejal terampai yang tinggi telah diperolehi sebelum pembinaan bahagian-bahagian tanah lembab). Perbezaan yang signifikan di antara musim kering dan basah telah diperhatikan untuk semua parameter-parameter kualiti air kecuali pH dan pepejal terampai. Di antara parameter-parameter kualiti air yang dianalisis, hanya min oksigen terlarut dan permintaan oksigen kimia untuk ketiga-tiga lokasi mematuhi had Kelas IIB iaitu 5 – 7 mg L^{-1} dan 25 mg L^{-1} sepanjang masa penyelidikan. Min kepekatan permintaan oksigen biologi, ammoniakal nitrogen, pepejal terampai adalah mematuhi had Kelas IIB iaitu 3 mg L^{-1}, 0.3 mg L^{-1} dan 25 mg L^{-1} selepas pembinaan bahagian-bahagian tanah lembab. Min pH yang direkod adalah lebih rendah daripada had Kelas IIB iaitu 6.5 – 9.0 di UN dan CW selepas pembinaan bahagian-bahagian tanah lembab. Dalam kajian ini, kenaikan peratusan sebanyak 5.1%, 8.3% dan 10.5% untuk IKA, pH dan oksigen terlarut telah diperhatikan untuk system tanah lembab buatan di Putrajaya. Di sampling itu,

pengurangan min pepejal terampai sebanyak 61% telah ditunjukkan di mana pepejal terampai sebanyakj 21.1 ± 11.6 mg L^{-1} dari aliran masuk telah dikurangkan ke 8.2 ± 3.9 mg L^{-1} di aliran keluar ke Sungai Langat. Kesemua pemerhatian yang signifikan ini telah mencadangkan bahawa tanah lembab buatan mempunyai impak positif yang lama ke atas kualiti air di sistem tanah lembab Putrajaya.

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS

ANOVA	Analyses of Variance
ANZECC	Australian & New Zealand Environment & Conservation Council
AN	Ammoniacal nitrogen
APHA	American Public Health Association
ARIMA	Autoregressive-Integrated Moving Average
BOD	Biochemical oxygen demand
COD	Chemical oxygen demand
CANOCA	Canonical Community Ordination
DO	Dissolved oxygen
DOE	Department of Environment
ERL	Electric Rail Link
FWS	Free water surface
GPT	Gross pollutant trap
HSF	Horizontal subsurface flow
INWQSM	Interim National Water Quality Standards of Malaysia
KLIA	Kuala Lumpur International Airport
LE	Lower east wetland cells
MARDI	Malaysia agricultural, research and development Institute
MMM	Marimas - Magna Prima - Mesra Hijau Sdn. Bhd. joint venture group
MMS	Malaysian Meteorological Services
NWI	National wetlands inventory

PCA	Principal Component Analyis
PJH	Putrajaya Holdings Sdn. Bhd
PP	Perbadanan Putrajaya
SD	Standard Deviation
SF	Subsurface Flow
Sg	Sungai
SKVE	South Klang Valley Expressway
TNB	Tenaga Nasional Berhad
TSS	Total Suspended Solids
UB	Upper Bisa
UE	Upper East
UN	Upper North
UPM	University Putra Malaysia
UV	Ultra Violet
UW	Upper West
USAGE	United Sate Army Corporation of Engineers
US EPA	United States Environmental Protection Agency
VSF	Vertical Subsurface Flow