Efficiency of ecological pond for stormwater pollutants removal

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Introduction

Recently Malaysia was shocked with twice flash flood tragedy happened within three weeks in Melaka, Pahang, Johor and Sabah. Johor recorded as the worse state in facing this scenario. There is believed that unpredictable weather is the one of the factor for this catastrophe as well undersized volume capacity of existing damn, limited outlet for runoff flows to the sea and increasing of impervious area also contribute to the flash flood. Million of ringgits are lost and thousand of peoples are evacuated. From this scenario, it shown that from the rapid grow of population and development effected the hydrological cycle. In order to avoid flash flood, Integrated Flood Management is needed to be implementing in Malaysia. A good implementation and management of stormwater runoff, not only solve flash flood problem but it also can help in improving stormwater runoff quality by intercept the pollutants before its flows to the downstream whether river or sea. Ultimately, rivers and sea pollution problems can be solved. For example the construction of detention or retention pond can be used for temporarily storing flood water to reduce peak floods downstream. While detention/retention pond hold the runoff water, sedimentation process which is primary removal mechanism, will retain a proportion of organics matters. Thus, concentration of pollutants will be decrease before water flows out from the ponds.

Department of Irrigation and Drainage Malaysia (DID) has taken the responsibility by launching the new manual called Urban Storm water Management Manual (MSMA) for Malaysia effective 2001. Even the manual are not fully implement by developers but DID make a good start in order to avoid flash flood, water shortage, river pollution and provide a good amenity and quality of life in urban and rural area.

Based on this manual, Bio-ecological Drainage System (BIOECODS) was constructed and become a pilot project for Malaysia's new development area. Covering an area of 320 acres, the construction of BIOECODS was completed at the end of December 2002 (Ab. Ghani et al., 2004; Zakaria et al., 2003). BIOECODS (Fig. 1) is a combination of Best Management Practices (BMP) techniques for a Sustainable Urban Drainage System (SUDS), consisting of three components namely ecological swale called Type A, type B and Type C depending on the numbers of modules available underneath the swale and Dry Ponds. These components are located at the upstream of the system (Fig. 1) followed by the third component known as Ecological Pond (Wetpond, Detention Pond, Constructed Wetland, Wading River and Recreational Pond) which is located at the downstream part.

Wet pond, detention pond and wetland having surface areas of 4500m^2, 10000m^2 and 9100m^2 respectively were constructed for further treatment of storm water runoff (Ayub et al, 2005). Several wetland species such as *Typha augustifolia, Lepironia articulata, Hanguana malayana* and *Eleocaris dulcis* were planted in order to improve storm runoff using their capability in providing oxygen and tolerance to organic matters in storm runoff (Mohd Sidek et al, 2004).

In this paper, the performance of the ecological pond in the purification of stormwater runoff for the period of 2006 is discussed. The water quality parameters chosen were checked against the Class II B, Interim National Water Quality Standard (INWQS) and Standard B EQA 1974.

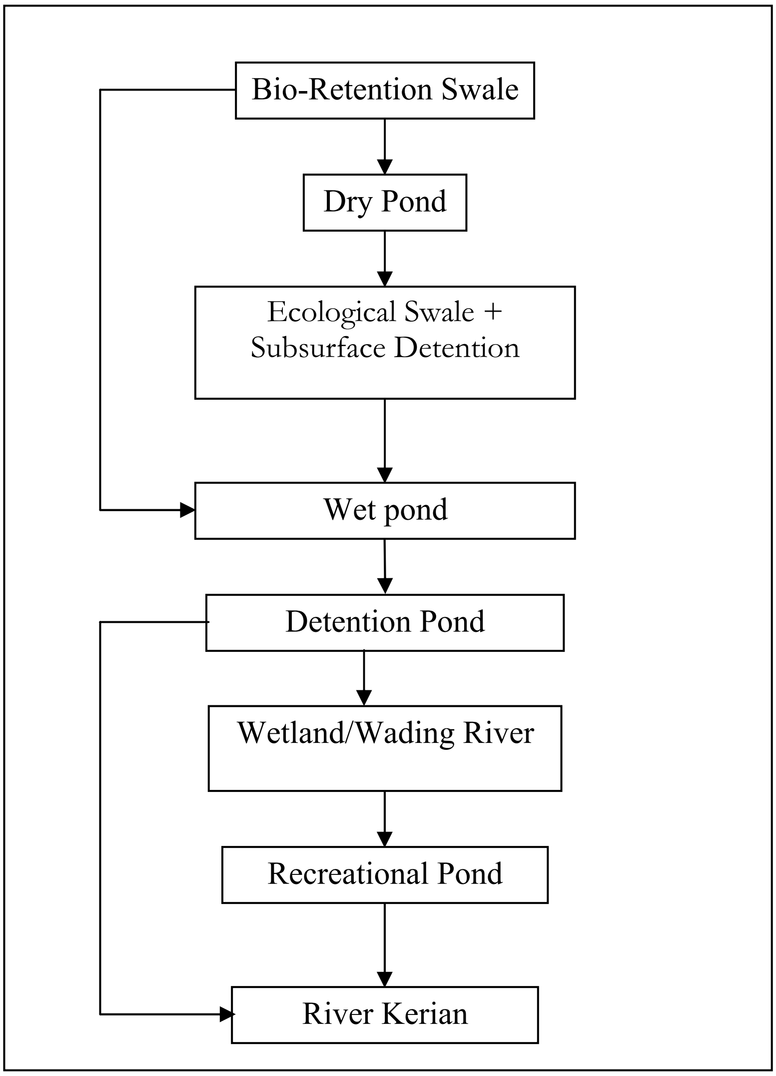

Fig. 1 Schematic Diagram of BIOECODS

Monitoring Site and Sample Collection

Downstream part of BIOECODS which is consisting of wetpond, detention pond, constructed wetland, wading river and recreational pond or known as ecopond has been studied during the year 2006 (Figure 2). These ecoponds located at the downstream of the system purposely to optimize and effectively attenuate and treat stormwater runoff generated from the USM Engineering Campus development area before it flows into Kerian River. Every inlet and outlet of the ponds is selected as a water quality sampling station (Figure 2). Event with 2-year, 5-year and 50-year return period (ARI) has been discussed in this paper and 10 parameters have been tested for the water samples: pH, Dissolved Oxygen (DO), Temperature, Turbidity, Biochemical Oxygen Demand (BOD_5), Total Suspended Solids (TSS), Total Phosphorus (TP), Chemical Oxygen Demand (COD), Oil & Grease, Ammoniacal Nitrogen (NH_3-N) and Total Solid (TS). By using grab sampling techniques, samples were collected immediately after storm events and the water samples were analyzed at Environment Laboratory, School of Civil Engineering, USM in accordance with Standard Methods for the Examination of Water and Wastewater 20th Ed. (APHA, 1998). Then water quality results were checked against the Class II B, Interim National Water Quality Standard (INWQS) and Standard B EQA 1974.

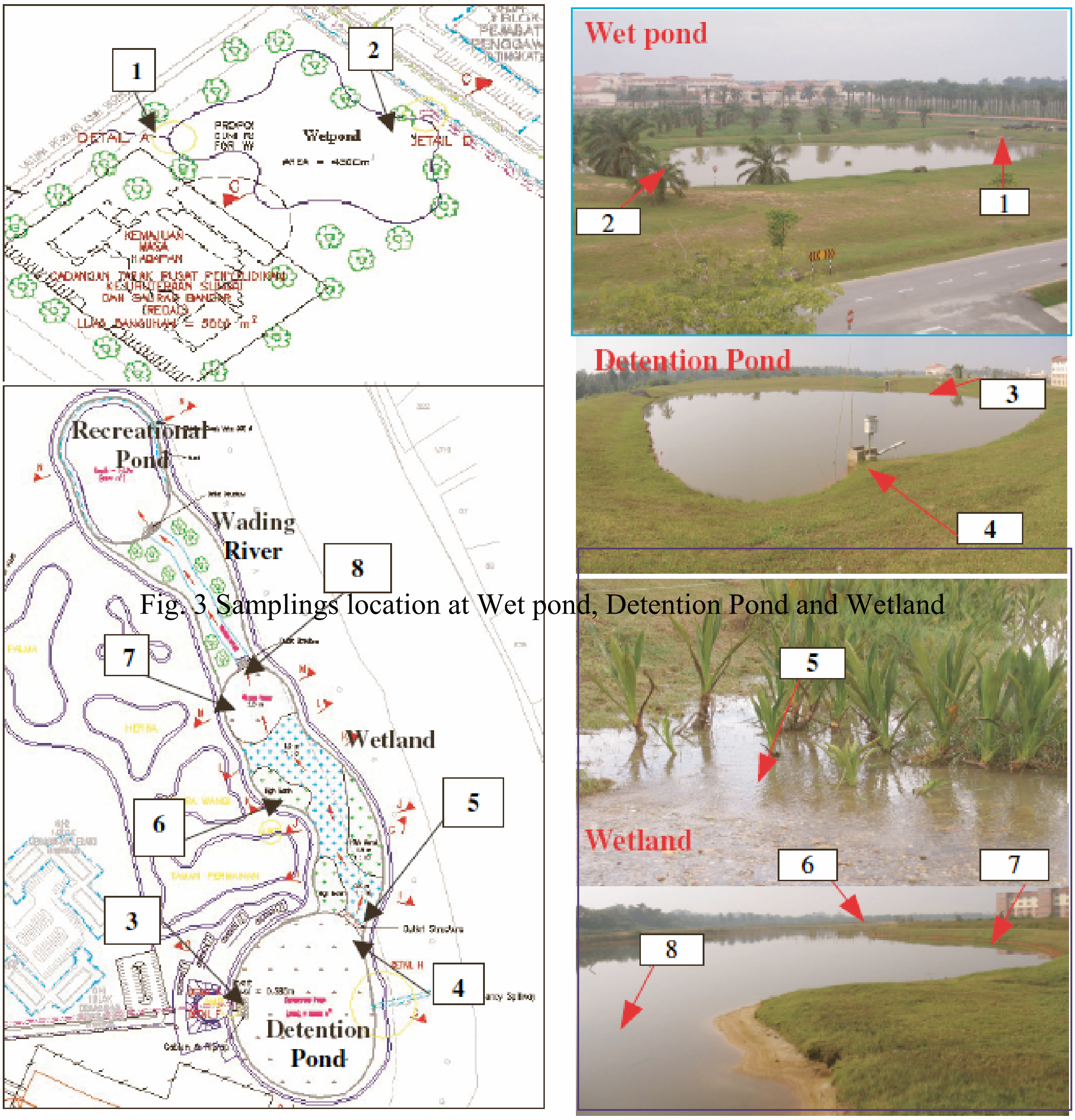

Fig. 3 Samplings location at Wet pond, Detention Pond and Wetland

concentration for 50 Year ARI (7 September 2006), but result in Table 2 shows a good treatment of turbidity were carried out during water flows from the Inlet Detention Pond to the Outlet Wetland. It is believed that macrophytes (*Lepironia articulata, Typha* *angustifolia, Hanguana malayana and Eleocharis variegate*) planted in constructed wetland act in purifying stormwater runoff not only in removing turbidity but also organic pollutant such as ammoniacal nitrogen (NH_3-N). All events show that NH_3-N removed about 77.3% (30 August 2006), 66% (7 September 2006) and 95% (26 September 2006) respectively. A good treatment by constructed wetland in removing pollutants is also significant to the species planted (Cheng et al., 2002). That shows with good combination of the treatment train, there is possible for us to treat and reduce concentration of pollutants in stormwater. Ecological ponds again proved its capability in reducing pollutants such as total solids for event 30 August 2006 (66.7%) and 7 September 2006 (71.4%). All pollutants for all dates fall onto the Class II B, INWQS.

Table 1 Stormwater Quality at Ecological Pond (30 August 2006: 2 Year ARI)

Station	pH	DO (mg/L)	Temp. (°C)	Turbidity (NTU)	TSS (mg/L)	COD (mg/L)	Oil & Grease (mg/L)	NH_3-N (mg/L)	TS (mg/L)
Inlet WP	6.4	4	21	33	0	13	0.0	0.4	0.0
Outlet WP	8.0	5	22	48	0	15	0.0	0.7	0.0
Inlet DP	8.5	4	21	61	0	29	0.1	0.8	0.0
Outlet DP	7.4	4	22	29	0	34	0.0	0.3	0.0
In. Wetland	7.3	4	21	13	0	28	0.0	0.4	0.0
High Marsh	7.6	4	22	4	0	21	0.0	0.1	0.0
Micro Pool	7.6	4	23	20	0	20	0.0	0.2	0.0
Out. Wetland	7.0	4	22	13	0	10	0.0	0.1	0.0
Mean	7.5	4	22	28	0	21	0.0	0.4	0.0
Median	7.5	4	22	25	0	21	0.0	0.3	0.0
Standard Deviation	0.6	0	1	19	0	8	0.0	0.3	0.0
Class II B, WQI	**6 - 9**	**5 - 7**	**-**	**50**	**50**	**25**	**-**	**0.3**	**-**
Standard B, EQA 1974	**5.5 - 9**	**-**	**40**	**-**	**100**	**100**	**10.0**	**-**	**-**

Table 2 Stormwater Quality at Ecological Pond (7 September 2006: 50 Year ARI)

Station	pH	DO (mg/L)	Temp. (°C)	Turbidity (NTU)	TSS (mg/L)	COD (mg/L)	Oil & Grease (mg/L)	NH_3-N (mg/L)	TS (mg/L)
Inlet WP	6.1	7	23	21	0	36	0.0	0.6	0.0
Outlet WP	5.9	6	23	73	0	24	0.0	0.5	0.0
Inlet DP	6.0	7	24	135	0	2	0.0	0.9	0.0
Outlet DP	6.2	7	22	112	0	2	0.0	0.3	0.0
In. Wetland	6.3	7	23	51	0	21	0.0	0.4	0.0
High Marsh	6.4	6	23	8	0	4	0.0	0.2	0.0
Micro Pool	6.4	8	24	22	0	14	0.0	0.2	0.0
Out. Wetland	6.3	7	22	21	0	22	0.0	0.2	0.0
Mean	6.2	7	23	55	0	16	0.0	0.4	0.0
Median	6.2	7	23	37	0	18	0.0	0.4	0.0
Standard Deviation	0.2	1	1	47	0	12	0.0	0.2	0.0
Class II B, WQI	**6 - 9**	**5 - 7**	**-**	**50**	**50**	**25**	**-**	**0.3**	**-**
Standard B, EQA 1974	**5.5 - 9**	**-**	**40**	**-**	**100**	**100**	**10.0**	**-**	**-**

Table 3 Stormwater Quality at Ecological Pond (26 September 2006: 5 Year ARI)

Station	pH	DO (mg/L)	Temp. (°C)	Turbidity (NTU)	BOD_5 (mg/L)	TSS (mg/L)	COD (mg/L)	Oil & Grease (mg/L)	NH_3-N (mg/L)	TS (mg/L)
Inlet WP	7.2	5	19	40	1.98	0	33	0.008	0.4	0.0
Outlet WP	7.0	5	19	32	1.45	0	17	0.015	0.5	0.0
Inlet DP	7.0	7	20	15	0.55	0	19	0.006	0.1	0.0
Outlet DP	7.1	6	21	64	0.95	0	29	0.008	0.9	0.0
In. Wetland	7.1	6	19	12	1.21	0	20	0.006	0.4	0.0
High Marsh	7.2	6	21	10	0.74	0	20	0.003	0.2	0.0
Micro Pool	7.1	6	19	25	1.31	0	18	0.012	0.3	0.0
Out. Wetland	7.2	6	19	8	0.65	0	16	0.005	0.0	0.0
Mean	7.1	6	20	26	1.1	0	22	0.0	0.3	0.0
Median	7.1	6	19	20	1.1	0	20	0.0	0.3	0.0
Standard Deviation	0.1	0	1	19	0.5	0	6	0.0	0.3	0.0
Class II B, WQI	**6 - 9**	**5 - 7**	**-**	**50**	**3**	**50**	**25**	**-**	**0.3**	**-**
Standard B, EQA 1974	**5.5 - 9**	**-**	**40**	**-**	**50**	**100**	**100**	**10.0**	**-**	**-**

Conclusions

The quality of storm water flowing along the ecological pond which is a part of BIOECODS has been improved year by year. With a good treatment train, it shows the system achieves the goals of MSMA in purifying the storm water runoff based on result discussed above. As a national pilot project of Malaysia, the system can be applied to new areas of development to realize Integrated Flood Management and Environment and Sustainable Development. The study also conclude that final end of treatment the water can also be used for the domestic and recreational activities.

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