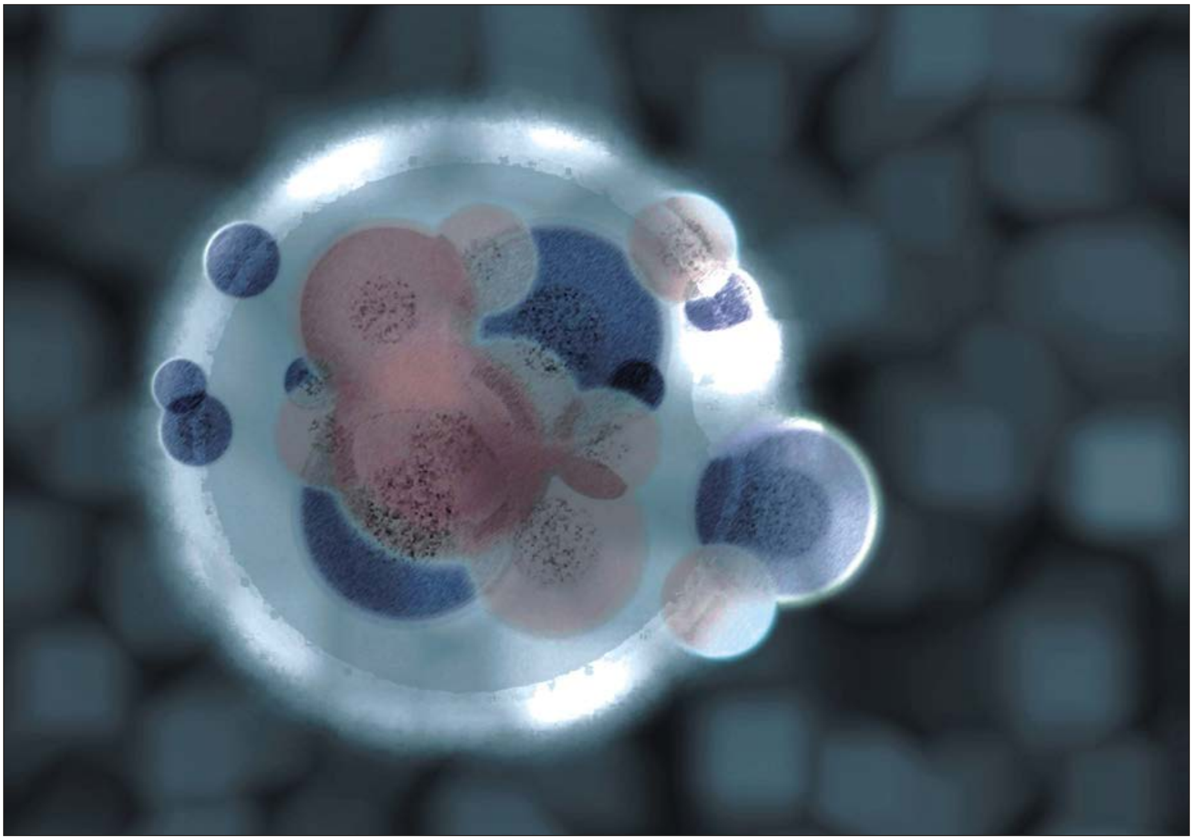

Journal of Biological Sciences

ISSN 1727-3048

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Journal of Biological Sciences 13 (6): 474-482, 2013
ISSN 1727-3048 / DOI: 10.3923/jbs.2013.474.482

Monitoring Urban River Water Quality Using Macroinvertebrate and Physico-Chemical Parameters: Case study of Penchala River, Malaysia

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Abstract: A study have been carried on urban river, Sungai Penchala to assess the river water quality by using benthic macroinvertebrates as biological indicator and also standard Department of Environment (DOE) water quality measurement for physical-chemical analysis of Water Quality Index (WQI). Sampling for benthic macroinvertebrate and water sample was done on 3 sampling sites, named upstream (S1), middle stream (S2) and downstream (S3). The benthic macroinvertebrate sampling was done in the same day at the same place the water samples were collected in 5 replicates, while the water samples were collected in 3 replicates for each river section. The benthic macroinvertebrates was sampled using Surber's net and water measurement for dissolved oxygen, temperature, pH and conductivity was measured in-situ using HYDROLAB Quanta®, multi-parameter water quality instrument. Collected water sample was transferred to laboratory for measurement of total suspended solid, BOD_5, chemical oxygen demand and ammoniacal nitrogen. The result from the assessment show that Sungai Penchala is classified as having good water quality on the upstream section but the water quality distorted in the middle and downstream section based on WQI and BMWP score. Non-parametric test of Kruskal-Wallis test show that most water parameter are significantly differ among river section ($p>0.05$, $\alpha = 0.05$).

Key words: Benthic macroinvertebrate, BMWP, WQI, Urban river, concrete drainage, river pollution

INTRODUCTION

River is very important asset that rich with benefit toward humankind especially early civilization (Lerner and Holt, 2012). However, the condition of river in urban area is highly influenced by the surrounding developments. They are filled with organic and organic loads of human activities which latter shall be carried away toward the sea and inviting another problem (Chin, 2006; Torrisi *et al*., 2010). Urban River is likely to cause problems such as flood due to the blocked water flow and in certain country it can be a mechanism for plague and disease transported. The river located in the urban area which heavily populated and urbanised, even though the catchment area situated in the upstream is clean the middle and downstream section is polluted and modified for drainage system.

Benthic macroinverterbate have long been used as biological indicator toward environmental changes. Several studies have highlight the importance of using benthic macroinvertebrates in monitoring purposes to support the result from physical and chemical parameters. The reasons to use benthic macroinvertebrate as supportive data as chemical monitoring alone is not enough as the approach of compound by compound analysis for all chemical that might be present in the sample is not realistic. The approach didn't account for additive, synergistic or antagonistic effect that might occur and also lack important data such trace metabolite and reaction products (Oertal and Salanki, 2003). Moreover, physical-chemical data only gives information regarding the situation of water at the time of sampling conducted (Rosenberg and Resh, 1993). It is undeniable that benthic macroinvertebrate could serve as good biological indicator of water quality deterioration (Turkmen and Kazanci, 2010) as they are ubiquitous in nature, abundance and rich with family thus offer spectrum of responses toward environmental changes; sedentary lifestyle and long lifespan (Turkmen and Kazanci, 2010) which making them as better candidate for biological monitoring agent when compared to other organisms such as fish. The ubiquitous and sessile nature

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of benthic macroinvertebrate could represent the condition of place the inhibit over period of times; while varied sensitivity of each family toward various types of pollutants, might useful to study and identify the synergistic effect of different type of pollutants on living organism.

Thus the integration of both approaches in water quality management would gives better understanding in the environmental condition of urban river and also helps the management (Butiuc-Keul *et al*., 2012). Therefore, the aim of this study is to determine diversity of benthic macroinvertebrates as part of river water quality assessment especially for urban type river in Malaysia. Supported by successful examples of the implementations and integration of physical-chemical based approach with biological approach; this study would open the possibilities for better understanding in water quality management in Malaysia.

MATERIALS and METHODS

Sampling site: The samples and data collection was conducted along the Penchala River which is one of the tributaries for highly polluted Klang River in the Selangor state (Mak, 2004; Fazleena, 2010). This river flows through the 3 chosen sampling stations, named; upstream (S1), middle stream (S2) and downstream (S3), respectively (Fig. 1, Table 1). The climate of the sampling area is a typical of the Peninsular Malaysia which having moderate average annual rainfall, high temperature and humidity.

The upstream section located deep in the recreational area which away from residential and industrial area. The site also abundance with vegetation covers that cover most part of the section thus limiting the direct sunlight. The middle stream and downstream section located in the urban area which is very close to residential area and main road. The river itself have been modified from natural to concrete type drainage for flood mitigation and this is very much different compared to the upstream section. Middle and downstream section have less vegetation cover and many drainage from residential and commercial area flow into the river. The condition of the river can change almost instantly and this depends on other factor such as chemical loading on that moment. Foul odour also detected on those sections.

Benthic macroinvertebrate sample collection: The benthic macroinvertebrates sampling was done using Surber's net samplers with area size of 0.3 m^2 mess size. The macroinvertebrate sampling was not randomly conducted as the area of sampling was chosen depending on the substrates types. This is because there is substrate preference among macroinvertebrate. Therefore, area with substrates such as vegetation and cobbler were chosen. Between slow moving water, ripple area with fast flowing, shallow water are the most suitable sampling area as they support varied groups of benthic invertebrates. The Surber's sampler was employed by placing the sampler opening facing the upstream flow. The area in front of the sampler was disturbed for about 3 minutes. Any organism in that area was collected by the sampler net. The sample trapped in the net was then transferred into plastic container and preserved using 90% ethanol. First, the sample was cleaned under slow moving water to remove any fine particles using sieve. Then the cleaned sample was transferred into the white coloured background container. The sorting of organism from the substrate and debris was done under sufficient light by using forceps. Organism sorted was placed in 75% newly added ethanol. The taxonomic identification to the family level was done by using microscope RaxVision and also by referring to the taxonomic reference book of Fresh Water Macroinvertebrate of the United States (Pennak, 1978) and Oligochaeta of World (Brinkhurst and Jamieson, 1971). The benthic macroinvertebrate sampled was then used in Biological Monitoring Working Parties index (BMWP) with reference to Thailand BMWP index (Mustow, 2002). This index was employed to determine the water quality of Penchala River in biological aspect and chosen rather than using other BMWP such from British or United State. Moreover Thailand have similar climate with Malaysia.

Measurement of physical and chemical water quality variables: Prior to sampling, all glassware and bottles used for the sampling was acid wash as purposed by APHA (2006) to eliminate any contamination that may influence the sample. The *in-situ* physical and chemical parameters were collected using HYDROLAB Quanta®,multi-parameter water quality instrument. The specification of transmitter used is on range of 2 to 12

Table 1: Geographical description of sampling area

State	District	GPS coordinate	Landscape
Kuala Lumpur	Wilayah Persekutuan	03° 08' 45.3" N 101° 37' 54.1" E	Recreational area (S1)
Selangor	Petaling	03° 07' 7.4" N 101° 37' 42.7" E	Urban (S2)
	Petaling	03° 04' 45.4" N 103° 37' 18.0" E	Urban (S3)

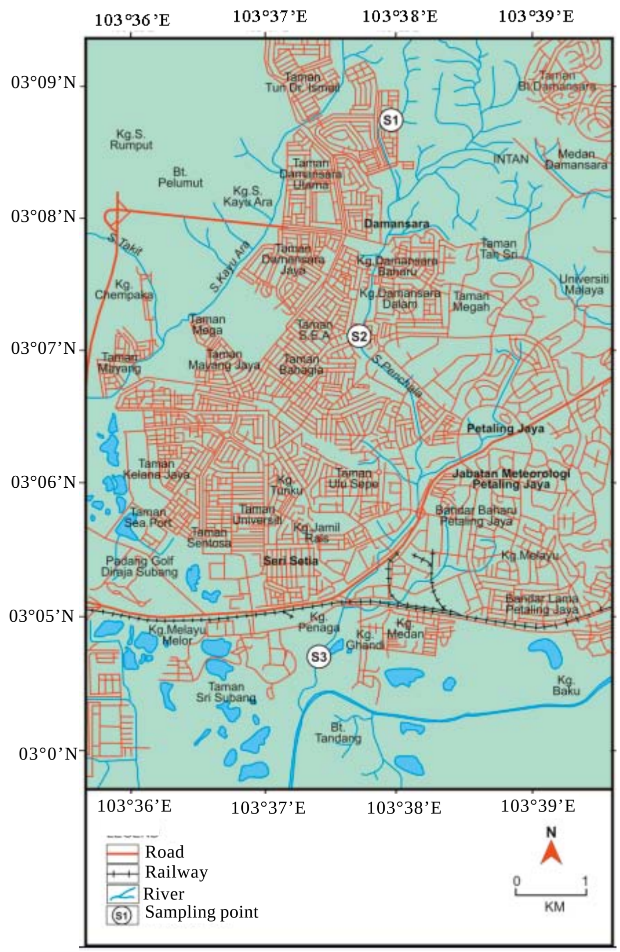

Fig. 1: Sampling points along Sungai Penchala

units for pH; 0 to 50 mg L^{-1} for Dissolved Oxygen (DO); 0 to 1000 NTU for turbidity and 0 to 100 m Sec cm^{-1} for specific conductance. Water sample for chemical parameter variable were collected facing the upstream water (HACH, 2005). The BOD water samples were collected by filling BOD bottles in the water without air space in the bottle and also capped while still in water. Water samples for chemical analysis of Chemical Oxygen Demand (COD), ammoniacal nitrogen (NH_3-N) and Total Suspended Solid (TSS), were collected in the 1 litre Teflon bottles. While water samples for BOD_5 were collected in the 300 mL BOD bottles. In total, 3 BOD bottles and 3 bottles were used to collect water samples for each sampling sites. The water samples were kept cool on ice of 4°C for transportation purpose from the sampling site to the laboratory (APHA, 2006). No acid was used to preserve the water samples as the test was conducted as soon as possible upon the time of arrival on laboratory.

The water selected chemical analyses were done within 24 h from the time of sampling except for BOD_5 which need to be preliminarily incubated.

Prior to the analysis upon arrival at laboratories all samples were let to room temperature. The 5 day BOD was done by primarily diluting the water samples in station 2 and 3. Dechlorinated tap water was used for dilution purposes with ratio water sample and dechlorinated water of 1:10, the declorinated water and saturated with air by stirring (HACH, 2005). The first dissolve oxygen (DO_1) measurement was done after dilution using YSI Model 5000; samples were then left for incubation for 5 days in incubator with temperature of 20°C before be measured against for second measurement of dissolved oxygen (DO_2). The COD was done according to reactor digestion method (Hach Method 8000). The COD digestion vial used in this study is 0.7 to 40.0 mg L^{-1} COD Ultra Low Range (ULR) for COD measurement of upstream samples and range 3 to 150 mg L^{-1} COD low range for measurement of middle and downstream sections. The digestion for COD was done base on the method stated and the measurement was taken using Hach spectrophotometer model DR2500; programme 431 COD ULR and 430 COD LR respectively, at wavelength of 420 nm. The Total Suspended Solid (TSS) measurement was done by filtering 200 mL of water sample Whatman 934-AH Glass Microfiber filters with pore size of 0.47 μm. The microfiber filter was dried till constant weight at 105°C, prior to filtering process and dried again after filtering the water sample at the same temperature until it reached constant weight. The NH_3-N measurement was done according to HACH Nessler Method (Hach Method 8038) and the measurement was done using Hach spectrophotometer model DR2500 with detection range between 0.02 to 2.50 mg L^{-1} at the wavelength of 425 nm; the water samples were diluted to 50% with deionised water before undergone analysis, except for water sample from upstream section (S1). The data obtained from 3 replicates measurement were averaged and were used for determination of water quality index (WQI-Table 3) based on index used by The Department of Environment Malaysia (Department of Environment, Malaysia, 2002) as described by Norhayati *et al*. (1997). This index is based on DOE opinion pool WQI and computed from equation of:

$$WQI = 0.22\ (SIDO) + 0.19\ (SI\ BOD) + 0.16\ (SICOD) + 0.15\ (SI\ AN) + 0.16\ (SISS) + 0.12\ (SI\ pH)$$

where, SI refers to the sub index function for each of the given parameters and the coefficients are the weighting factors derived from the opinion poll (Norhayati *et al*., 1997).

Statistical and data analysis : The data obtained for water quality variable were calculated for mean and standard deviation and presented according to the sampling site. Since the data didn't fulfil the precondition of One-way ANOVA and cannot be transformed to suit the condition, non-parametric test analysis of Kruska-Wallis was employed to see either there are statistically significant differences ($p<0.05$) between sites. While the BMWP is calculated using $BMWP_{Thai}$ score system derived by Mustow (2002).

RESULTS AND DISCUSSION

Water quality variables: Table 2 show that there is a difference among the three sites based on the temperature, conductivity, DO, BOD, COD and NH_3N. However, for pH the p-value (0.059) is greater than 0.05 which suggest no significant difference on the three sites (Kruskal-Wallis test). The recorded water parameter for June is similar to April but August is different with no significant different on ammoniacal nitrogen between the three site (Kruskal-Wallis $p>0.05$). This condition might due to the sampling effort that was conducted in raining period as this might due to the dilution of river water caused by rainfall. The increase of ammoniacal nitrogen in the middle (S2) and downstream (S3) section indicates the discharge of untreated wastewater into the river ecosystem. Activities such as agriculture, uncontrolled development and surface runoff due to rainfall may contribute to the deposition of ammoniacal nitrogen.

The Biological Oxygen Demand (BOD_5), the values show variable in high organic loading from surrounded area of S2 and S3. The foul odour experienced while sampling on S2 and S3 with addition to low DO measurement suggested high microbial activity due to anaerobic decomposition process of organic matter which produce by product such as methane. S3 having the highest BOD measurement, the BOD concentration that higher than 12 mg L^{-1} is part of characteristic of Class IV river (DOE, 1985). High organic load in the area is due to the residential area near the river and some part of the river is treated as dumping site by resident.

The temperature of the water increase as it goes down from the upstream to downstream and this is due to the lack of canopy cover or vegetation on the river bank. The condition of upstream site that covered by trees and shrub cause lower temperature on the upstream and high temperature on the middle and downstream, this show how plant vegetation play important role in regulating temperature in aquatic environment (Arimoro and Ikomi, 2009). The high temperature on middle (S2) and downstream section (S3) compared to the upstream section (S1) might also due to the altitudinal gradient, the difference on temperature between sites may have determine the species distribution of benthic macroinvertebrate by altering water oxygen retention capability by causing less DO level on high temperature (Wetzel, 1983), or influencing the thermoregulation process of benthic macroinvertebrate (Henriques-Oliveira and Nessimian, 2010).

pH would be the most stable parameter with small differences and also most stable for every 3 month with no drastic changes. Usually, polluted river would have unstable pH rather than stay in stable form; in this case it is suspected that the stable river pH is due to the geology factor as the river is situated in area with high carbonate deposit in the form of limestone. Thus keeping the water pH checked. However, there are also possibilities that the concrete drainage system in the middle and downstream or from the residential area might influence the water

Table 2: Range and SD for *in situ* parameters for 3 sampling stations for 3 periods of months (April-August 2012)

Parameter	St.1			St.2			St.3			P		
Month	April	June	Aug.	April	June	Aug.	April	June	Aug.	April	June	Aug.
Temperature (°C)	26.12±0.09 (0.09)	25.83±0.03 (0.03)	26.03±0.02 (0.02)	30.07±0.15 (0.15)	28.84±0.03 (0.03)	27.73±0.01 (0.01)	31.82±0.03 (0.03)	26.68±0.01 (0.01)	30.72±0.03 (0.03)	0.027	0.027	0.026
Conductivity (µ Sec cm^{-1})	0.07±0.00 (0.00)	0.08±0.01 (0.01)	0.09±0.00 (0.00)	0.24±0.00 (0.00)	0.27±0.00 (0.00)	0.19±0.00 (0.00)	0.38±0.00 (0.00)	0.19±0.00 (0.00)	0.4±0.00 (0.00)	0.02	0.02	0.02
DO (mg L^{-1})	7.56±0.02 (0.02)	5.77±0.05 (0.05)	6.66±0.08 (0.08)	3.68±0.75 (0.75)	3.08±0.81 (0.81)	0.28±0.00 (0.00)	0.35±0.17 (0.17)	0.2±0.04 (0.04)	0.57±0.12 (0.12)	0.027	0.027	0.027
pH	6.96±0.02 (0.02)	7.42±0.02 (0.02)	7.38±0.03 (0.03)	6.88±0.04 (0.04)	7.22±0.01 (0.01)	7.21±0.05 (0.05)	6.89±0.06 (0.06)	7.21±0.05 (0.05)	6.59±0.02 (0.02)	0.059	0.06	0.027
BOD (mg L^{-1})	0.27±0.17 (0.17)	0.4±0.10 (0.10)	1.58±0.18 (0.18)	13.47±1.40 (1.40)	13.67±0.45 (0.45)	3.16±0.08 (0.08)	28.7±2.82 (2.82)	46.03±6.82 (6.82)	34.97±3.26 (3.26)	0.027	0.027	0.027
COD (mg L^{-1})	5±1.00 (1.00)	4±1.00 (1.00)	2.67±1.30 (1.30)	25.67±7.23 (7.23)	50±2.00 (2.00)	163±2.00 (2.00)	51±4.00 (4.00)	163±2.00 (2.00)	66.67±2.31 (2.31)	0.027	0.027	0.027
Ammonical Nitrogen (mg L^{-1})	0.04±0.02 (0.02)	0.02±0.01 (0.01)	0.01±0.01 (0.01)	1.63±0.03 (0.03)	2.07±0.06 (0.06)	6.89±0.05 (0.05)	2.66±0.02 (0.02)	2.34±0.05 (0.05)	4.69±0.30 (0.30)	0.027	0.026	0.065

St: Sampljng station, P: Kruska-Wallis Test chemistry that flow on them. This is due to the leaching of minerals from this infrastructure into the water thus modified the water chemistry by making it tends to be neutral pH (Wright *et al*., 2011).

The COD is higher in the middle stream (S2) and downstream section (S3) with big difference among month of sampling. The increase of COD in those section compared to the upstream is due to high dissolved and particulate matter in the river. Literally high organic and inorganic compound in water body could cause higher COD values. As for middle and downstream section huge amount of oxygen were used to oxidise oxidisable mater in water. The source of the matter might come from anthropogenic activities such as industrial and domestic waste and naturally from death and as by product of living organism.

Conductivity is higher in middle (S2) and downstream section (S3) compared to upstream (S1). Raining period might alter conductivity significantly as rainwater have lower conductivity due to lack of minerals, this explain the huge variance between sampling periods that was conducted in raining season. Other than that, warmer environment of middle and downstream section increase the conductivity of water. In upstream minerals might play important role is conductivity measurement but for middle and downstream section conductivity might be influenced mostly by the industrial effluent that rich with dissolved solid which carry electrical charges. Thus we can observe high conductivity on the middle (S2) and downstream (S3) section.

Water quality index (WQI): The score of WQI for upstream was 96 for April, 92 for June and 94 for August by classing the upstream river as Class I river according to DOE (Table 3). The middle stream (S2) was classified as Class III for the month of April and June with WQI 62 and 52, respectively. However, the WQI is the lowest on August with score of 47 classing the river as Class IV because there was construction taking place near the river bank. While the downstream (S3) WQI would be lowest compared with the middle stream (S2) with WQI score of 38 in April, which fall in Class IV. The lowest WQI was on June with score of 25, (Class V) and in August the WQI was 30 (Class IV).

The WQI reflect the condition of water quality of the river on that specific time during the sampling period. WQI might be stable for the upstream section (S1) as there are no sources of pollution directed into the river section. However the middle (S2) and downstream section (S3) is as natural as the upstream section as there are many drainage and the area have highly density due to development and residential. Thus, the water quality is strongly influenced by human activity.

Benthic Macroinvertebrates and relation with water quality: The taxonomic identification of family level for benthic macroinverterbates reveals that the diversity of benthic macroinvertebrates decreases towards the river basin (S1 to S3) (Table 4). Thus the higher section of the river (S1) with better quality has more numbers of EPT families compared with other section of the river (S2 and S3) and this is indicated by present consistently at the clean water on the upstream environment. The same finding also found by Chin (2006), which found the order EPT only present in ecosystem with clean water. The EPT order is very sensitive toward pollution because it is morphologically susceptible to contamination especially metal contamination.

Order Chironomidae were found in high abundance on every part of river section throughout the sampling period. Chironomidae is not considered as sensitive order toward pollution as most of the member is quite tolerate to environmental changes. The presence of Chironomidae is usually reported as indicator of polluted environment by having preference on organic rich sediment (Spellman and Drinan, 2001; Ozkan *et al*., 2010) as in this case it not true for the upstream section as there are also sensitive EPT members which suggest abundance of Chironomid is not due to pollution but due to the capability of this order to inhibit wide range of ecosystem (Tamida, 2009). Other factor that might influence the presence of Chironomidae in the upstream is might due to the opportunistic response of the order toward abundance of food carried

Table 3: DOE water index classification

		Class				
Parameter	Unit	I	II	III	IV	V
NH_3-N	mg L^{-1}	<0.1	0.1-0.3	0.3-0.9	0.9-2.7	>2.7
BOD	mg L^{-1}	<1	1-3	3-6	6-12	>12
COD	mg L^{-1}	<10	10-25	25-50	50-100	>100
DO	mg L^{-1}	>7	5-7	3-5	1-3	<1
pH	-	>7	6-7	5-6	< 5	<5
TSS	mg L^{-1}	<25	25-50	50-150	150-300	>300
WQI	-	>92.7	76.5-92.7	51.9-76.5	31.0-51.9	<31.0

Table 4: Systematic list of taxa and number of macroinvertebrates found along the Penchala River

		April			June			August		
Order	Family	St.1	St.2	St.3	St.1	St.2	St.3	St.1	St.2	St.3
Coleoptera	Dytiscidae			2						
	Elmidae	3	4		1			21		
	Lampyridae	2					1			
	Ptilodactylidae				3			3		
	Amphizoidae	2								
	Scirtidae	2					3			
Diptera	Ceratopogonidae	3			1		1			
	Chironomidae	81	22	13	77	254	163	41	215	1
	Culicidae						11	1	1	
	Dixidae	2			3			10		11
	Simuliidae	29			2			6		
	Syrphidae					4				1
	Muscidae	1								
	Ephydridae					7	6		4	
	Stratiomyidae									
	Tabanidae				3					6
	Psychodidae				1	43	135		7	
	Tipulidae	4			5			23		
Ephemeroptera	Baetidae	48			63			41		
	Ephemerellidae	5			3			24		
	Heptageniidae	7			3			24		
	Leptophelebiidae	1			3			6		
Heteroptera	Gerridae	1								
Odonata	Coenagrionidae	2			1					
	Corduliidae	1								
	Amphipterygidae				1					
	Euphaeidae				3					
	Calopterygidae	1			6					
	Gomphidae	1			5	2		6		
Plecoptera	Perlidae	5			10			7		
	Leuctridae	1								
Trichoptera	Hydropsychidae	16			25			40		
	Hydroptilidae	3								
	Leptoceridae									
	Limnephilidae							1		
	Polycentropodidae									
Haplotaxida	Tubificidae		112	9		84	107		489	
	Naididae		18						30	9
Hirudinida	Hirudinidae					1			6	
Oligochaeta	Lumbricidae		7				34		49	19
	Branchiobdellidae		17			4				
Basommatophora	Physidae			2		40			21	2
	Lymnaeidae						1		1	1
	Thiaridae						1			3
Decapoda	Atyidae									
	Palaemonidae	1			1			1		
	Parathelphusidae									
	Potamidae	1			1			2		
Thai BMWP score		109	11	8	92	13	10	80	11	10

by flow of water during rainfall which in this case in raining season or from the riparian species near the river bank as upstream have more vegetation cover on its river bank compared to middle and downstream section (Mcshaffrey and Olive, 1985; Silva *et al*., 2008).

According to the BMWP index the upper section (S1) was classed as in either a very good water quality or good water quality with a slightly impacted which due to the area utilized as recreation area for urban resident (Table 5). The BMWP index also supports the water quality data (WQI) which also list the upper section in the

Table 5: BMWP score and classes

BMWP score	Category	Interpretation
0-10	Very poor	Heavily polluted
11-40	Poor	Polluted or impacted
41-70	Moderate	Moderately impacted
71-100	Good	Clean but slightly impacted
$\geq$100	Very good	Unpolluted, unimpacted

Class I. The middle stream (S2) and downstream section (S3) of the river is either in Class III or IV according to WQI. While the BMWP index listed the middle in either poor or very poor category or downstream section as very poor for the 3 month periods. This two section (S2 and S3) can be interpreted as polluted and very polluted water, thus need an attention. The difference in WQI is because it depends on water quality on that period of sampling, while benthic macroinvertebrate survive and lives before the sampling was conducted could resemble the condition of the river before the time of sampling and this provide result that measure the effect of pollution over a period of time. The upstream section receive less anthropogenic impact from its surrounding area which enable the good condition for sensitive species to live as for the chemical and physical parameter indicates this section didn't receive any organic or inorganic loads compared to the middle and downstream section. In other perspective, the sole view toward each the water parameters (Table 3) such as total dissolved solid and pH and didn't give enough information about the river condition. Thus need to be integrated in WQI calculation with support of BMWP index. The wide differences in water quality of upstream compared to the middle and downstream section is due to the fact that upstream section is a preserved area for public recreation, while the middle and downstream section exposed to the rapid development without proper planning and urban activities. It also observed the residential and industrial sewage released to the river along the middle and downstream section which believe to make the condition worsen. However, the increase and decrease of benthic macroinvertebrate composition along this period of month would indicate the positive and negative environmental condition of this urban river.

The variability of benthic macroinvertebrates distribution between the stations is also influenced by the substrates of the river bed, as in this case the concrete shaping the river, limit the presence of aquatic plant and it also observed that the substrates in the concrete river section is more silt and sand, that not favoured by most benthic macroinvertebrates. Thus this condition, limit the variability of substrate on the river bed and might also limit the abundance and types of macroinvertebrate benthic that have specific preference upon the surrounding environment as well the substrate they live on (Mandaville, 2000). The result obtained support that the unnatural concrete river would actually cause macroinvertebrate to decrease from the upstream section toward the downstream. The effect of habitat modification also limits the ranges of suitable niche for diverse benthic macroinvertebrates to fill in the ecosystem and might reduce the function of that ecosystem. Since part of the river is considered as clean river, where the other part is badly polluted, benthic macroinvertebrate would be also influenced by the changes of water quality variables (Spellman and Drinan, 2001) as it influence and limit the capabilities of benthic macroinvertebrate that live along the river section.

CONCLUSION

There is difference water quality among the river section which indicates the gradient of water quality from good to pollute. This is also supported with benthic macroinvertebrate composition along the river section with the environment sensitive families on upper section and less sensitive families on downstream section. Therefore, through the study, we found that the water quality of Penchala River experience degradation as it flow toward the downstream and benthic macroinvertebrates can serves as a good biological indicator to monitor river health.

ACKNOWLEDGMENT

This research is a Long-term Research Grant Scheme (203/PKT/6720004) supported by Ministry of Higher Education Malaysia. Under the title: Urban Water Cycle Processes, Management and Societal Interactions: Crossing from Crisis to Sustainability. With the collaboration of several educational institution as well as government sector. The scholarship has been sponsored by Ministry of High Education under the program of MyBrain15.

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