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The Effect of WQI on the Distribution of Fish in Labu river System in Sub-Langat Basin, Malaysia

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Abstract: A study on the effect of water quality towards distribution of fish community has been conducted in Labu River System and two selected sites in Langat River. Investigation on the impact of DOE-WQI parameters on the fish abundant was the main focus in this research. Six parameters viz nitrogen ammonia (NH_3-N), biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), pH and suspended solid (SS) are employed to calculate the water quality index (WQI). The recorded DOE-WQI was used to classify status of the rivers according to river classification scheme. Fish community shown species which tolerance with polluted environmental were being able to live in the rivers. Uppertream of the Labu River System exhibits larger number of fish ($p<0.05$) than downstream. Based on the acquired fish community, Langat River has experience direct adverse effect by waterborne pollutants from Labu River System. SS was the main contributor in determine the existence of fish community. Decreasing of the abundance and species of fish were also due to anthropogenic pollutants.

Key words: Labu River System, Langat River, DOE-WQI, fish community

Introduction

Labu River System comprising of Batang Labu River with the length approximated 17.9 kilometer (km), Labu River (31.1 km) and Batang Nilai River (6.4 km) plays as an important role in supply of water resources for catchment areas around Langat Basin and ecosystem services to the nearby area, mainly villages and agriculture fields. This system spans two states in Malaysia (Negeri Sembilan Darul Khusus and Selangor Darul Ehsan). Water bodies are currently been used by villagers for daily domestic activities, irrigation and recreational. Water pollution, flash floods and local scale extinction of aquatic organisms are often stated as the issues concerned. Waterborne pollutants from neighbouring ecosystem have posed adverse impact to the ecosystem of Labu River System in large scale.

The water quality of Labu River System has not been assessed as a whole although Department Environmental of Malaysia (DOE) has started monitoring the current water quality status at one segment of Labu River since 1978. Presence data do not reveal the overall water quality status due to insufficiency of sampling which only been done at the interval of three or four months in a year. Detection of the primary interaction between toxicant and fish can serve as an early warning indicator. Thus, be of maximum predictive value in terms of protection of the whole population and ecosystem (Haux and Forlin, 1988). Fishes have long been of particular value in effort to assess the degree pollution of inland waters (Lloyd and Swift ,1976; DOE, 1997) and water quality (Price ,1979). Appearance of fish community at particular location at riverine is influence by various factors, included physico-chemical parameters which usually affected by anthropogenic sources pollutants. The criteria of fish species which differing in tolerance to amount, types of pollution (EPA, 2001), environmental stresses and well establishing of fish taxon documented in the literature have allowed fish for use in assess or monitor environmental conditions. The extremely diverse of freshwater ichthyofauna in Southeast Asia (Zakaria-Ismail, 1994) has promoted fishes to be widely used to evaluate the watercourse quality. Batang Labu River, Batang Nilai River and Labu River are considered as Labu River System in this research project. The term upper reaches in this paper refers to assemble a group of stations which consist of St. 1, St. 2, St. 3, St.4, St. 5 and St. 6.

Materials and Methods

Determination of water quality was carried out twice a month between July 1999 and 2000 at eleven station in Labu River System and two selected sites in Langat River (Table1). Sampling and analyze of water samples were based on standard methods suggested by American Public Health Association APHA (1995) and Hach Manual 1998 (Hach, 1998). Six replicates of fish specimen collection have been done between November 1999 and 2000. Samplings were commenced from upperstream to downstream. All samples were collected and sent to the laboratory in the same day. Six parameters viz ammonia-nitrogen (NH_3-N), biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), pH and suspended solid (SS) were used to calculate the WQI proposed by DOE(DOE, 1998). The DOE-WQI formula was:

0.22*SIDO+0.19*SIBOD+0.16* SICOD+0.15* SIAN+0.16*SISS+0.12*SIpH.(* = stand for multiply)

Physical parameters (DO and pH) were measured *in situ* using calibrated portable instrument (DO meter and pH meter). The Hach quick method based on Spectrophotometer DR/2010 was used to analyze ammonia-nitrogen (NH_3-N) (Nessler method). The concentration of NH_3 and NH_4^+ were calculated based on formula given in Hach Manual 1998 (Hach , 1998). SS was determined in the laboratory using APHA method (1995) 2540D. APHA method 5210B (1995) and APHA method 5220B (1995) were employed for analyze BOD and COD respectively.

Table 1: Location of stations in Labu River System and Langat River

Station	Name of river
1	Batang Labu River
2	Batang Labu River
3	Batang Labu River
4	Batang Labu River
5	Batang Labu River
6	Batang Labu River
SBN	Batang Nilai River
7	Labu River
8	Labu River
9	Labu River
10	Labu River
SLU	Langat River
SLL	Langat River

Fish were caught using net or electro shocker dependent on the sampling areas. The duration of shocking was 10 minutes whilst net throwing was fixed 10 times as a standard effort. All specimens were immediately immersed in 10% formalin on sites and kept in closed containers which contain 70% alcohol in laboratory prior identification. This study was determining the influent of water pollution on fish distribution. Richness or diversity of fish in the rivers was not taken into consideration. Correlation test was performed to determine the relation within parameters.

Results and Discussion

The results acquired from analysis were listed and summarized in Table 2, 3 and 4. High dispersion of standard deviations indicates that variability in chemical composition between samples was influent by temporal variations that may cause likely by anthropogenic pollutants sources or climate factors.

Ammonia-nitrogen (NH_3-N): The average NH_3-N measured along the rivers ranged from 0.31 to 2.25 mg/l (Table 2). The lowest level of NH_3-N was acquired at St. 1 (0.31 mg/l) and highest at St. SBN (2.25 mg/l). Upper reaches of Labu River System have recorded concentration of NH_3-N between 0.31 and 0.49 mg/l, which within the INWQS value to support healthy aquatic life. The average NH_3-N concentrations observed at St. SBN, St. 8, St. 9, St. 10, St. SLU and St. SLL were exceeded the INWQS recommended threshold level (0.9 mg/l) and the water bodies only suitable for the used of irrigation. In this research project, NH_3 refers to the combined concentrations of un-ionized (NH_3) and ionized ammonia (NH_4^+). The calculated NH_3 ranged from 0.78 to 5.63 mg/l. NH_3-N level at upper reaches of Labu River System was below 2.00 mg/l whilst other segments of rivers included selected sites of Langat river were exceeded 2.00 mg/l. The acute lethal concentrations of NH_3 for a variety of fish species lie in the range of 0.2-2.0 mg/l (Alabaster and Lloyd, 1982). The increased concentration of NH_3 in aquatic system has heightened the toxic effect to fish community. Development toxicity of NH_3 in Labu River System was expected. The toxicity of NH_3 especially downstream of the rivers was affected by temperature, pH (Cairns *et al*., 1975), low DO concentration and existence of other toxic compounds (NCSU, 2001a).
Based on the correlation test, NH_3 has influent the fish distribution at the aquatic system (Table 2 , 3). Linear relation between NH_3 and pH was r = 0.28 and indicated that NH_3 was directly effected by pH in term of quantitative. A rose decline in fish abundant was observed at the segments of rivers with NH_3 above 2.00 mg/l.

Biochemical oxygen demand (BOD) and chemical oxygen demand (COD): The values obtained from BOD and COD have been used to deputize the organic content in the aquatic system. The average BOD concentration obtained ranged from 1.23 to 2.29 mg/l (Table 2). The highest level of BOD was measured at St. SBN in Batang Nilai River and lowest at St. 4 in Labu River. BOD level measured along the rivers was within the INWQS recommended threshold level which being able to support sensitive aquatic life. Batang Nilai River which receiving organic load from Nilai Industrial Zone has recorded the highest BOD concentration compared to other segments of the assessed rivers. The average level of COD acquired from the rivers ranged between 48.04 to 120.38 mg/l (Table 2). The INWQS recommended threshold level of COD to support healthy aquatic life is 50 mg/l. Based on this criterion, COD level at most segments of the study rivers has expressed adverse effect to support the aquatic organisms. The results acquired from statistical test shown BOD and COD were anti-correlated with DO, r = -0.73 and r = -0.43 respectively. The observed circumstances suggest that biodegradation and decomposition of organic constituents will lead to depletion of DO and trigger deoxygenating. Hence, there is an increase in the oxygen demand and a decline of DO level in aquatic system. The COD level along the assessed rivers except St. 1 was above the permissible threshold level (50 mg/l) to support aquatic life proposed for Malaysian rivers. The obtained results indicate that water bodies in study area were unsuitable to support aquatic life.
The adverse effect of biodegradable organic matter and persistent organics, a group of chemicals that are very resistant to decay (EPA, 1999) which represented by BOD and COD respectively were hardy to be justified directly and vague relation was observed. The correlation value between BOD-fish and COD-fish were r = -0.62 and r = -0.61 respectively. Biodegradation organic matter was considered contributes to secondary effect which accelerated DO depletion and may not pose direct physiological distresses to fish community.

pH: The average level of pH measured along the rivers ranged from 6.53 to 6.93 (Table 2) and lay in the range within INWQS recommended level (6.5-8.5) to support aquatic life. The highest pH level was obtained at St. SBN in Batang Nilai River (6.93) and lowest at St. 9 in Labu River (6.53).
Based on the obtained results, fish community in Labu River has seen safely acclimated and increase in number within pH level ranged from 6.67 to 6.75. Six stations viz St. 1, St. 2, St.3, St. 4, St. 6 and St. 10 have recorded the proposed trend. Positive correlation (r = 0.08) between pH and number of fish was obtained. The concentration of ion hydrogenion in aquatic system was not the limitation factor which inhibits the distribution of fish. Combinations of pH and temperature factors have provided an ideal condition for interaction of NH_3 and others ionic constituents.
The formation of iron oxides or hydroxides has emerged at range of temperature, 0-40 °C and pH 5-9 (Schneider and Schwyn, 1987). Soluble of iron salts which appeared were not pose physiological stresses. Precipitated hydroxide may be more toxic (Alabaster and Lloyd, 1982) than insoluble of iron salts. The effect of pH against toxic organic chemical materials is hard to predict (Mayer and Ellersieck, 1988). The declined pH value has lead to increasing solubility of cadmium, nickel and zinc (Brams & Anthony, 1988; Domergue and Vedy, 1992; Eriksson *et al*., 1990; Eriksson, 1990; Xian, 1989). This factor has increased metal availability and lending to greater metal uptake by organisms. Metal uptake may cause extreme physiological damage to aquatic life. Ammonia levels in zero-salinity surface water heighten with increasing pH and temperature (NCSU, 2001a). The un-ionized ammonia (NH_3) can cross cell membranes more readily at higher pH values (NCSU, 2001a) and pose substantial the toxic effect to aquatic organisms.

Dissolved oxygen (DO) :The average level of DO in this study ranged between 3.80 and 5.54 mg/l (Table 2) and within the INWQS recommended threshold level to support aquatic life (3.0-5.0 mg/l). Prolonged exposure to low dissolved oxygen levels may not directly kill an organism, but will increase its susceptibility to other environmental stresses. The average level of DO acquired at St. 4 was 4.92 mg/l, St. SBN (3.80 mg/l), St. 7 (4.90 mg/l), St. 8 (4.80 mg/l), St. 9 (4.42 mg/l), St. 10 (4.42 mg/l) and St. SLL (3.90 mg/l) were below 5.00 mg/l may lead to unfavourable condition for fish community. The DO level which satisfactory for most stages and activities in the life cycle for freshwater fish or tropical biota is 5 mg/l (Alabaster and Lloyd, 1982) or above 5 mg/l (Jain *et al*., 1977). St . SBN in Batang Nilai River and St. SLL in Langat River recorded DO below 4.00 mg/l have exhibit obvious decline in the numbers of fish obtained. Aerobic decomposition of organic matter by microbes causes depletion of oxygen from an aquatic system (NCSU, 2001b). Conversion of metallic ions from a lower reductive state to higher oxidative state may also consume dissolved oxygen in the water bodies (Norris and Charlton, 1962). DO was strongly correlated (r = 0.68) with abundance of fish. The effect of DO on fish community at other segments of the rivers was vague. DO level at St. 4 (4.92 mg/l) was below the value to support development of biota as proposed (Alabaster and Lloyd, 1982; Jain *et al*., 1977), nevertheless the numbers of biota was in greater quantity compared to St. 6 which recorded DO at the level above 5.00 mg/l. Four segments of Labu River System (St. 7, St. 8, St. 9 and St. 10) which receiving input of waterborne pollutants from Batang Nilai River have experience raised decrease in individuals of fish.

Suspended solid (SS): The average level of SS obtained along the rivers ranged from 37.88 to 318.19 mg/l (Table 2). The level of SS at St. 1 was within the INWQS recommended threshold level which being able to support healthy aquatic life (150 mg/l) whilst St.6 (152.69 mg/l), St. SBN (179.85 mg/l), St. 9 (169.04 mg/l), St. 10 (169.81 mg/l), St. SLU (318.19 mg/l) and St. SLL (219.81 mg/l) were exceeded the suggested value. Other segments of Labu River were acquired SS below 150.00 mg/l. Apparently, SS has threatened fish community in aquatic system.
The death rate of SS level higher than 200 mg/l has been observed (Alabaster and Lloyd, 1982). The numbers of filter-feeding invertebrates will decline due to clogged feeding mechanisms and lead to reduce the availability of food for fish in the water bodies. Likewise, fish may suffer clogging and abrasive damage to gills and other respiratory surfaces. Accumulation of silt particles in the gill and possible flocculation of iron salts affected the gills causing amphyxiation and high mortality (Mohsin and Law, 1980). The fish community usually avoids areas with higher SS by moving away from the sources of SS. Thus, degrees of injury and the actual effects observed to fish fauna in a given level of SS may be less pronounced because of the avoidance behavior.

Fish community: Twelve hardy species were obtained from the study rivers (Table 3). *Clarias batrachus*, Hemirphodon tengah, *ystacoleucus marginatus*, *Puntius binotatus* and *Rosbora sumatrana* were in greater quantity compared to other fish species. A decline trend in term of quantity and species were observed from upperstream to ownstream. Differences average individual of fish from quantitative analysis were considerable. The recorded result indicates that downstream of the Labu River and selected sites of Langat River have experience adverse impact by waterborne pollutants originate from upper reaches of the rivers. A rose drop in the numbers of fish began at St. 6 to downstream of Labu River System and selected sites in Langat River (St. SLU and St. SLL). Depletion of fish community along the river probably explained by high level of SS and avoidance behaviour practice by fish community to dodge from physiological stresses.

Table 2: Mean and standard deviation (±) of the WQI parameters of the study area. Observations were based on 26 replicates. The abbreviation 'St.' refers to station

St. No	NH_3 N	NH_3	BOD	COD	pH	DO	TSS
1	0.31±0.21	0.78±0.52	1.44±0.73	48.04±23.22	6.73±0.20	5.54±1.13	37.88±53.42
2	0.45±0.22	1.12±0.55	1.53±1.19	81.23±51.94	6.74±0.23	5.38±0.73	83.88±64.88
3	0.43±0.24	1.07±0.61	1.38±0.57	101.15±82.21	6.74±0.18	5.25±0.92	68.27±37.44
4	0.49±0.56	1.23±1.40	1.23±0.74	82.46±38.90	6.67±0.24	4.92±1.00	81.23±55.77
5	0.35±0.19	0.89±0.47	1.27±0.51	63.81±35.46	6.58±0.21	5.28±0.87	76.31±61.94
6	0.33±0.20	0.83±0.49	1.30±0.82	100.81±55.19	6.75±0.25	5.43±1.02	152.69±189.19
SBN	2.25±1.05	5.63±2.63	2.29±1.05	94.08±43.03	6.93±0.24	3.80±1.06	179.85±136.35
7	0.79±0.68	1.98±1.17	1.93±1.08	92.08±43.69	6.85±0.30	4.90±0.97	115.38±89.96
8	1.14±0.89	2.84±2.23	2.20±0.90	86.04±46.65	6.79±0.39	4.80±1.21	132.08±135.14
9	1.29±0.99	3.23±2.48	2.01±0.70	87.48±51.08	6.53±0.44	4.42±0.90	169.04±115.38
10	1.62±1.45	4.07±3.63	2.04±0.85	120.38±52.02	6.69±0.59	4.42±0.81	169.81±100.58
SLU	0.93±0.95	2.32±2.37	1.85±0.93	120.35±47.00	6.72±0.27	5.10±0.88	318.19±216.80
SLL	1.13±1.08	2.84±2.71	1.83±0.81	108.00±49.93	6.59±0.31	3.90±1.10	219.81±189.75

Table 3: Number of individuals for all fish collected at study area. Species are listed by rank order of numerical abundance. Observations were based on 6 replicates. The abbreviation St. refers to station

Species	St. No. and number of individuals											
	1	2	3	4	5	6	SBN	7	8	9	0	SLU	SLL
Betta anabatoides	3	0	1	1	0	0	0	0	0	0	0	0	0
Channa murulioides	1	2	0	0	0	2	0	1	0	0	0	0	0
Clarias batrachus	2	12	21	31	4	8	0	1	0	0	0	0	1
Hemirphodon tengah	24	0	0	3	7	2	0	0	0	0	0	0	0
Monopteus albus	1	0	1	0	0	0	0	0	0	0	0	0	0
Mystacoleucus marginatus	21	19	21	8	3	4	0	0	0	0	0	0	0
nemurus	0	0	0	0	0	0	0	0	0	0	0	1	0
Oreochromis mossambicus	0	0	0	0	0	0	3	4	21	0	1	0	0
Poecilia reticulatus	1	1	0	0	0	0	0	0	0	0	0	0	0
Puntius binotatus	66	27	57	17	7	15	0	4	3	0	0	0	0
Rosbora sumatrana	44	7	15	1	8	15	0	10	0	0	0	0	0
Trichogaster trichopterus	0	0	1	0	0	1	0	0	0	0	0	0	0
Total individual	164	70	120	65	34	53	3	27	32	9	11	1	1

Table 4: DOE-WQI index at different stations along Labu River System and Langat River. The abbreviation St. refers to station

Sub-index	St. No.												
	1	2	3	4	5	6	SBN	7	8	9	10	SLU	SLL
SIAN	70.21	64.94	65.81	63.44	68.53	69.45	24.69	53.76	44.72	41.35	35.18	49.90	44.76
SIBOD	94.32	93.92	94.58	95.19	95.05	94.90	90.72	92.23	91.11	91.89	91.78	92.59	92.64
SICOD	46.53	25.52	17.00	24.92	35.27	17.13	19.75	20.58	23.24	22.58	10.74	10.76	14.58
SIDO	74.90	75.65	73.40	65.45	71.70	74.12	47.68	67.37	65.43	58.41	58.40	70.89	48.58
SIpH	98.61	98.69	98.64	98.21	97.63	98.71	99.47	99.19	98.92	97.16	98.37	98.55	97.67
SISS	77.37	59.50	64.87	60.36	62.02	53.32	50.55	57.30	55.49	51.64	51.56	37.90	46.65
WQI-DOE	76.59	69.67	68.93	67.43	71.40	67.87	54.61	64.77	62.88	60.05	57.34	60.28	56.52

DOE-WQI > 92.7=Class I (very clean); 76.3-92.7=Class II (clean); 51.2-76.3=Class III (slightly polluted); 31.0-51.2=Class IV (polluted); < 31.0=Class V (very polluted).

Water quality index (DOE-WQI): Based on the DOE-WQI, St. 1 was classified as clean whilst other segments of the study rivers were in slightly polluted. An obvious deleterious in DOE-WQI along the gradient (Table 4). A strong linear relation (r=0.84) was recorded between abundance of fish and DOE-WQI. The result indicates that water bodies were suitable as a habitat for the survival of aquatic organisms. Community of fish in the assessed rivers has experience apparent effect from SS than others physico-chemical parameters. Avoidance behaviour showed by fish community to dodge from extreme microhabitat has reduced the numbers in particular segments of the rivers. Among the physico-chemical parameters, SS plays a key factor in determine the distribution of fish community. Fish has emigrated to other neighbouring ecosystem to avoid injured caused by SS. However, aquatic life community in the rivers also experienced adverse effect from anthropogenic toxic pollutants. Toxic constituents released from industrial site situated at upper reaches of the Langat River on 5th February 2000 and 6th June 2000 were suspected cause high mortality rate in meso scale to fish community. Physical characteristic of Labu River System which is alike a valley with the middle sections of river is deeper than upperstream and downstream has the ability to retain pollutants from anthropogenic sources for a long periods of time and decreased the DOE-WQI. Dilution and dispersal processes of pollutants have inhibited by slow current flow rate and limited of vertical turbulent. Thus, indirectly effected the distribution and abundance of fish.

Fish community along the study rivers has experience adverse impact not only from DOE-WQI parameters, but also toxic chemicals discharged by industrial processes. The numbers of fish acquired from the assessed rivers indicate that SS was the main contributor in determine the existence of fish community. Combination effects of anthropogenic pollutants have affected fish community and reduce the numbers and species of fish in study ecosystem. Further deterioration will aggravate the presence environment of Labu River System and the water quality not only unable to support aquatic organisms but also threaten the existence aquatic life.

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