FISH COMMUNITY STRUCTURE IN RELATION TO WATER QUALITY OF THE DOWN STREAM OF MUSI RIVER, SOUTH SUMATERA, INDONESIA

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ABSTRACT

Musi River is a large river with its drainage area covers three provinces, South Sumatera, Lampung, and Bengkulu, and with multi uses of its resources. At the down stream of Musi River, most activities are dominated by industries with their waste products go into the river which could harm its aquatic organism. Several assessment studies have been conducted in the Musi River, however they focused on physical and chemical aspects of the water. Aquatic organisms can reveal the real world effects of exceedences and consequent harm more precisely than can be predicted or measured on a chemical and or toxicity basis alone. Compared to other aquatic biota, fish are of particular interest for biological indicators. Species diversity and dominance are component of community structure that can be used to study several changes caused by the aquatic environment degradation The community structure of fish is frequently monitored to describe river conditions. Study in order to determine the fish community structure in relation to water quality of down stream of Musi River was conducted on April and June 2007. Sampling on physical and chemical parameters of the water and sediment, and fish sample were carried in each sampling site. Water sample was collected at a depth of 1.0 m from the water surface by using *kemmerer water sampler*. Some water quality parameters such as temperature, pH, and dissolved oxygen were directly analyzed in the field, while other water quality parameters such as total suspended solids, total dissolved solids, biochemical oxygen demand, nitrate, and phosphate were analyzed in laboratory. Fish sample was collected from the experiment fishing and from the fishermen. Two type of fishing gears, electrofishing, and gill net with 8 different mesh sizes were used. Fish sample from fishing experiment and from the fishermen were collected, sorted based on the species, labelled, measured for their weight and individual number, and then preserved with 10% off formaldehyde water quality parameters were analyzed using principle component analysis while fish relative abundances were analyzed with cluster. Fish community structure through simple diversity and dominance index, and proportionate abundance of species (relative abundance) were correlated with the quality of aquatic environment. The down stream of Musi River station starting from Gandus to PT. SAP station was in degradation prosses state indicated by diversity index in the range of 1 to 2 and high proportion of small fish than that the large fish.

KEYWORDS: **fish community structure, diversity, dominance, water quality, Musi River**

INTRODUCTION

Musi River is a large river with its drainage area covers three provinces, South Sumatera, Lampung, and Bengkulu, and with multi uses of its resources. At the down stream of Musi River, around the Palembang city, most activities are dominated by industries with their waste product go into Musi River which could harm its aquatic organism. Several monitoring and assessment studies have been conducted in Musi River (Badan Pengendalian Dampak Lingkungan, 1997) however they mostly focused on physical dan chemical aspects of the water, but biological aspects.

Unlike chemical water quality, the aquatic biota does not respond instantaneously to normal short term events, unless they are catastrophic in nature. This implies that one variable used in chemical criteria application cannot make or break the aquatic biota its own. The biota can reveal the real world effects of exceedences and consequent harm more precisely than can be predicted or measured on a chemical and or toxicity basis alone (Simon, 1998). There some aquatic biota used as indicators of aquatic environment degradation such as plankton, benthic organisms, and fish (DeYoe, 2001; Zivic *et al.*, 2004; Ganasan & Hughes, 1998; Le land & Fend, 1998; Soto-Galera *et al.*, 1998).

Compared to other aquatic biota, fish are of particular interest for biological indicators since; a) they present in most water bodies; b) their taxonomy, ecological requirement, and life histories are generally better known than those of other assemblages; c) they occupy a variety of trophic levels and habitats; and d) they have both economic and aesthetic values and thus help raise awareness of the value of conserving aquatic systems (Hughes & Oberdorff, 1998). The effect of environment degradation to freshwater fish can be approached from the population to the community level. Fish biotic integrity concept

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developed by Karr *et al.* (1986) *in* Smogor & Angenmeier (1998), is based on the hypothesis that there are predictable relationship between fish assemblages structure and physical, chemical, and biological condition of stream systems (Hughes & Oberdoff, 1998). This concept is widely used and adaptable specially for the countries having routine monitoring program and good data base record since the components to set up the index of fish integrity biotic index derived from spatial and time series data which are very seldom found in developing or some develop countries.

Species diversity and dominance are component of community structure that can be used to study several changes caused by the aquatic environment degradation (Odum *after* Newman, 1994). The community structure of fish is frequently monitored to describe river conditions (Schiemer, 2000). In addition, Ganasan & Hughes (1998) mentioned that the presence, absence, and proportionate abundance of species within fish assemblages indicate the quality of the physical, chemical, and biological condition in which they live.

The objective of this study was to determine the community structure of fish in relation to water quality of the down stream of Musi River, South Sumatera Indonesia.

MATERIALS AND METHODS

Field survey was conducted at the down stream of Musi River, South Sumatera Province of Indonesia on April and June 2007. Seventeen sampling stations were set up based on the characteristic of microhabitat such as the condition of riparian vegetation, the tributary and industrial area (Figure 1).

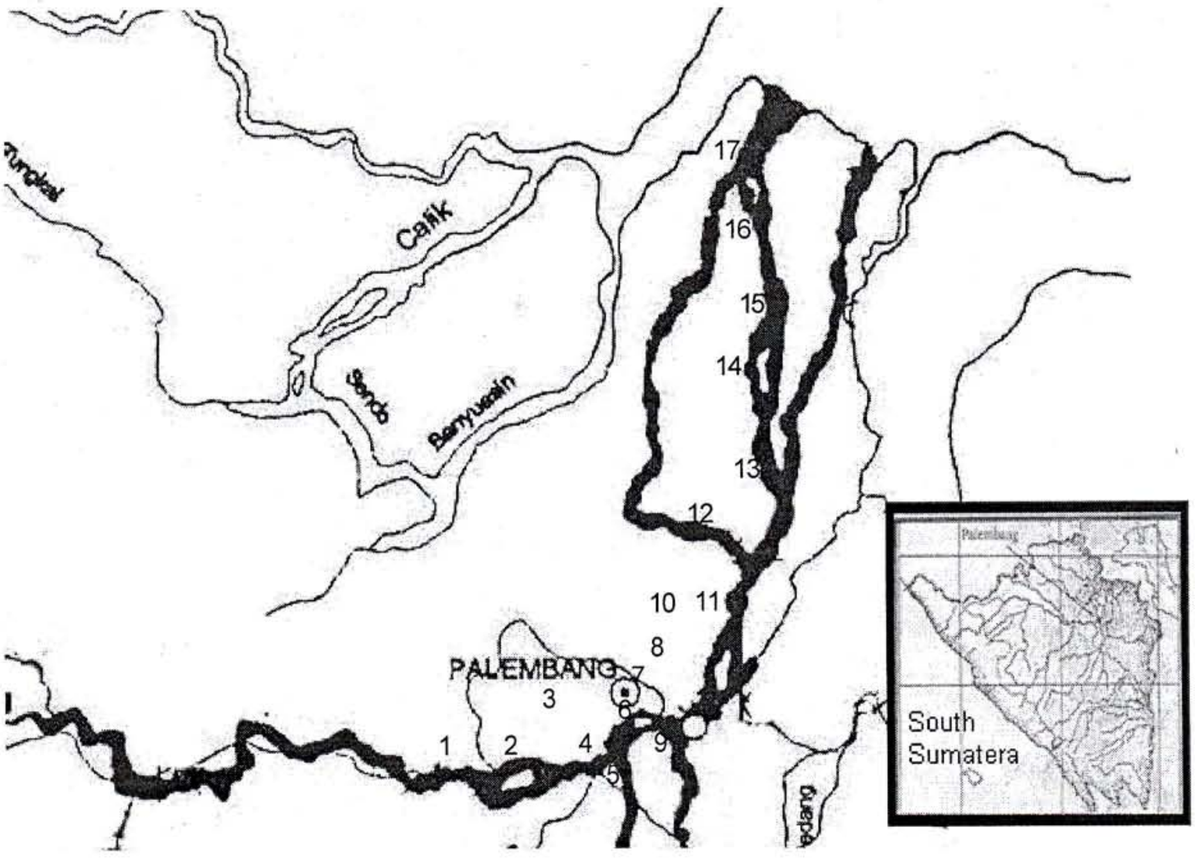

Figure 1. Sampling station for physical and chemical water quality parameters and fish sample at the down stream of Musi River, South Sumatera, Indonesia.

Remarks: 1. Pulokerto; 2. Gandus; 3. Musi II; 4. Muara Kramasan; 5. Muara Ogan; 6. Ampera; 7. Wilmar; 8. Pusri; 9. Hoktong; 10. Kundur River; 11. PT. SAP; 12. total suspended solids; 13. Upang; 14. Pre Cemara; 15. Cemara; 16. Pulau Payung; 17. Teluk Buyut

Water Quality Sampling

Water sample with volume of 3 L were collected at 1 m depth from the water surface at each of the sampling sites by using Kemmerer water sampler. The water sample was distributed into three of 500 mL plastic bottle and one dissolved oxygen and biochemical oxygen demand bottle. Two bottle of 500 mL plastic bottle was preserved at temperature of 4°C for laboratory measurement. Parameters measured in the field were temperature, conductivity, pH, salinity, total alkalinity, and total hardness, while in the laboratory, they were total suspended solids, total dissolved solids, organic carbon, phosphate, nitrate, nitrite, and ammonia (Table 1).

Table 1. Method used for measuring some water quality parameters

Water quality parameters	Method of measurement (APHA, 1980)
Temperature	Visual, thermometer
Conductivity	Conductivity meter
Salinity	Salinometer
pH	Colorimeteric
Total alkalinity	Titrimetric
Total hardness	Titrimetric
Total suspended solids	Gravimetric
Total dissolved solids	Gravimetric
Dissolved oxygen	Titrimetric (Winkler)
Biological oxygen demand (BOD_5)	Titrimetric (Winkler)
Orthophosphate (PO_4)	Ascorbic acid
Nitrate (NO_3)	Cadmium reduction
Ammonia (NH3)	Phenate

Fish Sampling

Fish samples were collected from the experiment fishing and from the fishermen. Two type of fishing gears, electrofishing, and gill net with experiment were used (Nakashizuka & Stork, 2002). Electrofishing is the single most effective gear for obtaining fish assemblages (Yoder & Smith, 1999). The specification of the electrofishing used was generator with power source of 2,500 W, amperage output of 4 A, volts DC output of 500, and it was equipped with a scoop net. The gear was set up in the motor boat and operated to downstream direction at 0.5 km length during the daylight. In each sampling station, electrofishing was operated at both side of the river. In each side, the electrofishing was operated two times.

Gill net experiment was carried out in each sampling stations. A sets of gill net with 8 different opening mesh sizes, 0.75, 1.0, 1.25, 1.5, 1.75, 2.0, 2.25, and 2.5 inche was operated at each size of the river of each sampling stations with operation time approximately 4 hours.

In addition to the fishing experiment, fish sample was also collected from the fishermen using different fishing gears such as electrofishing, gill net, and barrier and fence. Fish sample from fishing experiment and from the fishermen were collected, sorted based on their species, labelled, measured for their weight and individual number, and then preserved with 10% of formaldehyde. Identification of fish species was continued in the laboratory by using Kottelat *et al.* (1993); Weber & Beaufort (Vol. 1911-1940).

Data Analysis

Fish data was tabulated and analyzed further for their diversity and dominance indexs, and relative abundance by using the formula as follows:

Relative abundance:

$$RA = \frac{ni}{Ni} \qquad (1$$

where:

RA = relative abundance
ni = individual number of species-i
Ni = total individual number of species in station-i

Shannon-Wiener Diversity Indexs (Newman, 1994):

$$H' = \sum_{n=1}^{s} pi \ln pi \qquad (2$$

where:

H' = diversity indexs
S = total species number
pi = ni/Ni
ni = individual number of species-i
Ni = total individual number of species in station-i

Diversity indexs can be used to determine the status of aquatic environment degradation (Wilhm & Dorris, 1968 *after* Mason, 1981). A value of H' greater than 3 indicated clean water, value in range 1 to 3 were characteristic of moderately polluted condition and values less then 1 characterized heavily polluted conditions.

Simpson Dominance Indexs (Odum, 1971):

$$D=\sum\left(\frac{ni}{Ni}\right)2 \quad \text{...} (3$$

where:

- D = Dominance Index
- ni = individual number of species-i
- Ni = total individual number of species in station-i

Water quality parameter and relative abundance of fish were tabulated and analyzed with multivariate analysis. Water quality parameters were analyzed with principal component analysis while relative abundance of the fish calculated with cluster analysis by using statisca version 6 software program. All data were checked for their normal distribution before analyzing with these multivariate analysis. Non normal distribution data were transformed with standard transformation formula as described by Krebs (1989).

RESULTS AND DISCUSSIONS

Spasial Distribution of Physico Chemical Parameter

Principal component analysis on correlation matrix of physico chemical parameters of the down stream of Musi River on April and June indicated that the variance at the first, second, and third axis on April was 38.45, 17.89, and 14% respectively. The total variance of these three principal components was 70.34%, less than that the total variance recorded on June which was 78.02% (Figure 2 to 4). More variance that can be explained on June measurement may relate to the slow water current and water discharge during that time. Eventhough the water volume and water discharge were not measured in this study, it can be indicated by lower water depth and slower water current on June than that on April (Figure 5).

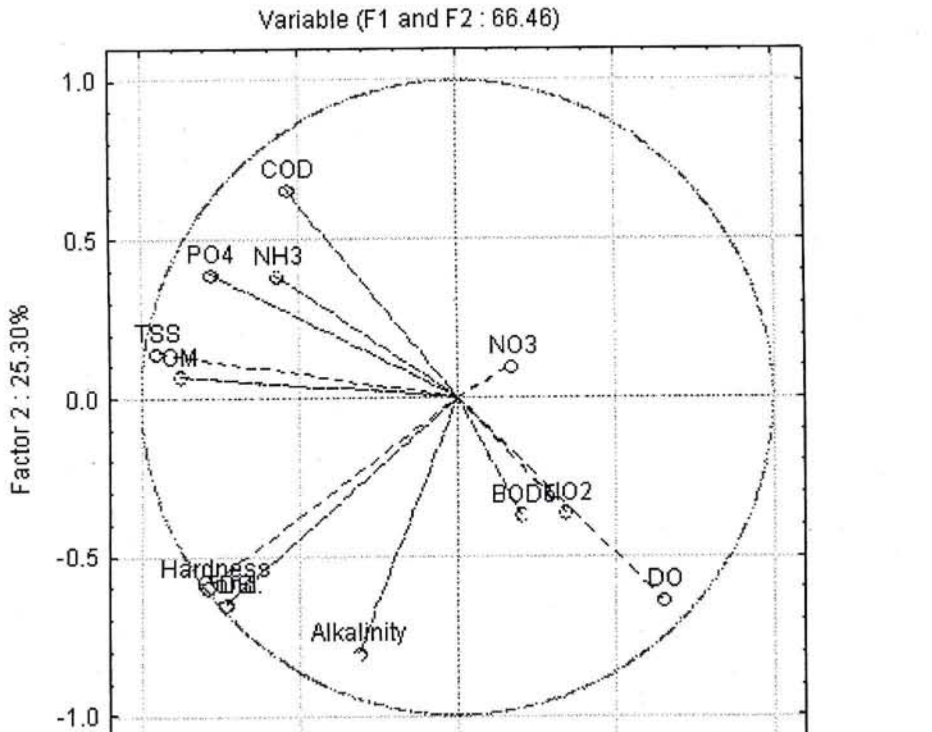

Figure 2. First and second axis of principle component analysis on June. Distribution of physico chemical parameters of the down stream of Musi River

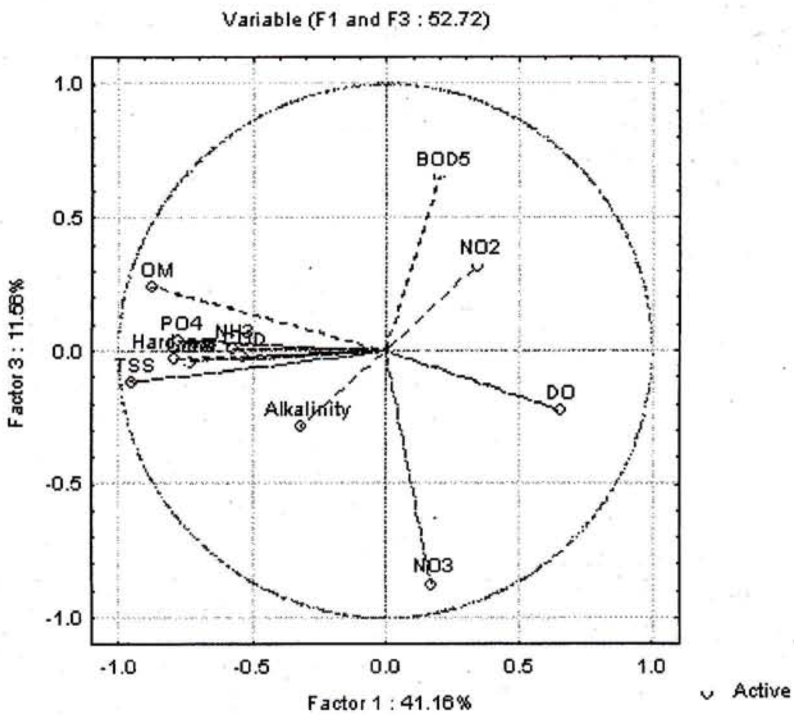

Figure 3a. First and third axis of principle component analysis on June. Distribution of physico chemical parameters of the down stream of Musi River.

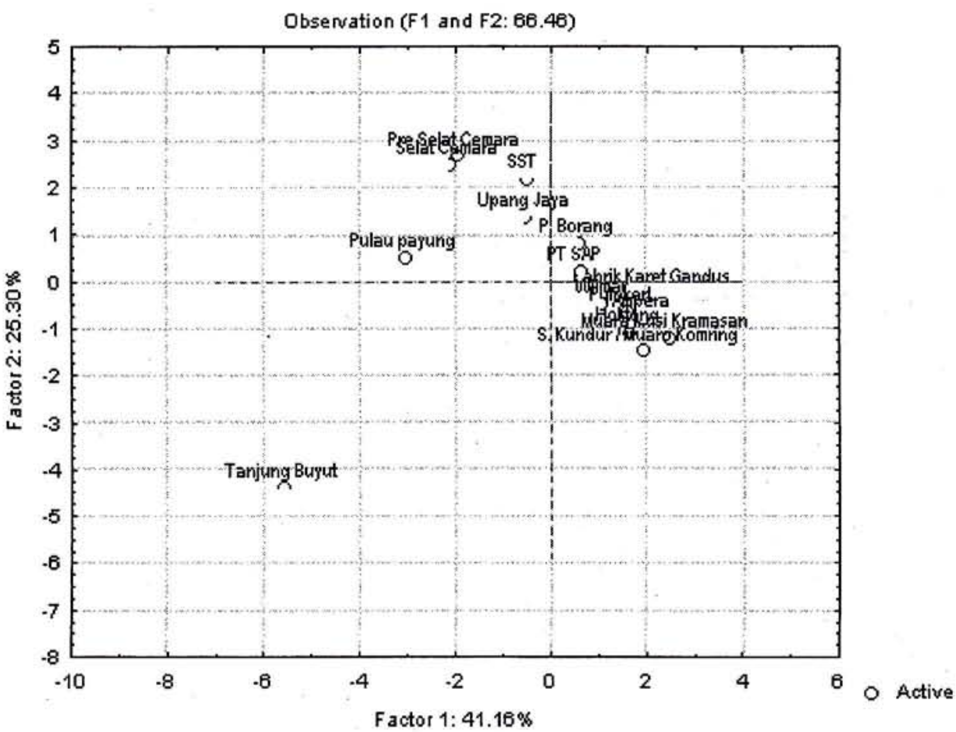

Figure 3b. First and second axis of principle component analysis on June. Distribution of stations of the down stream of Musi River.

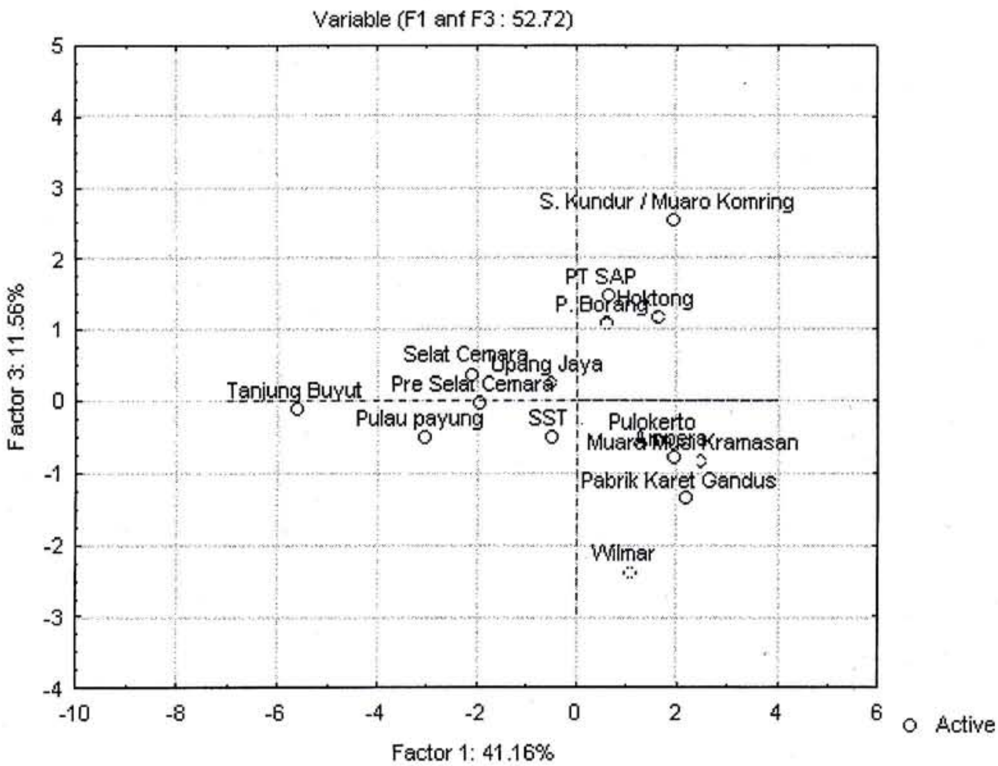

Figure 4. First and third axis of principle component analysis on June. Distribution of stations of the down stream of Musi River.

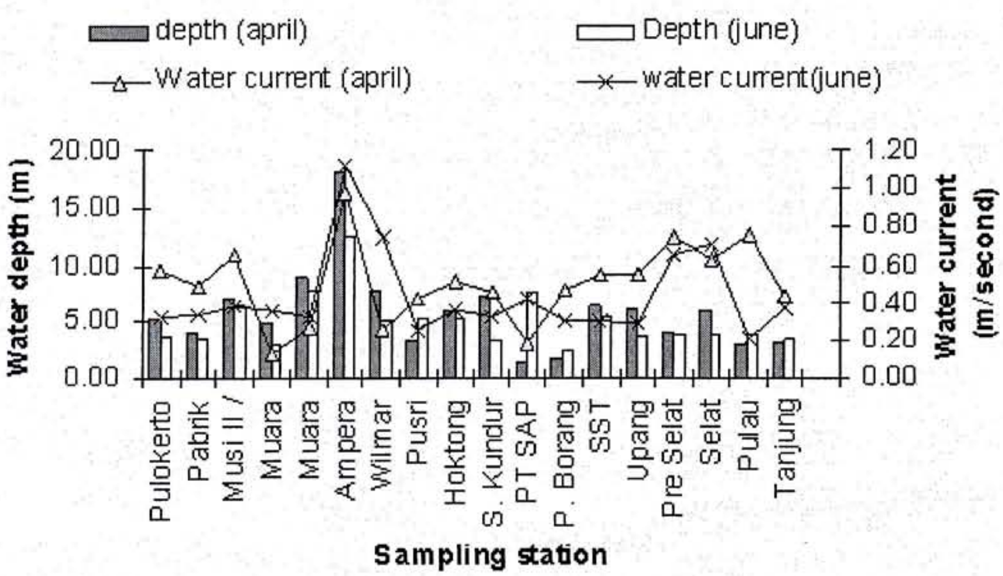

Figure 5. Water depth and current of the down stream of Musi River on April and June 2007.

Principal component analysis showed that there were six groups of station both on April and June observations. The first group were consisted of station Pulokerto, Gandus, and Muara Musi Kramasan. The second group was Musi II, Muara Ogan, and Wilmar. The third group were Pusri, Hoktong, and Kundur River. The forth were PT. SAP, Borang, total suspended solids, and the fifth groups were Upang, Pre Cemara, Selat Cemara, and Pulau Payung. The last group was Teluk Buyut.

In April, the first group was characterized by low concentration of total dissolved solids, organic matter and nitrate, while on June it was characterized by low concentration of hardness and phosphate. The second group was characterized by low concentration of total dissolved solids and organic matter but high concentration of hardness and nitrate. In June, it was similar except for extreme high conductivity and total dissolved solids, while in April, the third group was characterized by low hardness and high in ammonia, while in June, the water quality was in moderate concentration. In April the fourth group was characterized by low in total suspended solids and total dissolved solids, while in June it was characterized by high in ammonia. The fifth and the six group had characteristic almost similar with high concentration of all water quality parameters, except for low ammonia content of group six in April.

The first station group was located at the upper part of other station. Most of activity in this area was rice field with some of two rubber factory and one soya ketchup industry. A better water quality in this stations than that other stations was indicated by low to moderate concentration of physico chemical water parameter. The second station group, which is closed by to the first group, the extreme increasing in conductivity and total dissolved solids concentration in June might relate to sand mining activity located to Musi II stations. As already mention earlier that low water depth and slow water current was suitable for sand mining activities. In the third group, high concentration of ammonia on April could relate to the presence of in organic fertilizer industry. High concentration of most of water quality parameters in fifth and six group was mostly influence by the natural phenomenon since this two group closed by to the mouth of the Musi River.

Fish Community Structure in Relation to the Aquatic Environmental

The total number of fish species found at the down stream of Musi River in April and June was 112 species. In April the number species recorded was 55 species or 49.11% of total species found, while in June it was 105 species or 93.75% of the total species. High percentage of fish species found in June might relate to shallower water depth and slower water current than that in April. This condition make the chance of fish was captured by most of fishing gears. According to Hughes & Oberdoff (1998); Welcomme (2001), fishing activity in large river mostly affected by the water depth. Electrofishing was more effective operated in shallow water than that in deep water.

Analysis of diversity index revealed that in April, the diversity index in all station were less than 1 while on June it was in the range of 1 to 2 in most of stations, except at station Pusri and Teluk Buyut. Low diversity index on April could relate to the effectiveness of the fishing gear due to high water depth and water current. The diversity index in the range 1 to 2 showed that aquatic environment was in the degradation process. According To Whilm & Dorris (1968) *after* Mason (1981), the environment was in degradation process if the diversity index in the range of 1 to 3.

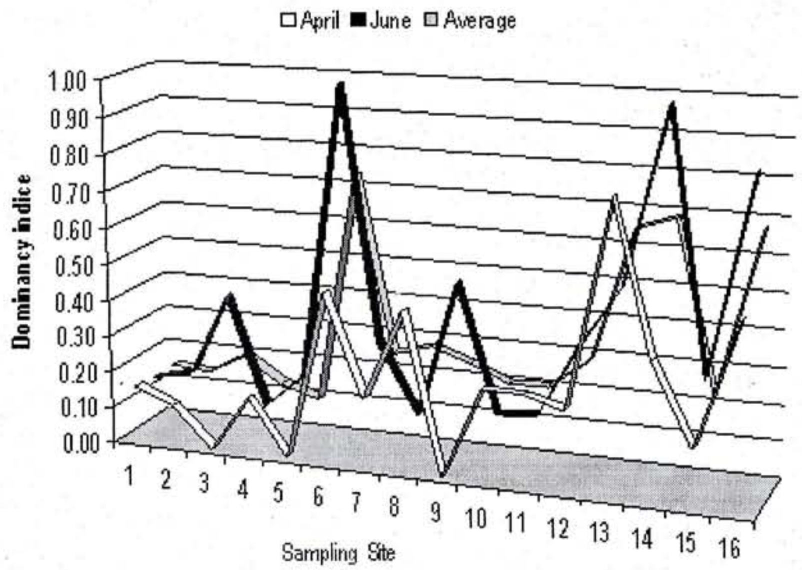

Figure 6. Dominance index of fish at the down stream of Musi River.

This finding was quite similar with study conducted by Husnah *et al.* (2007) that used macrozoobenthos as an indicator of aquatic degradation. The diversity index was in the range 1 to 2. The lowest diversity index was occurred in station Pusri and Selat Cemara.

A more clear picture on the condition of fish community structure can be extrated from dominance index (Figure 6). High Simpson Index at station Pusri and Selat Cemara supported the statement earlier on the low diversity index in both stations. Even though both Pusri and Selat Cemara Stations having low diversity index and high dominance index, the dominant fish species in Pusri was different from the dominant species in Selat Cemara. In Pusri station, fish community was dominated by small sized fish such as (*Rasbora* sp.) with relative abundance reached 60.61% while in Selat Cemara it was dominated by larged sized fish such as *Lycothrissa crocodiles* that it relative abundance reached 100% (Appendix 2). This phenomenon in accordance with Welcomme (2001) statement that decreasing quality of aquatic environment can be indicated by reducing fish size and domination of small sized Cyprinid fish.

Small number of fish being caught in April influenced the cluster analysis on relative abundance in relation to the aquatic environment (Appendix 1). Due to this fact, the result discussion presented in this considered more to June observation (Appendix 2). Station group resulted from this cluster analysis was quite different from the station group based on physico chemical parameter (Figure 7). Two station groups was found. The first station group was Pulokerto, Gandus, Muara Musi Kramasan, PT. SAP, Pusri, and Hoktong, and the second station group was the rest of all stations. The first group characterized by low concentration of phyco chemical water quality parameter but high in nitrite concentration, while the second station group characteristic was high concentration of all water quality parameters except nitrite. The first station group was dominated by small sized fish such as *Barbodes schwanenfeldii*, *Clupeoides borneensis*, *Crossochilus oblongus*, *Rasbora argyrotaenia var 1*, while the second group dominated by *Boesemania microlepis*, *Cyclocheilichtys enoplos*, *Mystus gulio*, and *Mystus wolfii*. *Boesemania microlepis* and *Cyclocheilichtys enoplos* were mid layer and economic fish with their average size longer than the fish species in group station 1.

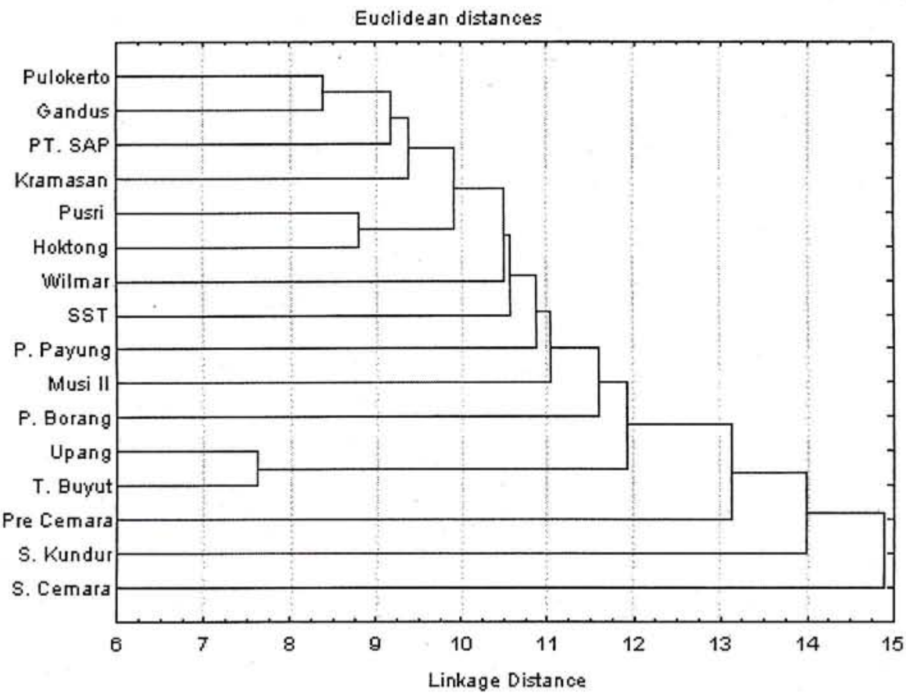

Figure 7. Cluster analysis of fish relative abundance based on station.

It can be summarized that fish community structure through simple diversity and dominance index, and proportionate abundance of species (relative abundance) can be used to determine the quality of aquatic environment. The down stream of Musi River station Gandus to PT. SAP was in degradation process state indicated by diversity index in the range of 1 to 2 and high proportion of small fish than that the large fish.

CONCLUSSIONS AND RECOMENDATIONS

Fish community structure through simple diversity and dominance index, and proportionate abundance of species (relative abundance) can be used to determine the quality of aquatic environment. The down stream of Musi River starting from station Gandus to PT. SAP was in degradation process indicated by diversity index in the range of 1 to 2 and high proportion of small fish than that the large fish. It recommend to find the alternative way to reduced total dissolved solids resulted from sand mining in Musi II station, and ammonia and nitrite concentration of Pusri and Hoktong stations.

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Appendix 1. Relative abundance of some fish at the down stream of Musi River on April 2007

Fish species	Relative abundance (%)/Sampling Sktes														
	1	2	3	4	6	7	8	10	11	12	13	14	15	16	17
Achiroides leucorhynchos	0	0	0	1.33	0	0	9.09	0	0	0	0	0	0	0	0
Achiroides melanorhynchus	0	0	0	0	0	0	9.09	0	0	0	0	0	0	0	0
Albulichthys albuloides	0	1.52	0	0	0	0	0	0	0	0	0	0	6.67	50	0
Barbichthys laevis	0	0	16.7	0	0	4.55	0	6.67	0	0	0	0	6.67	0	0
Barbodes schwanenfeldii	0	0	16.7	0	0	0	0	0	0	0	0	0	0	0	8.33
Boesemania microlepis	0	0	33.3	2.67	2.86	4.55	0	6.67	0	0	0	0	6.67	0	0
Bostrichthys sinensis	6.67	0	0	4	2.86	0	0	0	0	0	0	0	0	0	0
Chonerhinos remotus	0	1.52	16.7	0	0	0	0	0	0	0	0	0	0	0	0
Clarias batrachus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clarias nieuhofii	0	1.52	0	0	0	0	0	0	0	0	0	0	6.67	0	0
Clupeoides borneensis	0	0	0	0	0	0	0	6.67	0	16.7	0	0	0	0	0
Coilia borneensis	0	0	0	0	0	4.55	0	0	0	0	0	0	0	0	0
Crossochilus oblongus	20	6.06	16.7	2.67	0	0	0	0	0	0	0	0	0	0	0
Epalzeorhynchus kallopterus	0	3.03	0	2.67	0	0	0	0	0	0	0	0	0	0	0
Escualosa thoracata	0	6.06	0	0	2.86	9.09	9.09	0	0	0	0	0	6.67	50	0
Glossogobius giuris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glossogobius giuris spp2.	0	1.52	0	0	0	0	0	6.67	0	0	0	0	0	0	0
Hampala macrolepidota	0	0	0	1.33	0	0	0	0	0	0	0	0	0	0	8.33
Hemisilurus scleronema	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.33
Kryptopterus sp.	0	6.06	0	0	0	0	0	0	0	0	0	0	0	0	0
Kryptopterus apogon	0	0	0	0	0	0	0	0	12.5	0	0	0	0	0	0
Kryptopterus micronema	0	0	0	2.67	0	0	0	0	0	0	0	0	0	0	0
Kryptopterus minor	6.67	3.03	0	24	17.1	13.6	63.6	0	0	0	0	0	6.67	0	0
Labeo chrysophekadion	0	18.2	0	2.67	0	4.55	0	0	0	0	0	0	0	0	0
Labeobarbus cuvieri/Labeobarbus leptocheilus	0	3.03	0	0	0	0	0	0	0	0	0	0	0	0	0
Labeo erythropterus	20	1.52	0	0	0	0	9.09	0	0	0	0	0	0	0	0
Labiobarbus ocellatus	0	0	0	1.33	0	0	0	0	0	0	0	0	0	0	0
Laides hexanema	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.7
Leiocassis mahakamensis	0	0	0	0	0	0	0	0	0	0	0	25	6.67	0	8.33
Leptosynanceia asteroblepa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.33
Liza tade	0	0	0	0	0	0	0	6.67	25	16.7	0	0	6.67	0	0
Lycothrissa crocodilus	0	0	0	0	2.86	0	0	0	0	0	12.5	50	6.67	0	0
Mastacembelus erythrotaenia	0	3.03	0	0	0	0	0	0	0	0	0	0	0	0	0
Microphis brachyurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.7
Muraenesox talabon	0	0	0	0	0	0	0	0	0	0	87.5	0	0	0	0
Mystus gulio	0	0	0	0	0	4.55	0	6.67	0	0	0	0	0	0	0
Mystus nemurus	0	0	0	0	0	0	0	46.7	0	0	0	0	0	0	0
Ompok bimaculatus	0	1.52	0	1.33	0	0	0	0	0	0	0	0	0	0	0
Ophiocephalus striata/Channa striata	0	0	0	1.33	0	0	0	0	0	0	0	0	0	0	0

Continuing Appendix 1. Relative abundance of some fish at the down stream of Musi River on April 2007

Fish species	Relative abundance (%)/Sampling Sktes														
	1	**2**	**3**	**4**	**6**	**7**	**8**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Oreochromis niloticus	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Osteochilus hasseltii	20	22.7	0	0	0	22.7	0	0	0	0	0	0	0	0	0
Osteochilus melanopleura	0	3.03	0	6.67	0	0	0	0	0	0	0	0	0	0	0
Osteochilus schlegelli	0	3.03	0	0	2.86	0	0	0	0	0	0	0	0	0	8.33
Osteochilus vittatus/0. microcephalus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Otolithoides pama	0	0	0	1.33	0	0	0	0	0	0	0	0	0	0	0
Pangasius hypopthalmus	0	3.03	0	0	0	0	0	0	37.5	33.3	0	25	0	0	8.33
Pangasius polyuranodon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parachela oxygastroides	0	0	0	1.33	0	0	0	0	0	0	0	0	0	0	0
Parambassis macrolepis	0	0	0	0	0	0	0	0	0	16.7	0	0	0	0	0
Polynemus longipectoralis	0	0	0	0	0	0	0	0	12.5	16.7	0	0	0	0	0
Polystonemus multifilis	0	1.52	0	1.33	2.86	0	0	0	0	0	0	0	0	0	0
Puntius lineatus	13.3	9.09	0	29.3	65.7	31.8	0	0	12.5	0	0	0	6.67	0	0
Setipinna taty	0	0	0	5.33	0	0	0	0	0	0	0	0	0	0	0
Stolephorus indicus	0	0	0	0	0	0	0	6.67	0	0	0	0	0	0	0
Toxotes microlepis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichiurus sp.	6.67	0	0	1.33	0	0	0	0	0	0	0	0	0	0	0
Trichogaster pectoralis	6.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tricogaster trichopterus	0	0	0	0	0	0	0	0	0	0	0	0	33.3	0	8.33
Tylosurus leiurus	0	0	0	1.33	0	0	0	6.67	0	0	0	0	0	0	0
Zenarchopterus ectuntio	0	0	0	1.33	0	0	0	6.67	0	0	0	0	0	0	0

Remarks: 1. Pulokerto; 2. Pabrik Karet Gandus; 3. Musi II; 4. Muara Musi Kramasan; 5. Ampera; 6. Wilmar; 7. Pusri; 8. Hoktong; 9. Kundur; 10. PT. SAP; 11. Pulau Borang; 12. Total suspended solids; 13. Upang; 14. Pre Cemara; 15. Selat Cemara; 16. Payung Payung; 17. Teluk Buyut

Appendix 2. Relative abundance of some fish at the down stream of Musi River on June 2007

Fish species	Relative abundance (%)/Sampling sites															
	1	2	3	4	6	7	8	9	10	11	12	13	14	15	16	17
Achiroides leucorhynchos	0.97	0.09	0	0.45	0.98	0	0	0	2.42	0	0	0	0	0	0.15	0
Achiroides melanorhynchus	0	0	0	0.45	3.42	0	0	0	0	0	0.8	0	0	0	0.15	0
Albulichthys albuloides	0	0	0	0	0	0	2.36	10.3	0	4.59	1.6	0	0.26	0	0	0
Anabas testudineus	0	0.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arius macronothacanthus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arius trucantus	0	0	0	0.23	0	0	0	0	0	0	0	0	0	0	0	0
Bagroides melapterus	0	0.18	0	0	0	0	0	4.31	0	0	0	0	0	0	0	0
Balantiocheilus melanopterus	0	0.79	0	0.79	0	0	8.25	0	0.4	0	5.6	0	0.13	0	0.08	0
Barbichthys laevis	0.39	0.09	0	0.11	0	0	0	0	0	0	0	0	0	0	0	0
Barbodes schwanenfeldii	8.88	31.2	12.2	9.93	2.44	0	0.67	0	69.1	0.92	1.6	0	0	0	0	0
Boesemania microlepis	0	0	0	0	0	0	0	0.86	0	0	0	0	0.13	0	0.53	0
Bostrichthys sinensis	0	0.09	0	0.79	1.22	0	0.34	0	0	0.92	0	3.7	0.79	0	0	0
Butis butis	0	0.18	0	0.23	0	0	0	0	0	0.92	0	0	1.44	0	0	0
Butis humeralis	0.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Butis melanostigma	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0
Chanos chanos	0	0	0	0	0.24	0	0	0	0	0	0	0	0	0	0	0
Chonerhinos remotus	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0	0
Clarias batrachus	0	0.09	3.67	0.23	0	0	0	0.86	0	0	0.8	3.7	0	0	0	0
Clarias nieuhofii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clupeoides borneensis	0	0	0	0.56	1.22	0	33.7	0	0	3.67	0.8	0	0.52	0	53.3	0
Coilia lindmani	0	0	0	0	18.6	0	0	3.45	0	0	0.8	0	0.39	0	1.44	0
Coilia borneensis	0	0	0	0	0	0	0	0	0	0	0	0	0.13	0	0	0
Crossochilus oblongus	0.19	0.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyclocheilichtys enoplos	2.7	7.58	0	7.11	12.7	0	0	3.45	0.81	0	32	0	0.66	0	0	0
Cyclocheilichtys repasson	0	0	0	0	0.73	0	0	0	0	0	0	0	0	0	0	0
Cynoglossus feldmanni	0	0	0	0	0.24	0	0	0	0	0	0	0	0	0	0	0
Cynoglosus lingua	0	0	0	0	0	0	0	13.8	0	0	0	0	0	0	0	0
Datniodes quadrifasciatus	0	0	0	0	0	0	0	0	0	0	0.8	3.7	1.57	0	0.15	0
Drepane punctata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0
Eleutheronema tetradactylum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.45	0
Epalzeorhynchus kallopterus	0	0.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Escualosa thoracata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.51	0
Glossogobius giuris	1.54	0	0	0.23	2.2	0	0	0	10.9	3.67	0	0	2.23	0	2.95	4.17
Glossogobius giuris spp2.	0.19	0	0.41	0.11	0	0	0	0	0	0	0.8	0	0	0	0	0
Hampala macrolepidota	1.54	0.18	0.82	0	0	0	0	0	0.2	0	0.8	0	0	0	0	0

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Continuing Appendix 2. Relative abundance of some fish at the down stream of Musi River on June 2007

Fish species	Relative abundance (%)/Sampling sites															
	1	2	3	4	6	7	8	9	10	11	12	13	14	15	16	17
Hemipimelodus borneensis	0	0	0	0	0	0	0	15.5	0	0	0	0	0	0	0	0
Hemisilurus scleronema	0	0	0	0	0	0	0	0.86	0	0	0	0	0	0	0	0
Ilisha elongata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.17
Johnius belengeri	0	0	0	0	0	0	0	19.8	0	0	0	0	0.79	0	1.21	0
Kryptopterus sp.	0	0	0	0.45	0	0	0	0	0	0	0	0	0.13	0	0	0
Kryptopterus apogon	0	0	0	0	0	0	0	0.86	0	0	0	0	0	0	0	0
Kryptopterus cryptopterus	0	0.44	0	0	6.36	0	0	0	0	0	0	0	0	0	0	0
Kryptopterus micronema	0.39	0.18	0	0	0	0	0	0.86	0	0	0	0	0	0	0.08	0
Kryptopterus minor	0.58	0.18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Labeo chrysophekadion	0.58	0.18	0	0.56	1.22	0	0	0	0.4	0.92	0.8	0	0.13	0	0	0
Labeobarbus cuvieri/Labeobarbus leptocheilus	3.28	16.2	1.63	8.01	0.98	0	0	0	0	0	0	0	0	0	0	0
Labeo erythropterus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Labiobarbus ocellatus	0	0.18	0	0.56	0.49	0	0	0	0	0	0	0	0	0	0.08	0
Lagocephalus lunaris	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0	12	0
Laides hexanema	0	0	0	0.23	0	0	0	0	0	0	0	0	0	0	0	0
Lates calcarifer	0	0	0	0	0	0	0	0	0	0	0	0	0.52	0	0	0
Leiocassis rugosus	0.58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leiognathus decorus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0
Leiognathus dussumieri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.89	0
Leiocassis mahakamensis	0	0	0	0	0	0	0	0	0	0	0	3.7	0	0	0	0
Liza tade	0	0	0	0	0	0	0	0	0	0	0	0	0.13	0	0	0
Lycothrissa crocodilus	0	0	0	0	0	0	0.84	0	0	0	0	0	0	100	0	0
Macrochirichthys macrochirus	0	0	0	0	0	0	0	0	0	0.92	0	0	0	0	0	0
Mastacembelus erythrotaenia	0	0	0	0	0	0	0	0	0.2	1.83	0	0	0.66	0	0	0
Mastacembelus unicolor	0	0	0	0	0	0	0	0	0	0	0	0	0.13	0	0	0
Microphis brachyurus	0	0	0	0	0	0	0	0	0	0	0	0	0.52	0	0	0
Mystus gulio	2.7	0	0	0	0.49	0	0	0	0	0	0	55.6	2.1	0	0	91.7
Mystus nemurus	0.19	0.26	0	0	0	0	0	0	0.4	1.83	0.8	0	0	0	0.15	0
Mystus nigriceps	0.19	0.09	0	20.8	0	0	0.17	0	0	0	4	0	0	0	0	0
Mystus wolfii	0.19	4.85	0	0	0	0	0	0	3.43	0	0	0	71.9	0	1.59	0
Ophiocephalus striata/Channa striata	0.19	0	0	0.23	0	0	0	0	0	0	0	0	0	0	0	0
Oreochromis niloticus	0	0	0.41	0	0	0	0	0	0	0	0	0	0	0	0	0
Osteochilus hasseltii	1.93	1.59	0.41	0.34	0	0	0	0	0	0	0	0	0	0	0	0
Osteochilus melanopleura	3.09	0	0	0	0	0	0	0	2.02	0	0.8	0	0	0	0.15	0

Continuing Appendix 2. **Relative abundance of some fish at the down stream of Musi River on June 2007**

Fish species	Relative abundance (%)/Sampling sites															
	1	2	3	4	6	7	8	9	10	11	12	13	14	15	16	17
Osteochilus schlegelli	0.58	2.12	0	12.6	0.24	0	0	0	0.2	0	1.6	0	0.66	0	0	0
Osteochilus vittatus/ O. microcephalus	2.51	0.26	58.5	5.98	1.96	0	0.34	0	0.61	0	0.8	0	0	0	0	0
Otolithoides pama	0	0	0	0	0	0	0	1.72	0	0	0	0	0	0	1.89	0
Oxyeleotris uropthalmoides	0.19	0	0	0.56	0.24	0	0	0	2.02	0	0	0	0.39	0	0	0
Pangasius hypopthalmus	0	0.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pangasius polyuranodon	0	0.18	0	0	0.73	0	0	8.62	0	6.42	3.2	0	0.26	0	0	0
Parachela oxygastroides	0.19	0	0	1.13	0.24	0	4.21	0	0	0	0.8	0	0	0	2.27	0
Parambassis macrolepis	0.19	4.85	0	0.23	0	0	0	0	0	0	0	0	0.13	0	1.97	0
Parambassis wolffii	3.09	1.23	0	4.4	1.22	0	0	1.72	1.82	8.26	4	0	1.44	0	0.53	0
Parapocryptes serperaster	0	0	0	0	0	0	0	0	0	0	0	0	0.13	0	0.08	0
Periopthalmodon schlosseri	0	0	0	0	0	0	0	0	0	0	0	0	0.13	0	0	0
Poecilia reticulata	0.39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polynemus longipectoralis	0	0	0	0	0	0	0	0	0	21.1	0	3.7	0	0	0	0
Polystonemus multifilis	0	0	0	0	0	0	0	12.9	0	0	0.8	0	0	0	0	0
Pristolepis fasciata	1.93	0.53	0.82	1.02	0	0	0	0	0.61	3.67	0.8	0	0.13	0	0.08	0
Puntioplites bulu	0.77	0	0	1.13	0	0	0	0	0	0	0	0	0	0	0	0
Puntioplites waandersi	9.65	0	0	10.3	0	0	0	0	0	0	0	0	0	0	0	0
Puntius fasciatus	0	0.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rasbora argyrotaenia	17.2	8.82	0	3.39	36.4	0	0	0	0	0	3.2	0	0	0	0	0
Rasbora argyrotaenia var1.	30.7	16.9	20.3	6.43	5.38	100	43.3	0	4.04	12.8	20	18.5	6.56	0	0.53	0
Rasbora argyrotaenia var2.	0	0	0	0	0	0	4.38	0	0	0	0	0	0	0	0	0
Rasbora sp.	0.39	0	0	0	0	0	1.18	0	0.2	26.6	8	0	2.49	0	0	0
Redigobius isognathus	0	0	0	0	0	0	0	0	0	0	0	0	0.13	0	0	0
Scatopagus argus	0	0	0	0	0	0	0	0	0	0	0	3.7	0	0	0	0
Secutor interruptus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.95	0
Setipinna sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.68	0
Setipinna taty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.38	0
Stolephorus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stolephorus dubiosus	0	0	0	0.11	0	0	0	0	0	0	0	0	0	0	2.04	0
Stolephorus indicus	0.97	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0
Toxotes microlepis	0	0	0	0	0	0	0	0	0	0	0	3.7	0.39	0	0	0
Triacanthus brevirostris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.13	0
Trichiurus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.34	0
Tricogaster trichopterus	0.77	0	0.41	0.34	0	0	0	0	0	0.92	0.8	0	0	0	0	0
Zenarchopterus ectuntio	0	0	0.41	0	0	0	0.17	0	0	0	2.4	0	1.84	0	0.08	0

Remarks: 1. Pulokerto; 2. Pabrik Karet Gandus; 3. Musi II; 4. Muara Musi Kramasan; 5. Ampera; 6. Wilmar; 7. Pusri; 8. Hoktong; 9. Kundur; 10. PT.SAP; 11. Pulau Borang; 12. Total suspended solids; 13. Upang; 14. Pre Cemara; 15. Selat Cemara; 16. Pulau Payung; 17. Teluk Buyut