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HEAVY METALS POLLUTION IN RIVERS AT TANJUNG PUTING NATIONAL PARK, CENTRAL KALIMANTAN

by

AWALINA AND DEDE IRVING HARTOTO[1)]

ABSTRACT

A study to reveal the state of heavy metals pollution in Tanjung Puting National Park is conducted in 1995. Monitoring of iron, manganese, lead and mercury contents in water column, fish and sediment was done based on three sampling times at several sampling sites in River Sekonyer (buffer zone) and River Buluh Besar (core zone). Water samples were taken as a composite of the upper and bottom layer. Sediment samples were collected from the riverbed using Ekman-Birge Grab. Fish samples were taken only from River Sekonyer. Analysis of heavy metals was conducted using wet and dry ashing method prior to measurement by Flame-Atomic Absorption Spectrophotometry (AAS) but for mercury, the measurement was done by Cold-vapor-AAS method. Water and sediment samples were digested with HNO_3 before analysis with the AAS method. The results show that River Sekonyer water contained 0.099 mg Hg/L (990 times higher than that of safe concentration), 0.181 mg Pb/L (181 times), 0.273 mg Fe/L and 0.069 mg Mn/L. Meanwhile, River Buluh Besar water contained 0.177 mg Hg/L (1770 times), 0.105 mg Pb/L (1.05 times), 0.578 mg Fe/L, and 0.035 mg Mn/L. In average, River Buluh Besar sediment had iron (2851.703 mg/kg, dry weight) and mercury (22.742 mg/kg) concentration higher than in River Sekonyer, that were 1061.756 and 7.859 mg Hg/kg respectively. Lead concentration in River Sekonyer, both in water (0.181 mg Pb/L) and sediment (16.308 mg Pb/kg) were higher than the concentration in River Buluh Besar (0.105 mg Pb/L and 3.532 mg Pb/kg). Apparently, high activity of illegal gold mining and the usage of petroleum with its tetraethyl lead additive for motorboat fuel, contribute to this phenomenon. Average heavy metal bioconcentrations in fish are 5.805, 1.155, 12.540 and 0.005 mg of heavy metal atom/kg (dry weight) for lead, mercury, iron and manganese respectively.

ABSTRAK

PENCEMARAN LOGAM BERAT DI SUNGAI-SUNGAI DI KAWASAN TAMAN NASIONAL TANJUNG PUTING, KALIMANTAN TENGAH. *Studi untuk mengungkapkan pencemaran logam berat telah dilakukan di Taman Nasional Tanjung Puting pada tahun 1995. Pemantauan kandungan besi, mangan, timbal dan merkuri telah dilakukan di kolom air, sedimen dan daging ikan dengan tiga kali pengambilan contoh pada beberapa stasiun pengambilan contoh di Sungai Sekonyer (zona penyangga) dan Sungai Buluh Besar (zona inti). Contoh air diambil secara komposit dari lapisan atas dan dasar, sedangkan sedimen diambil dengan Ekman-Birge Grab. Contoh ikan hanya diambil dari S.*

1) Research Center for Limnology, Indonesian Institute of Sciences, Kompleks LIPI Cibinong 16911 Cibinong – Bogor, Indonesia. Tel: 021-8757071 Fax: 021-8757076, E-mail: awalina.satya@lipi.go.id

Sekonyer. Sampel diolah dengan cara pengabuan basah dan kering sebelum diukur dengan Metoda AAS (Atomic Absorption Spectrophotometry) Nyala Api, kecuali untuk merkuri yang dilakukan dengan Metoda Uap Dingin-AAS. Contoh air dan sedimen dihidrolisis dengan HNO_3 sebelum dianalisis secara AAS. Hasilnya menunjukkan bahwa konsentrasi merkuri di air S. Sekonyer adalah sebesar 0,099 mg Hg/L (atau 990 kali lebih besar dari konsentrasi aman untuk kehidupan akuatik), timbal 0,181 mg Pb/L (1,81 kali), 0,273 mg Fe/L dan 0,069 mg Mn/L. Air S. River Buluh Besar mengandung 0,177 mg Hg/L (177 kali), 0,105 mg Pb/L (1.05 kali), 0,578 mg Fe/L, dan 0,035 mg Mn/L. Secara rata-rata, sedimen S. Buluh Besar mengandung konsentrasi besi (2851,703 mg/kg, bobot kering) dan merkuri (22,742 mg/kg) yang lebih tinggi dibandingkan dengan konsentrasi logam yang sama di S. Sekonyer yaitu masing 1061,756 and 7,859 mg Hg/kg. Lead Konsentrasi timbal S. Sekonyer, baik di air (0,181 mg Pb/L) atau di sedimen (16,308 mg Pb/kg) lebih tinggi dari pada konsentrasi logam tersebut di S. Buluh Besar (0,105 mg Pb/L and 3,532 mg Pb/kg). Nampaknya aktivitas penambangan emas tanpa ijin dan pengunaan bensin yang mengandung timbal tetra etil asetat menyebabkan fenomena ini. Rata-rata konsentrasi logam berat pada ikan adalah 5,805, 1,155, 12,540 and 0,005 mg/kg atom logam berat (bobot kering) masing-masing untuk timbal, merkuri, besi dan mangan.

INTRODUCTION

Many studies on flora and fauna already conducted in Tanjung Puting National Park but mostly on vegetation, birds, reptiles and mammals (FAKULTAS KEHUTANAN-INSTITUT PERTANIAN BOGOR 1976; HAERUMAN *et al.* 1976, DARJADI *et al.* 1980; BISMARK, 1980, PRASETYO *et al.* 1991 AND RAHMAN *et al.* 1995). There are very little information on ichthyofauna communities of this national park, except NASH and NASH (1987) statement on the existence of dragon fish *(Scleropages formosus)* that was already listed in IUCN Red Data Book. Large part of Tanjung Puting is permanently water logged with 50 percent of its area consists of peat swamp forest that characterized with black water of low pH. Up to now there are also very few limnological studied that ever conducted in this national park (Hartoto and Yustiawati, in publication).

Around 1990's, in the upstream part of River Sekonyer Simpang Kiri, at Aspai area, a hundred hectares of illegal gold mining was operated by the illegal miners (Banjarmasin Post, 6 July 1995). Beside observable increased in turbidity, it was suspected that another type of pollution also exist due to this mining. Dr. Carry Yaeger an American mammalian researcher, resident at Natay Lengkuas sampled the roots of plants and sediment in 1992 and analyzed the samples in United States with Atomic Fluorescence Spectrophotometer. She reported that the mercury concentration at that time already reached 0.25 mg/L. Her sampling conducted with the officers from Tanjung Puting National Park in 25 June and 11 July 1995 resulted that the concentration of mercury in the water analyzed with mercury test already reached up to 10 mg/L (Banjarmasin

Post, 27 July 1995). These data of mercury concentration was very high probably because the methods she used are known among the chemical limnologist as an insensitive one. In relation to this condition, this study was aimed to reveal the state of lead, iron, manganese and mercury pollution in some sites in Tanjung Puting National Park river system.

MATERIAL AND METHODS

The samples that are consisted of water, sediment and fish were taken from several sampling sites in River Sekonyer and River Buluh Besar. Those sampling sites represent the wilderness zone, buffer zone and the core zone of Tanjung Puting National Park (Fig. 1). Water samplings were done three times during 1995 (1 August 1995, 4 October 1995 and 20 November 1995) at five sampling sites. River Sekonyer in this study was divided into three sampling sites, namely SS1, SS2, and SS3. Two sampling sites were located in River Buluh Besar. The description of the sampling sites presented on Table 1.

From each sampling site, water samples were collected compositely from the upper and bottom water layer. Sediment samples were taken from the bottom of each sampling sites using an Ekman-Birge Grab.

Fish samples were collected only from River Sekonyer. These fishes were captured using experimental gill nets, hook and lines, or bought from the local fishers that caught the fish using other fishing gears. Fish samplings conducted at the same time with water and sediment sampling.

One to twenty five grams of fish muscle from body part between pectoral and anal fin were sampled from randomly selected individuals. The samples were preserved in metal free formaldehyde to be analysed for heavy metals in the laboratory.

Analysis of iron (Fe), manganese (Mn), lead (Pb) and mercury (Hg) in fish are conducted by wet and dry ashing method that is followed by digestion before the samples were measured with the Atomic Absorption Spectrophotometer (AAS). Half to one gram of dried samples were burnt until scorched, and then it was ground until fine. Five millilitres of concentrated HNO_3 were added to the sample prior to heating on a hot plate until brownish nitrate vapour disappeared. After this step, five ml H_2O_2 30 % were added to the sample before the heating continues up to two hours. The black brownish sludge resulted was diluted with 5 % HNO_3 (v/v). The slurry then pours into Kjeldahl flask fitted with reflux condenser. The samples were distilled for 3-4 hours and the vapour phase were condensed and collected in metal free polyethylene vials. This step was to ensure that no acid accumulates in the sample and to minimize contamination. The distillates

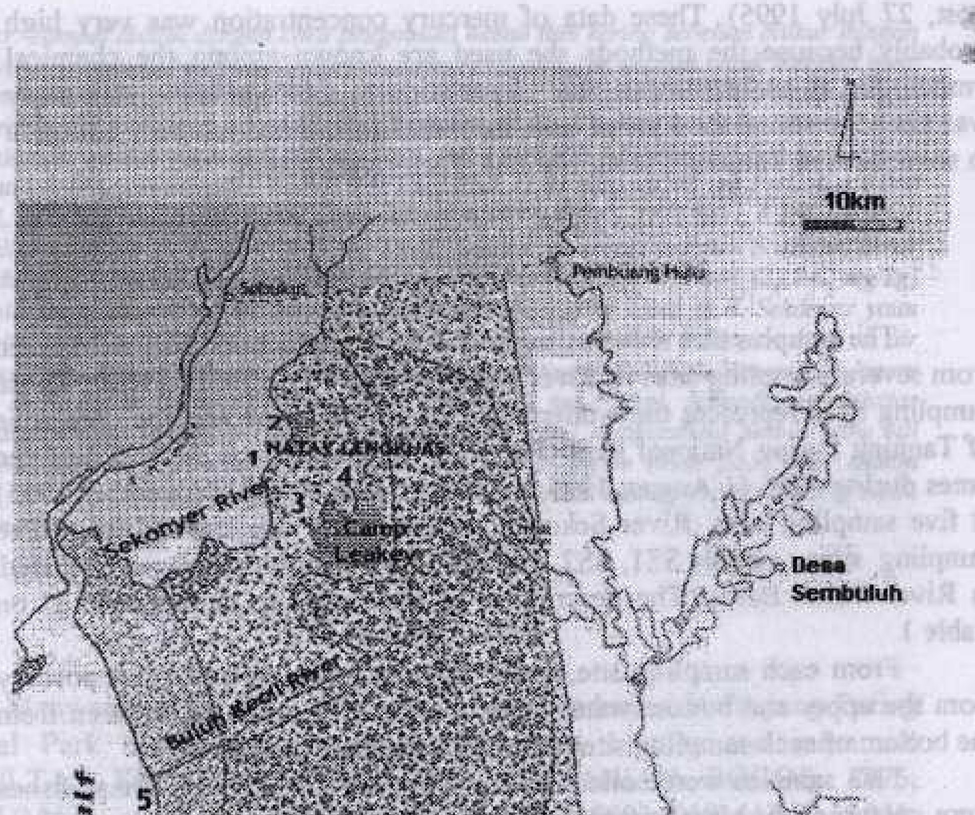

Figure 1. The sampling sites at Tanjung Puting National Park (Source: McKinnon, 1983)

Table 1. Description of the sampling sites for limnological study at Tanjung Puting National Park

Name of the river	Code of Sampling Sites	Description of the sampling sites
River Sekonyer	SS1	Natay Lengkuas segment at Sekonyer Simpang Kiri, the right bank belong the wilderness zone the left bank outside the boundary of national park, and the type of vegetation on both banks are heath forest.
	SS2	Pondok Ambung segment, at Sekonyer Simpang Kanan, both banks belong to wilderness zone. Left bank with heath forest vegetation, the right bank high peats swamp.
	SS3	Danau Panjang segment, at Sekonyer Simpang Kanan, left bank belong to wilderness zone, right banks belong to special utilization zone. Vegetation in the left bank consists of heath forest, on the right banks high peat swamps riparian system.
River Buluh Besar	BBS1	Upper segment of River Buluh Besar, belong to the core zone with high peat swamps as its banks.
	BBS2	Estuarine segment of River Buluh Besar, both bank belong to buffer zone, with *Nypa* sp and peaty swamps as its banks.

Table 2. Heavy metal concentration in water of two rivers at Tanjung Puting National Park

Name of the river and sampling site	Heavy metals concentrations in water (mg/L)											
	Sampling Time I (1 August 1995)				Sampling Time II (4 October 1995)				Sampling Time III (20 November 1995)			
	Pb	Fe	Mn	Hg	Pb	Fe	Mn	Hg	Pb	Fe	Mn	Hg
Sekonyer												
SS1	0.333	0.326	0.005	0.095	0.045	0.317	0.012	0.096	0.088	0.303	0.149	0.070
SS2	0.382	0.227	0.004	0.229	0.039	0.094	0.102	0.051	0.023	0.317	0.048	0.107
SS3	-	-	-	-	0.017	0.130	0.009	0.037	0.356	0.327	0.165	0.044
Average	0.358	0.277	0.005	0.162	0.034	0.180	0.041	0.061	0.155	0.315	0.121	0.074
Buluh Besar												
BBS1	0.023	0.036	0.004	0.745	0.063	0.354	0.011	0.034	0.400	0.882	0.072	0.122
BBS2	0.063	0.294	0.007	0.042	0.018	0.673	0.031	0.041	0.059	1.230	0.084	0.080
Average	0.043	0.165	0.005	0.394	0.041	0.514	0.021	0.038	0.230	1.056	0.078	0.101

were later analysed using the AAS. Dilution up to ten times was performed if necessary. The analysis for mercury was executed according to Cold Vapour (flameless)-AAS method described by CANTLE (1982).

Table 3. Heavy metal concentration in sediment of two rivers at Tanjung Puting National Park

Name of the river and Sampling site	Heavy metal concentrations in sediment (mg/ kg-dry weight)								
	Sampling time								
	I	II				III			
	Hg	Pb	Fe	Mn	Hg	Pb	Mn	Fe	Hg
Sekonyer									
SS1	26.336	22.623	1128.880	13.940	3.428	25.574	1173.716	6.689	2.058
SS2	12.523	41.212	906.061	702.055	-	8.437	3161.878	36.302	2.812
SS3	-	12.754	2418.520	18.895	10.628	5.775	303.815	10.501	1.750
Average	19.430	25.530	1484.487	244.863	7.028	13.262	1546.470	17.831	2.207
Buluh Besar									
BBS1	115.978	0.871	4915.180	22.866	0.272	3.397	860.666	15.055	0.809
BBS2	18.478	7.059	6434.450	53.254	0.155	9.866	9899.919	117.600	0.760
Average	67.228	3.965	5674.815	38.060	0.214	6.632	5380.293	66.328	0.785

The procedure for analysis of heavy metals in sediment is as follows. One gram of sediment was weighed in beaker glass then determines the water content by gravimetry. Three millilitres of 70 % HNO_3 (v/v) was added to the dried sample, and heated on hot plate at 80 °C for more one hour. After cooling, six millilitre of distilled water; was added and shook with shaker for two hours. Let it stand until the solid residues precipitated. Five millilitres of supernatant were diluted to 25 ml before determination of the metals using AAS according to Cantle Method.

For analysis of heavy metal in water, the procedure was as follows. Transfer a measured volume of well mixed, acid preserved water sample appropriate for the expected metals concentration to a flask. Add five millilitres concentrated HNO_3 and few boiling chips. Then the solution was brought to a slow boil and evaporates on a hot plate to the lowest volume possible (about 10 to 20 ml) before precipitation occurs. The heating was continued with addition of concentrated HNO_3 until digestion complete as shown by a light colour but clear solution. The solution then was cool, dilute to mark and mix thoroughly. A portion of this solution was taken for metal determinations with AAS. The AAS method for analyses of iron, manganese and lead is the Acetylene-Air Flame; meanwhile for mercury the analysis is conducted using the Cold-Vapour (flameless)-AAS method (EATON *et al*. 1995).

RESULTS AND DISCUSSION

On the first sampling time (1 August 1995), samples were only taken from SS1 and SS2 in River Sekonyer. At that time, lead concentration (0.333 mg Pb/L on SS1, and 0.382 mg Pb/L on SS1) were quite high if compared to BBS1 (0.023 mg Pb/L) and BBS2 (0.063 mg Pb/L) that located on River Buluh Besar. Meanwhile, on the second sampling time (4 October 1995) on River Sekonyer, the lead concentrations tended to decrease (0.045 mg Pb/L on SS1 and 0.039 mg Pb/L on SS2). Danau Panjang segment (SS3) at the first sampling time show the result as high as 0.017 mg Pb/L. At this time, River Buluh Besar did not indicate increasing lead concentration (0.063 mg Pb/L on BB1 and 0.018 mg Pb/L on BB2), but on the third sampling time (20 November 1995), lead concentration tended to increase on two sampling sites that were SS3 (0.356 mg Pb/L) in River Sekonyer and BBS1 (0.400 mg Pb/L) in River Buluh Besar. The increase was so dramatic if compared to another sampling sites that indicated relatively lower results that were 0.088 mg Pb/L (at SS1), 0.023 mg Pb/L (at SS2) and 0.059 mg Pb/L (at BBS2). On the average lead concentration in the water of both, River Sekonyer and River Buluh Besar were 0.181 mg Pb/L and 0.105 mg Pb/L respectively.

According to BOYD (1990), for lead, the safe concentration for aquatic life is 0.1 mg Pb/L. From this point, it can be said that on the certain time lead concentration in River Sekonyer could be rise until 3-4 times higher than that of safe concentration for aquatic life. The pattern for River Sekonyer inclined to decrease except for SS3. River Buluh Besar had a little different pattern that was tended to increase up to four times higher than safe concentration and relatively constant. It was suspected that the number of motorboats that went back and forth along the river influences the fluctuation of lead in river water. It was also suspected that the residues of fossil fuel combustion strongly contribute to the elevation of lead because it had been known that tetra ethylene-lead was added as an anti knocking additive in gasoline.

The data of iron concentration in water was shown in Table 2. Sampling site SS1 on River Sekonyer had relatively constant iron concentration from the first sampling time to the third sampling time these were 0.326, 0.317, 0.303 mg Fe/L respectively. Sampling site SS2 show a little difference that was inclined to decrease and increase on the third sampling (0.227, 0.094, 0.317 mg Fe/L) respectively. The iron concentration in water of SS3 sampling site indicated a tendency to increase up to three times from the second (0.102 mg Fe/L) to the third sampling time (0.327 mg Fe/L). River Buluh Besar indicate decreasing trend from the first sampling to the third sampling for both BBS1 and BBS2. The BBS2 sampling site had iron concentration in water column higher than the BBS1. According to Boyd (1990), concentration of iron in natural waters is about five mg/L. From this statement, it was clear that all of sampling sites contained iron concentration that is still within its natural range. But, it deserves to be noted that the estuarine segment of River Buluh Besar (BBS2) showed the highest iron level compare to the other sampling sites, including the ones in River Sekonyer. Seemingly, it caused by BBS2's position as an estuarine segment, which is probably, received more input from its vicinity than the other sampling sites.

Table 2 shows that in River Sekonyer, the total manganese concentration on SS1 showed increasing pattern from the first to the third sampling. The SS2 sampling site had a slightly different pattern where the elevation (0.004, 0.102, 0.048 mg Mn/L) was not as large as the SS1. The highest increase was found on the SS3, where the manganese concentration increased from 0.017 mg Mn/L in the second to 0.165 mg Mn/L in the third sampling time. Both of BBS1 and BBS2 sampling sites on River Buluh Besar had almost similar pattern with SS2 on River Sekonyer. On the first to the third sampling time, the manganese concentration in BBS1 were 0.004, 0.011, 0.072 mg Mn/L, and for BBS2 were 0.007, 0.031, 0.084 mg Mn/L respectively. In average (Table 4), River Sekonyer had higher manganese concentration than River Buluh Besar. According to Boyd (1990), manganese concentration in natural waters ranging from 0.2 to 0.5 mg/L. Based on this criteria, the manganese concentration in both River Sekonyer and River Buluh Besar were still in its natural range.

On the first to the third sampling times, the SS1 on River Sekonyer seemed indicate an almost constant mercury concentration (0.095, 0.096, 0.070 mg Hg/L). It was a quite different for SS2, where the mercury concentration fluctuates sharply (0.229, 0.051, then 0.107 mg Hg/L). For SS3, the mercury concentration did not show drastic change. The BBS2 on River Buluh Besar had a pattern, which was relatively similar to SS1 (0.042, 0.041, and 0,080 mg Hg/L). On the contrary, for the BBS1, the concentration of mercury fluctuated sharply from 0.745 mg Hg/L in the first to only 0.034 mg Hg/l in the second sampling time, and then rose to 0.122 mg Hg/L in the third sampling time. In average, River Sekonyer indicated lower (0.099 mg Hg/L) mercury concentration than River Buluh Besar (0.177 mg Hg/L) does. According to Boyd (1990), safe concentration for aquatic life in relation to mercury is 0.0001 mg Hg/L. In another words, the mercury concentration in River Sekonyer and River Buluh Besar were 990 and 1770 times higher than that of safe concentration. Apparently, this phenomenon occurred because of the existence illegal gold mines in the upstream part of the river that use mercury as the main extracting chemical during the amalgamation process. Mercury in liquid metal form is very volatile material, and potential to condense in the atmosphere and some of them will include in the rainfall (MOORE and RAMAMOORTHY, 1984).

From Table 3, it can be shown that on the first sampling time, the analysis of lead in sediment was not conducted. The sediment from SS1 on River Sekonyer had lead concentration that was relatively similar to the second and the third sampling time, that are 22.623, and 25.574 mg Pb/kg dry weight respectively. The SS2 showed the highest lead content in its sediment in the second sampling time but decreased into only 8.437 mg Pb/kg (dry) in the third sampling time. The SS3 also had similar pattern to SS2 but the amount was less. Oppositely, lead concentration in sediment of River Buluh Besar tended to increase but still in fewer amounts than in River Sekonyer. The lead concentration in the sediment of BBS1 on the second sampling was 0.871 mg/kg (dry weight) and then risen to 3.397 mg/kg. The sediment of BBS2 showed lead concentration that was a bit higher than the BBS1 (7.059 mg/kg dry weight) on the second to 9.866 mg Pb/kg) in the third sampling time. In average, the concentration in River Sekonyer sediment (16.308 mg/kg dry weight) was higher than in River Buluh Besar sediment (3.532 mg/kg dry weight). It seemed that these trends were influenced by the same causes as the concentration of lead in water.

Table 3 shows that at the SS1 of River Sekonyer, the iron concentrations of sediment in the second to the third sampling time tended to elevate from 1128.880 to 1173.716 mg/kg (dry weight). Similar pattern was also observed on SS2, but the elevation was higher, which were from 6.061 to 3161.878 mg/kg. Opposite pattern was observed at SS3, where the iron concentration in sediment descent from 2418.520 to only 303.815 mg/kg. The BBS1 in River Buluh Besar also indicated the same trend with the SS3, where the iron concentration in sediment was higher on the second sampling time. The values were 4915.180 mg Fe/kg in the second sampling time but dropped to 860.666 mg/kg in the third sampling time. Equal to the SS2 pattern, the BBS2 sediment also indicated an increasing iron concentration (6434.450 mg Fe/kg, dry weight) on the second to the third sampling time (9899.919 mg Fe/kg). In this case, it deemed that high peat concentration in the swamp adjacent to SS2, SS3, BBS1 and BBS2 strongly influenced the fluctuations of iron concentration.

The sediment of SS1 in River Sekonyer indicated a decreasing manganese concentration from 13.940 mg/kg in the second to 6.689 mg Mn/kg (dry weight) in the third sampling time. The highest manganese (702.055 mg Mn/kg) concentration was found on the SS2 in the second sampling time but in the third sampling time, the concentration dropped into only 36.302 mg Mn/kg. The SS3 had almost similar pattern to SS1 but with a slightly higher concentration (18.895 mg Mn/kg) in the second compared to the third sampling time (10.501 mg Mn/kg dry weight). The manganese

Table 4. Average concentration of heavy metals in water of two rivers at Tanjung Puting National Park

No.	Name of the river	Total heavy metals concentration, mg/l			
		Fe	Mn	Pb	Hg
1.	River Sekonyer	0.273	0.069	0.181	0.099
2.	River Buluh Besar	0.578	0.035	0.105	0.177

Table 5. Average concentration of heavy metals in the sediment of two rivers at Tanjung Puting National Park

No.	Name of the River	Average of heavy metal concentration in the sediment, mg/kg (dry weight)			
		Fe	Mn	Pb	Hg
1	R. Sekonyer	1061.756	126.498	16.308	7.859
2	R. Buluh Besar	2851.703	34.796	3.532	22.742

Table 6. Comparison of the average of some heavy metals Sediment-Water Accumulation Factor (A_{SW}) in two rivers at Tanjung Puting National Park

No.	Name of the river	Sediment-Water Accumulation Factor (A_{SW}) of heavy metal			
		Fe	Mn	Pb	Hg
1.	R. Sekonyer	4508.0	1474.3	1169.0	79.7
2.	R. Buluh Besar	4173.4	901.0	96.8	103.9

Table 7. Average heavy metals bioconcentrations and Bioaccumulation factors (BAF) in some of fish (dry weight) from River Sekonyer, Tanjung Puting National Park

No.	Parameter	Heavy metals			
		Fe	Mn	Pb	Hg
1.	Bioconcentrations, mg/kg dry weight	12.540	0.005	5.802	1.155
2	Bioaccumulation factors	37.78	0.03	15.09	10.80

Table 8. Comparison of the average of some water quality parameters of two rivers at Tanjung Puting National Park

No.	Name of the river	ORP (mV)	Secchi Depth (cm)	Con-ductivity (mS/cm)	Turbi-dity (NTU)	Tempe rature (°C)	Dissol-ved Oxygen (mg/L)	pH
1.	R. Sekonyer	453.6	86.6	0.022	19.1	26.0	2.6	4.49
2.	R. Buluh Besar	420.2	75.4	1.983	13.5	26.7	3.3	4.32

concentration in the sediment of the BBS1 on River Buluh Besar tended to decrease from 22.866 mg Mn/kg in the second to 15.055 mg Mn/kg in the third sampling time. In opposite to all, the manganese concentration in BBS2 seemed to elevate from the second (53.254 mg Mn/kg) to the third sampling time (117.600 mg Mn/kg). However, River Sekonyer had manganese concentration in sediment that was higher in average (126.498 mg/kg) than in the River Buluh Besar (34.796 mg Mn/kg).

The sediment mercury of River Sekonyer on SS1 had a pattern that tended to decrease from the first sampling time to third sampling time (26.336, 3.428, 2.058 mg Hg/kg in sequence). The SS2 also showed similar pattern that decreased from 12.523 mg Hg/kg (dry weight) in the second to only 2.812 mg Hg/kg in the third sampling time. The SS3's sediment which were only had taken in the second and the third sampling time showed an increase from 10.628 mg Hg/kg to only 1.750 mg Hg/kg. The pattern at River Buluh Besar was slightly different from River Sekonyer. At the first sampling time, the BBS1 showed the highest (115.978 mg Hg/kg) concentration, then dropped to only 0.272 mg Hg/kg (dry weight) in the second, but it rose again to 0.809 mg Hg/kg in the third sampling time. The pattern for BBS2 was similar to BBS1 but in lower levels (18.479, 0.155, 0.760 mg Hg/kg dry weight). In River Buluh Besar, the sediment contained mercury (22.742 mg/kg) at higher concentration than that of River Sekonyer (7.854 mg/kg). This fact was in concomitant with the data of heavy metals levels in river water (Table 4), where River Buluh Besar water had higher average of mercury concentration (0.177 mg/L) than River Sekonyer (0.099 mg/L).

Apparently, the different pattern relates to the differences on sediment and hydrochemistry characteristics of both rivers. According to MOORE and RAMAMOORTHY (1984), the release of sorbed mercury from sediment bed into bulk water is depending on partition coefficient, pH, oxidative reductive potentials, amount of chloride ion, and natural chelating agent. The sampling sites at River Buluh Besar, especially the BBS2, was slightly different from River Sekonyer, because of its position that is nearby an estuarine. Moreover, it deserves to be remember that the existence of gold mining in the upstream of River Sekonyer probably strongly contributes to the excessive of lead and mercury in water and sediment. It should be aware that those metals pollution would. endanger the sustainability of Tanjung Puting National Park ecosystem.

Sediment-water accumulation factors (A_{sw}) presented in Table 6 indicate that the sediment of River Sekonyer tended to more retain the heavy metals compared to sediment of River Buluh Besar. This probably because River Buluh Besar is a relatively short river where its water directly flow to the sea. On the other hand, the water from River Sekonyer flows to River

Kumai. The detail mechanisms that control the differences in the absorption of heavy metals in the sediment are interested to be studied further.

The data on heavy metals concentration in fish muscle only available for fish that lives on River Sekonyer. The fish species that were analysed for its heavy metals concentration in their muscle are *Mystus nemurus* (omnivore) and *Channa micropeltes* (carnivore or piscivore), *Pristolepis fasciatus* (herbivore) and *Helostoma temminckii* (herbivore). The data of bioconcentrations that shown in Table 7 is the average of bioconcentrations values of the above fish species.

As reported by MOORE and RAMAMOORTHY (1984) omnivorous and carnivorous fish in the Illinois River had average residues of 0.7 and 0. 6 mg Pb /kg respectively in muscle tissue, where as the level in invertebrates range up to 39 mg/kg. Another data has shown that the perch inhabiting two Swiss lakes had fishes muscle residues ranging from 0.06 to 0.21 mg/kg. In River Sekonyer fish, the average lead and mercury concentration were 5.802 mg Pb/kg and 1.155 mg Hg/kg respectively (Table 7). From these facts and the data of heavy metals in the water compartment, it had been shown that even though the iron (12.54 mg/kg) showed the highest bioconcentration, it still considered as non-pollutant heavy metals. On the other hand, lead and mercury, which is already considered as pollutants, the highest concentrations was 5.802 mg/kg and 1.155 mg/kg (dry weight) respectively. Physically, as far as the samples that had been examined, the fish from River Sekonyer seemed normal, without any peculiarity, even though they contain more heavy metals (Pb and Hg) than data that reported in MOORE & RAMAMOORTHY (1983). The ratio of heavy metal concentration in fish and in water refers as the Bioaccumulation Factor (BAF). From Table 7, we can observe that Bioaccumulation Factors for iron is the highest and for the manganese is the lowest. This pattern is understandable since iron is one of the important substances that composed the fish blood. On the other hand, lead and mercury seemed to accumulate in the muscle of the fish captured in River Sekonyer.

HUTCHINSON (1957) stated that heavy metals behaviour in natural waters is a combination of precipitation equilibrium and their linkage with inorganic and organic ligands. The degree of its mobility depends on the physical-chemical state of aquatic environment. Physicol-chemical parameters that supposed to give strong influence to the state of aquatic environment in this case are Oxidative Reductive Potentials (ORP), Secchi Depth, conductivity, turbidity, water temperature, dissolved oxygen (DO) and pH (Table 8). It is shown in Table 8 that the average ORP on River Buluh Besar (420.2 mV) was a little bit lower than average ORP on River Sekonyer (453.6 mV). All these values indicated a relatively oxidating water. This pattern was also tended to similar for other parameters such as Secchi depth, turbidity, water temperature, dissolved oxygen and pH. The exception was only for conductivity, in which the value for River Buluh Besar was absolutely higher (1.983 mS/cm) compared to River Sekonyer (0.022 mS/cm). This also probably means that the River Buluh Besar had ionic salt concentration (represented by conductivity) that was around 90.1 times higher than that of River Sekonyer. It can be explained that River Buluh Besar, by its nature is a relatively short river, which flows directly to the sea that, contained more dissolved mineral salts than River Sekonyer. Turbidity on River Sekonyer (19.2 NTU) is slightly higher than turbidity on River Buluh Besar (13.5 NTU). It seems this had a relationship with the operation of gold mining on the upstream segment of River Sekonyer.

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