Bull. Environ. Contam. Toxicol. (2000) 65:591–597

DOI: 10.1007/s001280000164

Bulletin of Environmental Contamination and Toxicology

Metals in Water in the Central Kalimantan, Indonesia

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Received: 6 April 2000/Accepted: 25 July 2000

In the world, river water has been used as a drinking water and an irrigated water for agriculture and fish culture. In Central Kalimantan of Indonesia, the rivers also play important roles on traffic and economic activities. Studies of the water quality are needed to test their validity. Cross-sectional studies of the impact of excreta use in aquaculture, and of waste water use in irrigation have been carried out in several countries. In South Kalimantan of Indonesia, Prihartono et al. (1994) reported that 37% of the households regularly or occasionally mix boiled with unboiled water for drinking, or use unboiled water alone. Blumenthal et al. (1992) described that in Indonesia, waste water/excreta was used but some health protection that measure existed did not have domestic exposure to pond water, whose quality was around forty times higher than the tentative WHO bacterial guideline for fishpond water. Sometime water reuse has caused the habitants to be infected with diseases. Cross et al. (1976) reported that 5.6 % of 3017 inhabitants in West Kalimantan were detected malaria infection.

On the other hand, it is well known that the haze has occurred by the burn rice cultivation in Kalimantan. This fire is considered to be influenced in water ecosystem to ground water and peat water. The Kenyah Dayak in East Kalimantan, who migrated from their mountainous homeland to a riverine village in the 1940s, have subsisted on slash-and-burn rice cultivation. To cope with rapidly increasing population, the villagers have not changed their farming practice to increase land productivity but instead have exploited fields in remote riverbanks, using motorized canoes (Abe et al. 1995).

However there is little information of water quality in Central Kalimantan in Indonesia. From views of these information, in this study, in order to assess as a base-line study of water environment in Kalimantan, we assayed water quality of river, lake, channel in Central Kalimantan. The significance of the obtained results were discussed to elucidate the geographical distribution and the background levels of total trace elements in water environmental in Central Kalimantan.

MATERIALS AND METHODS

Water from the rivers of Kapuas, Kahayan and Sebangau was collected on December 11 to 14. In addition, water samples of Tundai Lake, two channels and fish culture center were also collected to compare the water quality with river water. All water samples were stored in sterilize polypropylene conical tubes (Falcon, USA) (50 ml). Total number of the sampling sites was 13 sites as shown in Fig. 1. The GPS data of each sampling site was also recorded (not shown).

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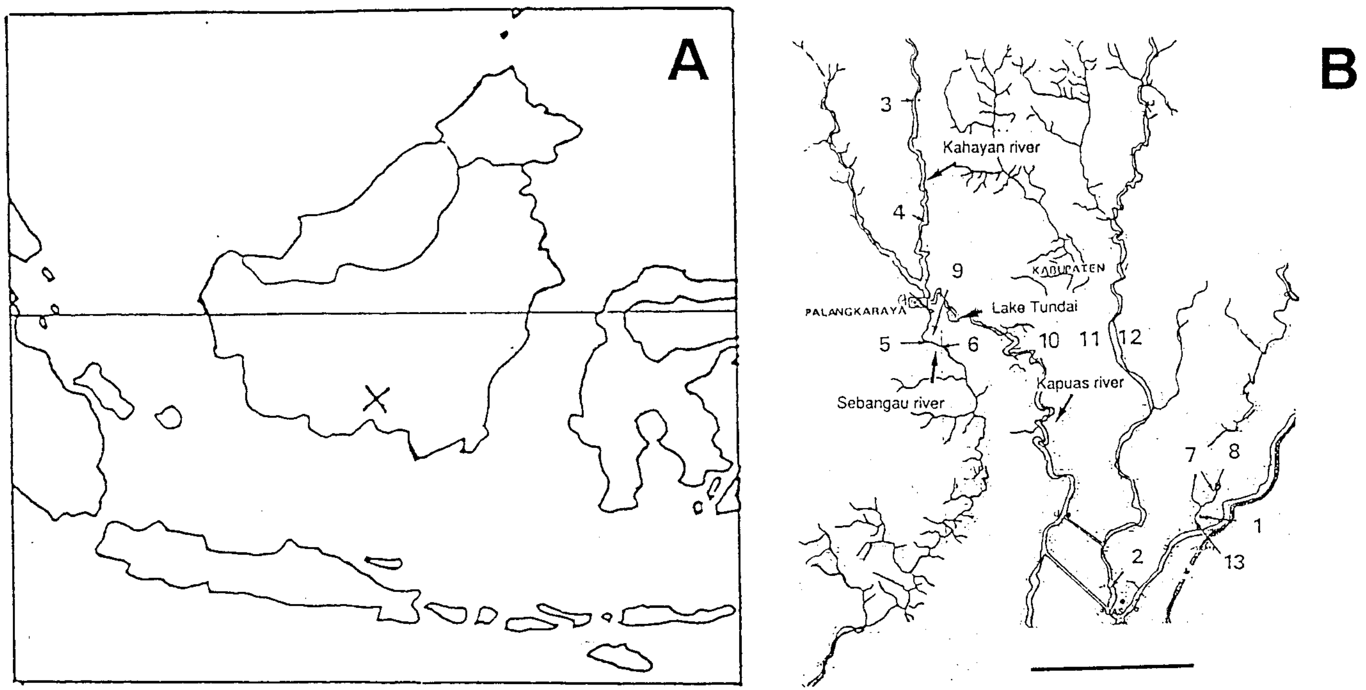

Figure 1. Sampling points in Central Kalimantan. Scale bar represents 50 km in B

The water temperature, conductivity and pH of the samples were measured immediately at each sampling point with a thermometer (Tanita model 5432, Japan), a pH meter (Shindengen, model pH boy-P2, Japan) and a specific conductivity meter (Iuchi model TDS-can3, Japan), respectively. For measuring anion concentrations, the water samples were filtered suction through a 0.45 μm Millipore (USA) filter. The anion concentrations (SO_4^{2-} and Cl^-) of the samples were determined with a high performance liquid chromatography (Hitachi HPLC system Lachrom, Japan) using a anion column (4.6 x 50 mm) (Waters IC-Pak, USA). To determine metal contents in water samples, 5 ml of ultrapure analytical grade concentrated HNO_3 (Tawa Chemical, Japan) was added to 5 ml of the samples. After digestion of insoluble materials at 80 °C for 12 hr, the contents of Mg, Co, Sn, Au, Cd, Pb, Hg, Fe, Cu and Zn in the water samples were analyzed with an Inductively coupled plasma mass spectrometry (ICP-MS, Seiko SPQ-6500, Tokyo, Japan) as previously described (Hanada et al., 1998). Furthermore Na, K and Ca contents of the samples were measured with a Hitachi Flame Atomic Absorption Spectrophotometer, model 180-80 (Japan).

RESULTS AND DISCUSSION

This study investigated water quality in total 13 sites in 4 rivers (Kapuas, Murung, Kahayan and Sebangau rivers), 2 channels (Dadahup and Kelambangau), one lake (Lake Tundai) and one pond (for fish culture) in Central Kalimantan, Indonesia to assess as a base-line study of water environment in Kalimantan. The air temperature, water temperature, conductivity, pH and 2 anion ions (SO_4^{2-} and Cl^-) concentrations of water samples from rivers, and lake, channels and pond in Central Kalimantan are listed in Table 1 and Table 2, respectively. And the metal concentrations (Mg, Co, Sn, Zn, Cu, Cd, Pb, Hg, Fe, Au, Na, K and Ca) of water samples from rivers, and lake, channel and pond in Central Kalimantan are shown in Table 3 and Table 4, respectively.

Table 1. pH, conductivity and anion concentration of river water

Site No.	Site	Air °C	Water °C	Conductivity ms/m	pH	SO_4^{2-} mg/l	Cl^- mg/l
1	Murung river	32.0	31.3	10.0	4.8	24.9	0.8
2	Kapuas river	32.6	29.6	6.0	4.2	10.7	0.8
3	Kahayan river 1	33.1	30.8	2.0	6.7	N.D.	0.8
4	Kahayan river 2	33.6	30.0	2.0	6.6	N.D.	2.0
5	Sebangau river 1	32.8	28.8	6.0	4.0	N.D.	0.7
6	Sebangau river 2	33.4	31.8	5.0	3.9	N.D.	0.7

N.D. means not detected

Table 2. pH, conductivity and anion concentration of channel, lake and pond water

Site No.	Site	Air °C	Water °C	Conductivity ms/m	pH	SO_4^{2-} mg/l	Cl^- mg/l
7	Channel Dadahup 1	34.0	31.0	38.0	2.9	75.3	1.4
8	Channel Dadahup 2	34.3	33.0	61.0	2.6	110.0	6.2
9	Ch. Kelambangau	32.1	30.8	4.0	4.0	N.D.	0.8
10	Lake Tundai 1	35.0	30.3	1.5	4.6	2.5	0.4
11	Lake Tundai 2	35.8	34.6	4.0	3.8	N.D.	0.9
12	Lake Tundai 3	35.0	31.0	2.0	4.5	3.6	0.3
13	Fish culture pond	32.0	34.1	12.0	4.2	24.8	0.5

N.D. means not detected

It was noted that the pH values of water samples from rivers except Kahayan river were low indicating that these river water maintained acidic condition. Usually it is considered that pH of river water should show a neutral range, about pH 6.5 to 8.0 to use the drinking water and irrigated water for agriculture (Yamagata, 1979). As shown in Table 2, it is surprising that the water of Dadahup channel located in the region of one hundred million hector planning showed pH 2.6 and 2.9 (see Site 7 and 8 in Table 2). This channel has been used as an irrigated water for rice cultivation and an living water for habitants. From the analyses of anion ions, the acidic condition of the channel water was estimated to be caused by sulphonic ions (Table 2). The reasonable explanation regarding that the sulphonic ion has been accumulated in the water is still unclear. However we speculate that these acidic condition was occurred by the peat soil after the burn rice cultivation. As other remarkable features in the Dadahup channel, high conductivity (Table 2), high Mg, Co and Zn concentrations (Table 4) and also high Na and K concentrations (Table 4) were observed. There is no major difference of the other metal concentrations between Dadahup region and other regions including river and lake sites. The pH, conductivity, and sulphonic anion concentration of water samples from No. 1 and No 13. Water qualities of the two samples were shown the same tendency to compare with those from Dadahup channel. These sites were thought to receive the influence of Dadahup Channel, because the water from Dadahup flowed into near at these sampling points. In conclusion, from the data presented here the water relating to Dadahup channel is considered to be not suitable for agriculture and drinking water. If the rice cultivation will be continued in this region, the water and soil should be neutralized using of alkali reagents for efficient rice cultivation and protecting inhabitant health.

In sample water from Lake Tundai (Table 4 site No. 10), Pb concentration was higher than that of Japanese Environmental Standard (10 μg/l) (Global Environmental Forum, 1997). In several sampling points from rivers, the Pb concentration showed also a high level, although the Pb level is lower than that of Japanese Environmental Standard (Table 3). Recently, Heinze et al. (1998) supposed that children attending schools in urban areas with high traffic density in Jakarta were a high risk group for Pb poisoning. It is well known that Pb poisoning may lead to anemia, because activities of haem synthesis enzymes is inhibited by Pb exposure. In the case of Jakarta, Heinze et al. (1998) presumed that from analyses of tap water and soil Indonesian children living in urban areas were received Pb poisoning by increasing of automobile at increased risk for blood Pb levels above the actual acceptable limit. In the Central Kalimantan, motorboats are utilized as an important public traffic way. The fuel containing Pb might be caused by the Pb pollution in these river and lake.

There were many miners to obtain alluvial gold in the Kahayan river. In the purification process of gold, Hg is widely used. Then we expected to detect Hg in the water sample from Kahayan river. However no Hg was detected in the all sample except that from Dadahup Channel (Table 3 and 4). Hg is analyzed by using Parr bombs during acid digestion, because after heating Hg change to vapor. Since in this study, we used open system for acid digestion, it is difficult to determined whether Hg is contaminated into water of Kahayan river. Regarding Hg poisoning in Indonesia, there are several recent reports as follows. Burger and Gochfeld (1997) reported that Hg and Mn concentrations were significantly higher in cattle egrets from Bali compared to Sulawesi in Indonesia. Nakagawa and Hiromoto (1997) described that total Hg and methyl Hg levels in hair of residents of Indonesia was lower than in residents of Japan. However their total Hg levels in Indonesian are still higher than that in South Asian countries (Feng et al. 1998).

Other risk factors such as Cd were detected as low level in the all sampling points in Central Kalimantan in comparison with the level of Japanese Environmental Standard (Table 3 and 4). Suzuki et al. (1980) founded that Cd contents in 116

Table 3. Metal concentrations of river water

Site No.	Site	Mg mg/l	Co μg/l	Sn μg/l	Zn μg/l	Cu μg/l	Cd μg/l	Pb μg/l	Hg μg/l	Fe μg/l	Au μg/l	Na mg/l	K mg/l	Ca mg/l
1	Murung river	1.16	2.46	0.05	15.03	0.64	0.01	1.71	N.D	117.24	N.D	2.31	3.27	0.63
2	Kapuas river	0.49	0.91	0.11	12.41	1.57	0.02	0.96	N.D	268.63	N.D	1.94	1.44	0.43
3	Kahayan river 1	0.58	1.12	1.90	22.15	3.42	0.07	5.23	N.D	32.61	N.D	2.27	1.31	1.23
4	Kahayan river 2	0.48	0.85	0.09	6.40	2.71	0.01	2.09	N.D	215.43	N.D	2.23	1.29	1.16
5	Sebangau river 1	0.04	N.D.	0.01	1.50	0.54	N.D	0.09	N.D	492.68	N.D	0.45	0.73	0.14
6	Sebangau river 2	0.06	0.02	0.01	5.12	0.66	0.00	0.41	N.D	485.64	N.D	0.75	1.75	0.20

N.D. means not detected

Table 4. Metal concentrations of channel, lake and pond water

Site No.	Site	Mg mg/l	Co μg/l	Sn μg/l	Zn μg/l	Cu μg/l	Cd μg/l	Pb μg/l	Hg μg/l	Fe μg/l	Au μg/l	Na mg/l	K mg/l	Ca mg/l
7	Channel Dadahup 1	2.23	6.45	0.13	16.83	1.50	0.03	0.33	N.D	251.21	0.01	7.07	4.47	0.61
8	Channel Dadahup 2	3.08	10.13	0.08	39.69	1.65	0.03	1.28	0.29	232.41	0.01	8.34	7.20	1.01
9	Ch. Kelambangau	0.04	0.02	0.01	2.76	0.32	N.D.	0.10	N.D	487.32	N.D	1.08	1.96	0.10
10	Lake Tundai 1	0.31	0.16	0.05	7.99	1.57	0.00	11.48	N.D	237.74	N.D	1.42	1.10	1.03
11	Lake Tundai 2	0.14	0.10	0.05	5.75	1.90	0.02	0.28	N.D	447.79	N.D	3.42	1.18	0.71
12	Lake Tundai 3	0.24	0.40	0.13	8.36	1.47	0.01	0.76	N.D	208.89	N.D	1.27	1.25	1.19
13	Fish culture pond	1.11	2.22	0.09	13.49	2.35	0.01	0.51	N.D	340.69	N.D	2.16	2.61	0.69

N.D. means not detected

polished and unpolished rice samples produced in the Java Islands of Indonesia were determined to be 0.040 ± 0.042 ppm. Using the fact that Indonesians consume about 300 g of rice, the daily intake of Cd would exceed the tolerable limit proposed by FAO/WHO and could cause slight chronic renal damage to the rice eaters. However in Central Kalimantan Cd content in the rice grown using the water at sampling point was expected to be lower than that reported by Suzuki et al. (1980). Especially in Sebangau river, the concentrations of metals showed adequate levels. On the other hand, other river water contained Zn and Fe was enough to use as drinking water. As only drinking water, total dietary intakes of Zn of the people from these river except Sebangau was estimated to be more than 20 mg/person, which was higher than the recommended dietary allowance of daily Zn intake from foods by the American standard diet (15 mg/person). Prihartono et al. (1994) performed follow-up survey of the same households during 6 months to measure prevalence. They indicated that 97% of the households regularly boil their drinking water. However, 37% of the households regularly or occasionally mix boiled with unboiled water for drinking, or use unboiled water alone. They concluded that the use of unboiled water was associated with higher rates of childhood diarrhoeas. From the view point of public health, the relationship between drinking water and infections in Central Kalimantan should be investigated.

Corwin et al. (1995).and Blumenthal et al. (1992) described that use of river water for drinking and cooking ($P < 0.001$) was associated with high prevalence communities. WHO (1989) guidelines can be tested using cross-sectional epidemiological studies which indicate that guidelines for restricted irrigation and for aquaculture may be around the right level. Mosquito species which intermediated malaria were reported in irrigated and rain-fed rice fields of North Sulawesi, Indonesia (Mogi et al. 1995). Changes in habitat quality and custom, expressed as the abundance per dip (index of density per unit water area), also need to be investigated to elucidate the risk of infection concerning water quality.

Further investigation will be needed to study the water environment and effects of water quality on habitant health in Central Kalimantan in Indonesia.

Acknowledgments. The authors are gratefully indebted to Ms Slastri, Aquatic Dynamics Division, Research and Development Center for Limnology, Bogor, and Mr. Suwido H. Limin, Faculty of Agriculture, University of Parangka Raya for their helpful advice and discussion, and for sampling of water. Part of this research was supported by Grant-in-Aid for Core University Program between Hokkaido University, Japan and R & D Center of Biology, LIPI, Indonesia sponsored by Japan Society for the Promotion of Science.

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