Running Head: Water Quality in Indonesia and Japan

Title:

Comparison of general water quality of rivers in Indonesia and Japan

Machiko KIDO [a], YUSTIAWATI [b], M. Suhaemi SYAWAL [b], SULASTRI [b], Toshiyuki HOSOKAWA [c], Shunitz TANAKA [a,d], Takeshi SAITO [e], Toshio IWAKUMA [f], and Masaaki KURASAKI [a,d,]*

[a] Division of Environmental Science Development, Graduate School of Environmental Science, Hokkaido University, Sapporo 060-0810, Japan

[b] RC for Limnology, Indonesian Institute for Sciences, Indonesia

[c] Research Division for Higher Education, Center for R&D in Higher Education, Hokkaido University

[d] Section of Integrated Environmental, Research Faculty of Environmental Earth Science, Hokkaido University

[e] Department of Health Sciences, Hokkaido University School of Medicine

[f] Section of Environmental Biology, Research Faculty of Environmental Earth Science, Hokkaido University

*Corresponding author: Masaaki KURASAKI

Group of Environmental Remediation,
Faculty of Environmental Earth Science, Hokkaido University.
Kita 10 Nishi 5, Kita-ku Sapporo 060-0810 JAPAN
Phone: +81-11-706-2243, fax: +81-11-706-4864
e-mail: kura@ees.hokudai.ac.jp

Abstract

In Java and Kalimantan in Indonesia, river water plays important roles in human life; for example, for transportation, and economic activities of the inhabitants. However, industrial, agricultural and domestic water is discarded into rivers directly in many developing countries, including Indonesia, since drainage systems have not been completely constructed. In this study, to evaluate the water quality and to compare those levels of environmental contaminants in developing and developed countries, water quality and contents of endocrine disrupters were measured in a total of 64 water samples (Indonesia; 28 samples and Japan; 36 samples) from 53 sites. The results indicated that, rivers in both capital cities, Jakarta and Tokyo, were contaminated. Water in rivers in Indonesia was not so heavily polluted as in Japan. Pollution in the river water in Indonesia appeared to be caused by the lack of sewerage systems. In addition, the findings on endocrine disrupters indicated that the concentration of alkylphenol in water samples was large enough to affect living organisms.

Key words: Indonesia; Japan; water quality; endocrine disrupter; river water; mercury

1. Introduction

River water has been used as drinking water and irrigation water for agriculture and for fish culture throughout the history of mankind. However, water pollution has become one of the most serious problems in many countries, especially in developing countries. In West Java and Central Kalimantan in Indonesia, the rivers also play important roles in transport and economic activities. Therefore, studies of water quality are important. Cross sectional studies of the impact of excreta in aquaculture, and of the wastewater used in irrigation have been carried out in several countries (Hart et al. 2002; Potter et al. 2004; Burt et al. 2007; Lesage et al. 2007; Liu et al. 2007).

Rapid urbanization in developing countries brings about not only economic development of the cities, but also a negative impact on people's health and the environment. Uncontrolled urbanization intensifies the frequency and severity of flooding, which is one of the big problems in urban areas of Asian cities. Jakarta has a tropical climate with on average annual temperature of 27.8ºC and average annual precipitation in Jakarta of 2,000 mm with the highest rainfall in January. Most of Jakarta lies in lowland, 0–10 m above the mean sea level. The Ciliwung River is one of the major rivers used as a water source in Jakarta (Phanuwan et al. 2006). One of the most serious problems in Jakarta is the lack of sewerage systems in urban areas; less than 3% of Jakarta's population is connected to a sewer system (Gracy et al. 1976). Jakarta is frequently flooded due to its low elevation and the absence of an adequate drainage system. The peak of floods in Jakarta is in January and February in every year. More than 70 areas have been identified as prone to flooding, and the worst affected area is called Kampung Melayu in the Jatinegara district in East Jakarta. Waterborne diarrheal disease is a major public health problem. In 2002, more than 35,000 people in

Jakarta suffering from diarrheal disease were recorded (www.urbanpoor.or.id on 1 July 2004), but the agents causing the diarrhea were unknown. Moreover, most of the factories in West Java do not have drainage disposal facilities with the exception of a few large factories. Since they cannot purify their drainage, the contaminated water flows into rivers around the factories. Excessive organic compounds and heavy metals from the drainage have caused river pollution. Contamination by mercury in the Jakarta gulf has been reported. Furthermore, since little sewage is treated in the Jakarta metropolitan area (Jakarta, Bogor, Tangeran, Bekasi), domestic wastewater including human waste penetrates underground or flows directly into rivers. However, the inhabitants in this area, especially those who live beside the rivers, daily use the river water for cooking, washing, bathing and even drinking. If these contaminating agents in such polluted water are accumulated in humans and wildlife for long periods, their health will be affected by these pollutants.

On the other hand, in South Kalimantan, Prihartono et al. (1994) reported that 37% of the households regularly or occasionally mixed boiled with unboiled water for drinking, or used unboiled water alone. Blumenthal et al. (1992) reported that in Indonesia, waste water/excreta was used but that most did not have domestic exposure to pond water, whose quality was around forty times higher than the tentative WHO bacterial guideline for fishpond water. To cope with the rapidly increasing population, the villagers have not changed their farming practice to increase land productivity but instead have exploited fields on remote riverbanks, using motorized canoes (Abe et al. 1995). From these circumstances, it can be understood that there is little information on water quality in West Java and Central Kalimantan.

From these points of view, in order to conduct a baseline study of water environment and pollutants in Java and Kalimantan, Indonesia, the general water quality, and contents of endocrine disrupters in rivers and lakes in West Java, including the Jakarta area, and Central Kalimantan were measured. In addition, the obtained results were compared with those for river water in Japan (Tokyo area and Hokkaido area).

2. Materials and methods

2.1 Sampling sites and dates

A total of 53 sampling sites, 17 in West Java and 4 in Kalimantan, in Indonesia, and 21 in Hokkaido and 11 in the Tokyo capital area, in Japan were chosen as shown in Figs. 1 and 2.

In West Java, water from the Ciliwung, Cisadane, Cikaniki and Citarun rivers and water from the Cikaret, Citatah, Cibinone, Sunter, and Saguling lakes was collected for the first time from June 8 to 15, 2006 and the second time from September 14 to 23, 2006. In Central Kalimantan, water from the Kahayan and Sebangau rivers was collected from September 17 to 18, 2006. In all there were a total of 21 sites in West Java (17) and in Central Kalimantan (4).

In Hokkaido, water from the Shiribetsu River was collected on November 17, 2005 and November 6 to 9, 2006. Water from the Ishikari, Toyohira, Sousei, Yoichi, Chitose and Shiribeshi-toshibetsu rivers was collected from October 18 to November 5, 2006. Water from the Tokachi and Satsunai rivers was collected from November 12 to 14, 2006.

In the Tokyo area, water from the Tsurumi river was collected on June 28, 2006. Water from the Arakawa, Naka and Ayase rivers was collected on October 17, 2006. Water from the Kanda and Tama rivers was collected from December 1 to 11, 2006.

2.2 Sample collection

All water samples were stored in polyethylene bottles (500 ml). Before collecting water, each bottle was washed three times with river water to remove any contaminants in the bottle.

2.3 General water quality

The water conductivity, pH, COD, NO_2, NO_3, PO_4, Cl and *Escherichia coli* (*E. coli*) in the samples were measured immediately at each sampling point with a pH meter (Shindengen, model pH boy-KS701, Japan) and a specific conductivity meter (Iuchi model TDS-can3, Japan), with simple water quality test packages used for measuring for COD, NO_2, NO_3, PO_4 and Cl, and (Kyoritsu chemical-check, WAK-Cl [200], Japan) according to their instruction manuals. Bacteria numbers were measured with simple detection paper (Shibata, Japan.)

2.4 Mercury concentration

For measuring the Hg concentration, 100 ml of a water sample was filtered by suction through a 0.45 μm Millipore (USA) filter. The filtered samples were incubated with 10 ml of 60 g/l of $KMnO_4$ and 10 ml of 18 M sulfuric acid at 100ºC until the dark violet color disappeared. After cooling to less than 40ºC, 2 ml of $KMnO_4$ was added to the sample and the sample was heated again ensuring that color remained for 30 min after the addition of $KMnO_4$. Then, after cooling to less than 40ºC, the obtained sample volume was increased up to 250 ml with distilled water. The Hg concentration in an aliquot of the sample was determined with an Hg meter (Hiranuma, HG-1, Japan) as indicated by Akagi et al. (2000).

2.5 Endocrine disrupters

Bisphenol A(BPA) and alkylphenol (APE) contents in the water samples were measured using BPA and APE ELISA kits (Environment Chemicals, Japan) according to the manufacturer's instruction manuals. BPA and APE contents in the samples were accurately estimated from the obtained standard curve.

2.6 Statistical analysis

Principal component analysis (PCA) was used to determine the characteristic features of each region. The data used for PCA were collected in autumn 2006 and are shown in Fig. 3. Statistical computation software 'R' and its PCA component 'prcomp' were employed.

Single-factor analysis of variance (ANOVA) was applied to each measured data set, followed by Fisher's test. The data were divided into four regions, West Java, Central Kalimantan, Tokyo and Hokkaido (Figs. 1 and 2). These four regions were used as the factors for this ANOVA. The software named 'StatView-J' was used for the calculation.

3. Results

Both environmental standards in Indonesia and Japan were listed in Table 1.

3.1 West Java

The island of Java is well known to be the most developed area in Indonesia, especially West Java, which contains the capital city, Jakarta. The results obtained in

West Java are summarized as follows.

The pH values in the water samples in West Java ranged from 6.1 to 8.6 (Table 2). The highest value of pH was 8.6 in Cikaret Lake (No 13 in Fig. 1).

The points with high water conductivity were Sunter Lake, (52 $\mu S\ cm^{-1}$: No. 15 in Fig. 1), and Ciliwung River downstream in Jakarta and Citarum River in Bandung (49 $\mu S\ cm^{-1}$: No. 17 in Fig. 1). These values were markedly high, though the Indonesian water standard values for conductivity is 225 $\mu S\ cm^{-1}$.

The highest value of COD in the samples from West Java was 100 mg l^{-1} in Ciliwung River downstream in Jakarta (No. 5 in Fig. 1). As shown in Tables 2 and 3, the COD values in the water samples in Indonesia were generally high compared with those in Japan, because there is lack of sewerage systems in Indonesia compared with in Japan.

The highest NO_2 and NO_3 concentrations in West Java were 1.5 mg l^{-1} and 15 mg l^{-1} downstream beside a pulp factory on the Cisadane River (No. 9 in Fig. 1) and midstream in the Bogor Botanic Garden in the Ciliwung River (No. 3 in Fig. 1), respectively (Table 2). These values exceed Indonesian Environmental Standard (Table 1). It was interesting that the lowest concentration of NO_3 in Indonesia was observed downstream in Jakarta in the Ciliwung River (No. 4 in Fig. 1).

The highest phosphate concentrations in Indonesia and Japan were 5 mg l^{-1} and 45 mg l^{-1}, respectively (Tables 2 and 3). These points are downstream of the Ciliwung River in Jakarta (No. 5 in Fig. 1) and Tama River in Tokyo area (No. 49 in Fig. 2). The phosphate concentrations in West Java were higher than those in Japan.

The *E. coli* concentration in the river water in Indonesia was expected to be much higher than that in Japan, because domestic wastewater is discarded directly into rivers in Indonesia.

As expected, much *E. coli* was found at all of the sampling points in Indonesia (Table 2). In the Ciliwung River midstream in the Bogor Botanic Garden (No. 3 in Fig. 1), an extremely high *E. coli* level was detected. An environmental standard for water quality in Indonesia concerning *E. coli* is 100 per mL (Table 1). Nine out of 17 sampling points exceed the environmental standard (Table 2).

3.2 Central Kalimantan

Central Kalimantan is a developing state in Indonesia. In this area, the lowest pH was 4.3 in the Sebangau River (No. 18 in Fig. 1). The pH of the river (4.3) was only acidic (Table 1). The reason for this lower pH was considered to be contaminating humic acids, because the water in the Sebangau River was black.

3.3 Mercury concentration in Indonesia

In West Java and Central Kalimantan, Indonesia, it has been reported that mercury contamination is detected in water from the Cikaniki River in West Java, and Kahayan River in Central Kalimantan, because of gold mining activity, in which mercury is used to extract gold from gold ore. Thus, we expected to detect Hg in the water samples from these rivers. The mercury concentrations in the water samples ranged from 0.14 ppb to 1.06 ppb (Table 4). These values were almost under the environmental standard for mercury concentration in Indonesia (1.0 ppb: Table 1). However the water of underground in West Java near by Cikaniki River was 4.1 ppb Hg.

3.4 Tokyo area in Japan

In the capital area in Japan, it is feared that environmental pollution is spreading, although of course environmental quality standards are enforced by the Japanese government. In the present study, high conductivity levels in Japan were 45 $\mu S\ cm^{-1}$ and 35 $\mu S\ cm^{-1}$ in the Kanda River in Shinjuku (No. 45 in Fig. 2) ward and in the Tama River at the Maruko Bridge (No. 49 in Fig. 2), respectively. There was no major difference between the conductivity levels of Indonesian and Japanese river water.

The highest value of COD in the samples from Japan was 50 mg l^{-1} in the Koayase River (No. 51 in Fig. 2).

The highest NO_2 and NO_3 concentrations in Japan were 6 mg l^{-1} and more than 45 mg l^{-1} downstream in the Tama River (No. 49 in Fig. 2) and in Kanda River (No. 45 and 46 in Fig. 2), respectively (Table 3). Japanese environmental standard for NO_3 is 10 mg l^{-1}. Three out of 11 points in Tokyo area exceed the environmental standard. In addition, these NO_2 and NO_3 concentrations in Japan, especially in the Tokyo area, were higher than those in Indonesia.

Higher concentrations of chloride ions were found of all measuring points in the Tokyo area than in Hokkaido, Japan and in Indonesia (Tables 2 and 3). In the Tokyo area, chloride ions might be used for detoxification of river water.

3.5 Hokkaido area in Japan

The Hokkaido area has played a role as a stable provider of grain and livestock in Japan. The pH values in water samples in Hokkaido ranged from 6.45 to 8.27 (Table 3). The lowest value was 6.45 in the Fushiko River (No. 31 in Fig. 2). The point with the highest pH was the Ishikari River (No. 33 in Fig. 2) and Shiribetsu River (No. 23 in Fig.

2). The conductivity in Sousei River (No. 30 in Fig. 2) showed the highest value, which was similar to Tama River (No. 49 in Fig. 2) in the Tokyo area. The highest amount of *E. coli* was observed in the Shiribetsu River (No. 23 in Fig. 2). These values exceed the Japanese environmental standard (Table 1).

3.6 BPA and APE

To examine whether endocrine disrupters such as BPA and APE, contaminated the river water, the contents of these chemical substances were measured. BPA was detected in water samples from the Cisadane River (No. 9 in Fig. 1), Ciliwung River (No. 1-4 in Fig. 2) and Cikaniki River (No. 10-11 in Fig. 1) in Indoensia and 20 samples from many rivers in Japan. APE was detected at 9 points in Indonesia as shown in Table 2. On the other hand, APE was detected at 15 points in Japan (Table 3). In 10 and 9 sampling points from Indonesia and Japan, respectively, both BPA and APE were detected.

3.7 ANOVA

To clarify the differences among the four sampling areas, ANOVA was carried out (Table 5). The analysis showed significant differences in pH ($p<0.01$), COD ($p<0.05$), NO_3 ($p<0.05$) and Cl ($p<0.01$). Fisher's multicomparison test revealed the following. For pH, only the comparison between West Java and Hokkaido showed no significance. The comparison of West Java and Tokyo showed relatively low significance ($p<0.05$). Other comparisons showed higher significance ($p<0.01$). The order of pH was Hokkaido > West Java > Tokyo >> Central Kalimantan.

The comparison between West Java and Hokkaido ($p<0.01$), and West Java and Tokyo ($p<0.01$) showed significant differences in COD. The difference was due to high conductivity in West Java.

In the case of NO_3, the West Java and Tokyo were significantly different ($p<0.01$). There were significant differences between Tokyo and Central Kalimantan, and Tokyo and Hokkaido ($p<0.05$). The concentrations of NOx in Tokyo were markedly high.

For Cl, there were significant differences between Hokkaido and Tokyo ($p<0.01$), and Central Kalimantan and Tokyo ($p<0.05$). The order of Cl was Tokyo >> West Java >> Hokkaido ≥ Central Kalimantan.

3.8 Principal component analysis

The numbers in Fig. 3 indicate sampling sites; 1 to 14 in West Java, 18 to 21 in Central Kalimantan, 23 to 39 in Hokkaido, and 43 to 53 in the Tokyo area. In 9 sampling sites in West Java, levels of BPA, COD, *E. coli* and Cl were high. In sampling sites in Central Kalimantan and 11 sampling sites in Hokkaido covering wide areas, pH and APE levels were high. In sampling sites in the Tokyo area, NO_2 and NO_3 levels were high. Locations of the numbers shown in Fig. 3 are listed in Tables 2 and 3.

4. Discussion

In this study, to understand the situation of pollution in developing and developed countries, 64 water samples from lakes and rivers were collected in West and Central Java and Central Kalimantan in Indonesia, and the Tokyo and Hokkaido areas in Japan. Monitoring of criteria of water quality and chemical substances, including endocrine disrupters, in river and lake water provides useful information on environmental contaminants in a country. From this point of view, the collected water samples were measured for factors such as pH, conductivity and endocrine disrupters.

The results presented in this study showed, major differences between pH, COD, contaminated *E. coli* and phosphate concentrations in the water samples from Indonesia and Japan. These values in Indonesia were higher than those in Japan except for the pH value. The pH value in Central Kalimantan was the lowest among these 4 areas (Table 5). Previously we reported that the low pH in water of Central Kalimantan was caused by sulfuric acid in the soil (Kurasaki et al. 2000).

From the results (Tables 2 and 5, and Fig. 3), it was considered that river and lake water in Indonesia showed high organic compound and agricultural chemical contents as compared with those in Japan, because sewage is less treated in Indonesia. *E. coli* was also detected at high levels in the water samples in Indonesia. Although there are few factories in Central Kalimantan, higher amounts of *E. coli* was detected in Sebangau (No. 18 in Fig. 1) and Kahayan Rivers (No. 19-21 in Fig. 1). In addition, *E. coli* was the most common organism detected in 2 of 2 groundwater samples in the West Java area (data not shown). The greater microbial contamination level in the river water than in the ground water was a higher health risk to the people, because human waste, factory drainage and domestic wastewater flowed directly into rivers. In addition, agricultural chemicals used in rice fields around the rivers also flowed directly into the rivers, as sometimes there was no drainage system. From these observations, to promote the environment of river water in Indonesia, sewerage and drainage system should be established as soon as possible.

On the other hand, in Japan, especially in the Tokyo area, the values for conductivity, NO_2 and NO_3 in the rivers in the Tokyo area were higher than those in Indonesia (Table 5 and Fig. 3). The reason why NO_2 and NO_3 increased in the river water in the Tokyo area is still unknown, because increases of NO_2 and NO_3 are signs of pollution by fertilizers. However there was a possibility that increases of NO_2 and NO_3 were caused by acid rain and exhaust gases.

In the Hokkaido area, good environmental conditions for human life were maintained except in the Tokachi River (No. 36-39 in Fig. 2). NO_3 was detected at levels of from 10 to 20 mg l^{-1} in the Tokachi River. As livestock and agricultural farms are located around the river, fertilizer probably affected the water quality in this area.

Chloride ions themselves are not harmful. The detection of concentrations of chloride ions of more than 50-100 mg l^{-1} in fresh water suggests the presence of pollution. Human waste, sewage and factory drainage are usually considered to be sources of pollution in noncoastal areas (Clara et al. 1997), whereas seawater is contaminated in coastal areas. The standard value of chloride ions for drinking water without purification in Indonesia is 600 mg l^{-1}. The World Health Organization's (WHO) guideline for drinking water suggests that the concentration in drinking water should less than 0.01 mg l^{-1}.

The concentration of chloride ions was relatively high in Japan, especially in Tokyo and Saitama compared to Indonesia (Tables 2 and 3). The highest concentration of chloride ion was found in water from the Kanda River (No. 46 in Fig. 2).

The results of PCA (Fig. 3) indicated that water quality, indicated by the levels of COD, NO_2, NO_3, Cl, *E. coli*, APE and BPA, in Central Kalimantan and Hokkaido was similar. The pH and APE levels in these areas were high. On the other hand, Cl and *E. coli* levels were high in developed areas (West Java and the Tokyo area). The features of water quality in developing areas and developed areas were different. In developing areas, more sampling sites had high pH and APE values. In developed areas, high levels of Cl and *E. coli* were prominent.

In West Java and Central Kalimantan, Indonesia, there are several rivers that have been polluted by mercury, because of many gold mining activities in which mercury is used to extract gold from gold ore. Mercury waste is often associated with causing problems as in Minamata, Japan where two thousands of babies were born with abnormalities in Minamata owing to Hg pollution in Minamata Bay.

As the processing in gold mining is very simple, it is estimated about 4.8 tons of mercury being dumped into the Cikaniki River per month. The river water then flows to the mouth of the river passing many villages along the way (Limbong et al. 2005).

Mercury was detected in most of the samples in Indonesia except in the Cisadane River (No. 6, 7 and 9 in Fig. 1: Table 4). The mean value of mercury concentration in lakes was higher than that in rivers and groundwater. These values were almost less than those of the water standards for drinking water in Indonesia. In Japan, mercury was hardly detected in any of the water samples.

To clarify whether there was pollution by endocrine disrupters such as APE and BPA in the rivers, contents of APE and BPA were measured in water samples in Indonesia and Japan using ELISA kits. As shown in Tables 2 and 3, APE was detected in 40 of the 64 water samples from Indonesia and Japan. On the other hand, BPA was detected in water samples in domestic wastewater in Indonesia. It is well known that nonylphenol has endocrine-disrupting effects in wild animals. In addition, nonylphenol affects apoptosis as described by Aoki et al. (2004), who indicated that more than 10 ppb of nonylphenol enhanced apoptosis. In this study, more than 10 ppb of nonylphenol was detected in 24 samples in Japan and Indonesia. Thus, there is a possibility of APE effects on the development and differentiation of humans and wildlife, especially aquatic wildlife. This indicates that environmental pollutants such as endocrine disrupting chemicals should be reinvestigated as disrupting factors for differentiation and development. Whereas in this study, BPA was hardly detected, only one water sample contained less than 5 ppb BPA. A potential endocrine disrupter, BPA is widely used as a monomer for the production of plastics, resin and coating, and is extensively used in the food-packaging industry and dentistry. Recently, it was reported that BPA could be detected in fetuses, suggesting BPA transfer to them. From this viewpoint, it is important that contents of BPA be monitored continuously to protect against the toxicity of endocrine disrupters.

5. Conclusion

It was expected that river water in Indonesia would be more polluted than that in Japan. However, the results in this study were very interesting. From the view point of industrial pollution, water of rivers in Indonesia was not so heavily polluted as that in Japan. The results for Indonesia and Japan suggested that pollution in river water in Indonesia was caused by lack of in few sewage systems whereas pollution in river water in the Tokyo area in Japan was caused by the large population and industries. The environmental circumstances in Indonesia are expected to be improved by the introduction of sewerage systems.

Acknowledgments

This research was supported by Grants-in-Aid from the Japan Society for the Promotion of Science (No.18404004 for M. Kurasaki and No.18590548 for T. Hosokawa). The authors are also indebt to Dr. Dede Irving Hartoto, RC for Limnology, Indonesian Institute for Sciences and Prof. Sulumin Gumiri, University of Parangka

Raya for useful discussions.

References

Aoki, M., Kurasaki, M., Saito, T., Seki, S., Hosokawa, T., Takahashi, Y., Fujita, H. & Iwakuma, T. (2004). Nonylphenol enhances apoptosis induced by serum deprivation in PC12 cells. *Life Sciences, 74,* 2301-2312

Abe, T., Ohtsuka, R., Watanabe, M., Yoshida, M. & Futatsuka, M. (1995). Adaptation of the resettled Kenyah Dayak villagers to riverine environment in east Kalimantan: a preliminary report. *Journal of Human Ergology, 24,* 33-36

Akagi, H., Castillo, E.S., Cortes-Maramba, N., Francisco-Rivera, A.T. & Timbang, T.D. (2000). Health assessment for mercury exposure among schoolchildren residing near a gold processing and refining plant in Apokon, Tagum, Davao del Norte, Philippines. *The Science of the Total Environment, 259,* 31-43

Brumental, U.J., Abisudjak, B., Cifuentes, E., Bennet, S. & Ruiz-Palacious, G. (1991-1992). Recent epidemiological studies to test microbiological quality guidelines for wastewater use in agriculture and aquaculture. *Public Health Reviews, 19,* 237-242

Burt, A., Maher, W., Roach, A., Krikowa, F., Honkoop, P. & Bayne, B. (2007). The accumulation of Zn, Se, Cd, and Pb and physiological condition of Anadara trapezia transplanted to a contamination gradient in Lake Macquarie, New South Wales, Australia. *Marine Environmental Research, 64,* 54-78

Clara, M., Scharf, S., Scheffknecht C. & Gans O. (2007). Occurrence of selected surfactants in untreated and treated sewage. *Water Research, 41,* 4339-4348

Gracy, M., Ostergaard, P., Adnan, S.W. & Ivson J.B. (1979). Faceal pollution of surface water in Jakarta. *Transactions of the Royal Society of Tropical Medicine and Hygiene, 73,* 306-308

Hart, B.T., van Dok, W. & Djuangsih, N. (2002). Nutrient budget for Saguling Reservoir, West Java, Indonesia. *Water Research, 36,* 2152-2160

Kurasaki M, Hartoto, D.I., Saito, T., Suzuki-Kurasaki, M. & Iwakuma, T. (2000). Metals in water in the Central Kalimantan, Indonesia. *Bulletin of Environmental Contamination and Toxicology, 65,* 591-597

Lesage, E., Rousseau, D.P.L., Meers, E., Tack, F.M.G. & De Pauw, N. (2007). Accumulation of metals in a horizontal subsurface flow constructed wetland treating domestic wastewater in Flanders, Belgium. *The Science of the Total Environment, 380,* 102-115

Limbong, D., Kumampung. J., Ayhuan, D., Arai, T. & Miyazaki, N. (2005). Mercury pollution related to artisanal gold mining in north Sulawesi Island, Indonesia. *Bulletin of Environmental Contamination and Toxicology, 75,* 989-996

Liu, J.R., Pang, Y.X., Tang, X.L., Dong, H.W., Chen, B.Q. & Sun, C.H. (2007). Genotoxic activity of organic contamination of the Songhua River in the north-eastern region of the People's Republic of China. *Mutation Research, 634,* 81-92

Phanuwan, C., Takizawa, S., Oguma, K., Katayama, H., Yunika, A. & Ohgaki, S. (2006). Monitoring of human enteric viruses and coliform bacteria in waters after urban flood in Jakarta, Indonesia. *Water Science and Technology, 54,* 203-210

Prihartono, N., Adisasmita, A., Costello, C., Damayanti, R., Prasetyo, S. & Syarif, S. (1994). Water preparation practices in south Kalimantan, Indonesia. *Journal of Diarrhoeal Diseases Research, 12,* 279-286

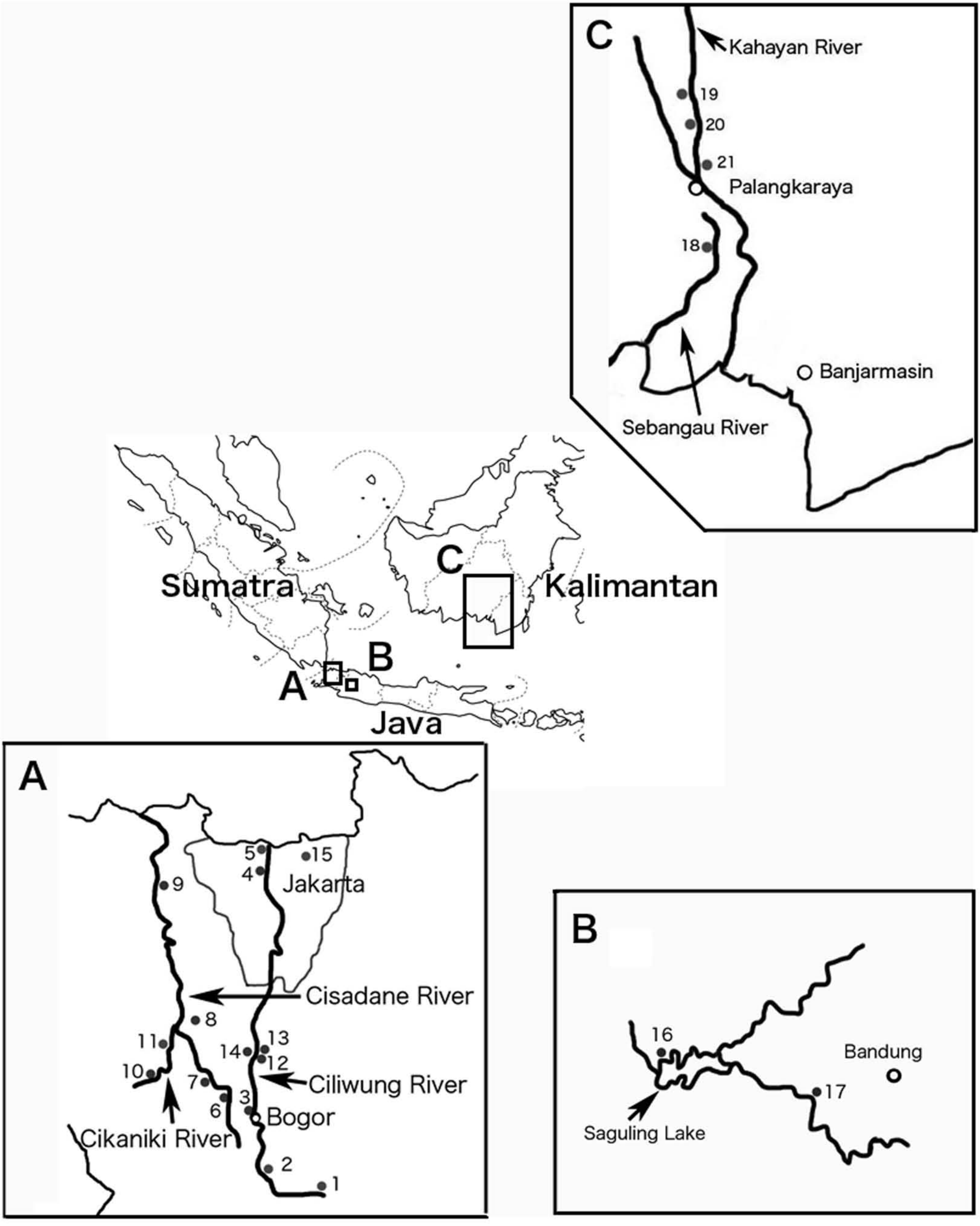
Potter, K.M., Cubbage, F.W., Blank, G.B. & Schaberg, R.H. (2004) A watershed-scale model for predicting nonpoint pollution risk in North Carolina. *Environmental Management, 34,* 62-74

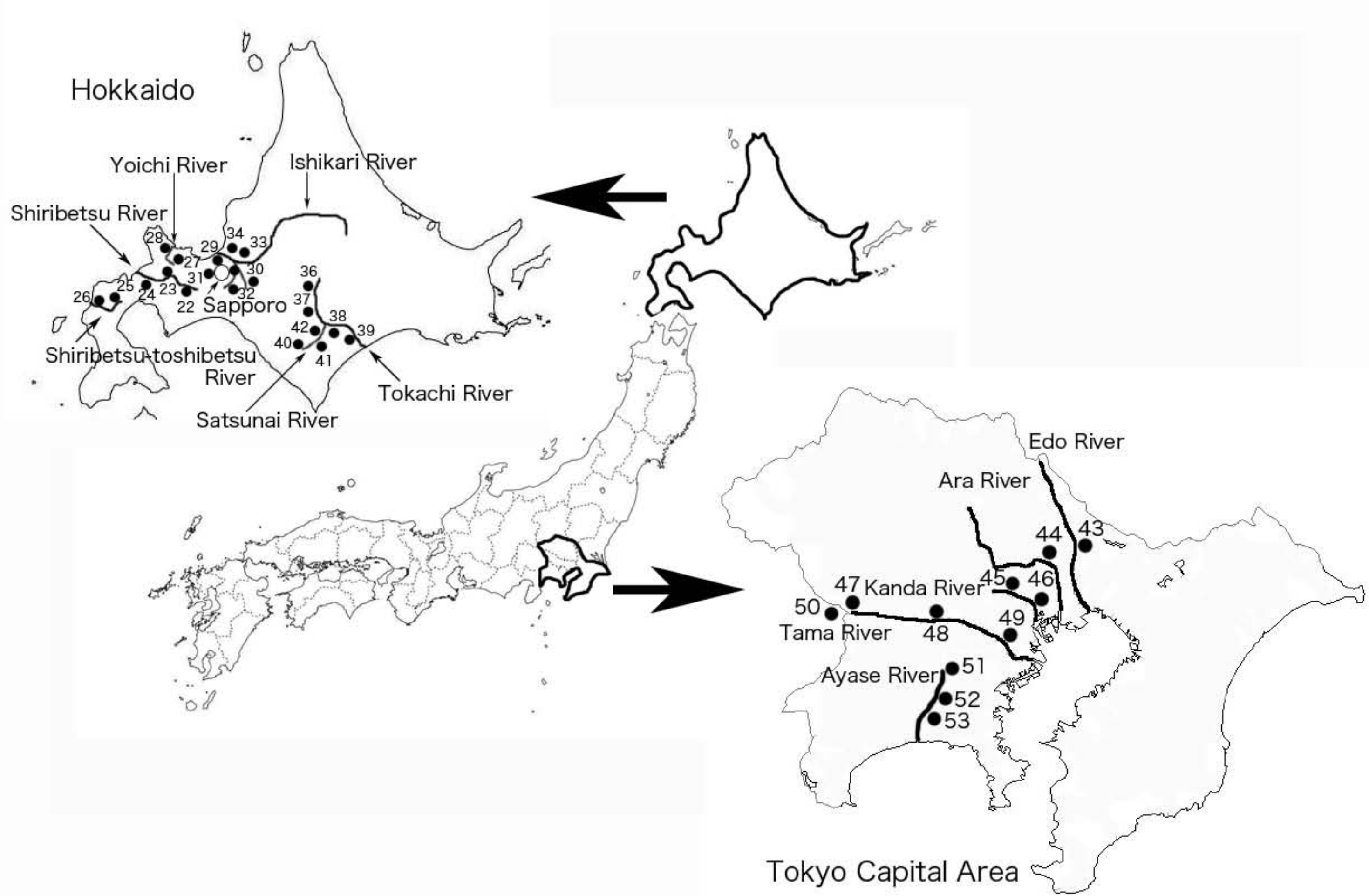
Figure Captions

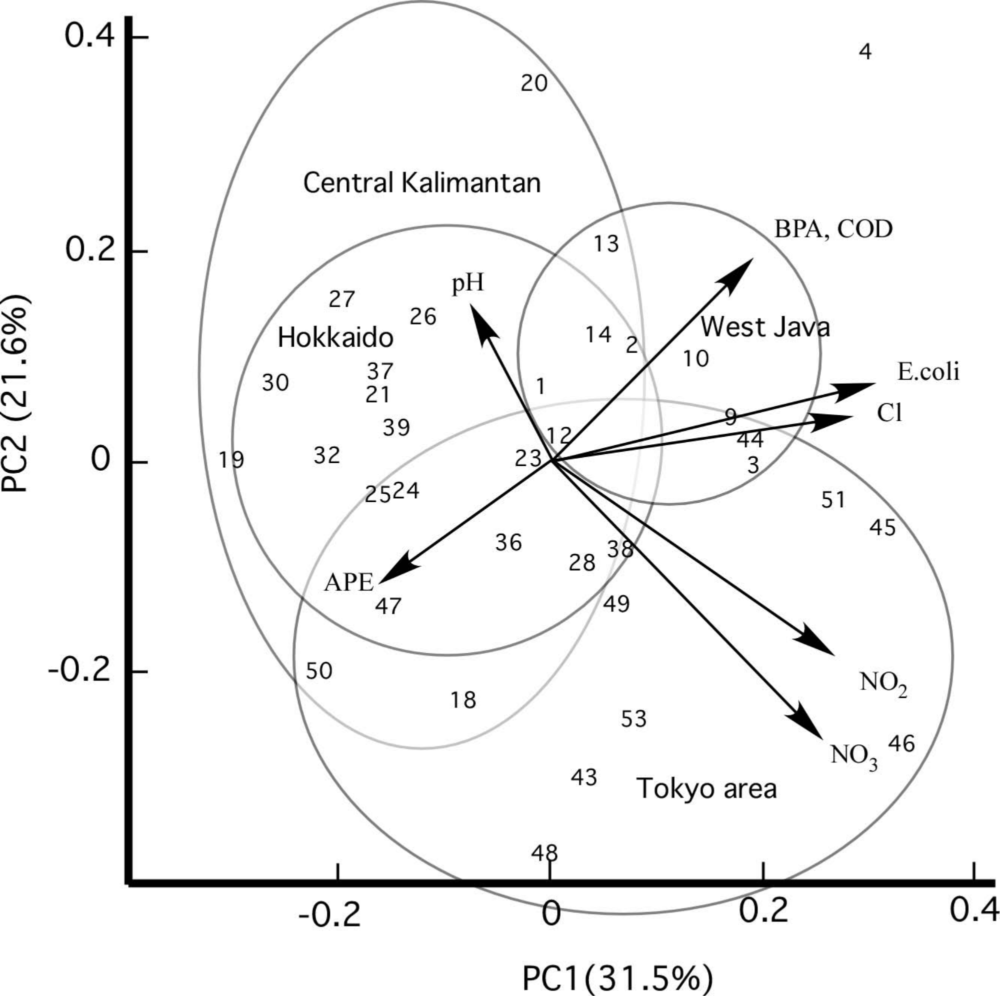
Fig. 1 Sampling points in West Java, around Jakarta (A) and Bandung (B) and Central Kalimantan (C) in Indonesia. Each sampling point is shown in the figure, numbers 1 to 21.

Fig. 2 Sampling points in Hokkaido and Tokyo areas in Japan. Each sampling point is shown in the figure, numbers 22 to 53.

Fig. 3 Principal component analysis for water quality in four areas. Each circle shows the sampling area. The X-axe is a principal component 1. The Y-axe is a principal component 2. The values in parentheses are contribution ratios for each component. The vector arrows show the direction and quantity of loading for each parameter. Parameters are COD, NO_2, NO_3, Cl, *E. coli*, APE and BPA.


C
Kahayan River
19
20
21
Palangkaraya
18
Banjarmasin
Sebangau River
Sumatra
C
Kalimantan
B
A
Java
A
5
15
4
Jakarta
9
Cisadane River
8
11
13
14
12
10
Ciliwung River
7
6
3
Bogor
Cikaniki River
2
1
B
16
Bandung
17
Saguling Lake


Hokkaido
Yoichi River
Ishikari River
Shiribetsu River
28
27
29
34
33
31
30
36
25
24
23
22
32
26
Sapporo
37
38
42
39
40
41
Shiribetsu-toshibetsu River
Tokachi River
Satsunai River
Edo River
Ara River
44
43
45
46
47
Kanda River
50
48
49
Tama River
51
Ayase River
52
53
Tokyo Capital Area



0.4
0.2
0
-0.2
PC2 (21.6%)
-0.2
0
0.2
0.4
PC1(31.5%)
Central Kalimantan
Hokkaido
West Java
Tokyo area
BPA, COD
pH
E.coli
Cl
APE
NO2
NO3
4
20
13
27
26
14
2
10
30
37
21
1
39
9
12
44
19
32
23
3
25
24
51
45
36
38
28
47
49
50
18
53
46
43
48

Table 1. Environmental standards in Indonesia and Japan

	pH	COD* (mg/l)	NO_2^- (mg/l)	NO_3^- (mg/l)	Cl (mg/l)	E. coli (num./ml)	Hg (µg/l)
Indonesia TypeB (for water supply)	5 - 9	20 - 500	1	10	600	100	1.0
Japan level3 (for water supply)	6.5 - 8.5	160	10	10	200	50	0.5

*effluent standard

Table 2. Data for general water quality of water samples in West Java and Central Kalimantan, Indonesia.

Map number	sampling point	date	pH	Conductivity (μS/cm)	COD (mg/l)	NO_2^- (mg/l)	NO_3^- (mg/l)	PO_4^{3-} (mg/l)	Cl (mg/l)	E. coli (num./ml)	BPA (μg/l)	APE (μg/l)
West Java												
1	Ciliwung 1	Sep. 2006	7.5	5	7.5	0.01	1	0.2	20	11	0.28	33.2
2	Ciliwung 2	Jun. 2006	8	10	10	0.02	1	0.3	-	109	n.d.	n.d.
		Sep. 2006	7.9	10	13	0.02	1	0.2	75	50	0.16	298.3
3	Ciliwung 3	Jun. 2006	6.8	0.7	7.5	1	15	1	-	588	n.d.	n.d.
		Sep. 2006	7.4	25	80	0.5	4.5	2	20	71	0.46	191.4
4	Ciliwung 4	Sep. 2006	7.2	49	90	0.005	1	-	75	191	0.83	n.d.
5	Ciliwung 5	Jun. 2006	6.5	35	100	0	n.d.	5	-	14	n.d.	n.d.
6	Cisadane 1	Jun. 2006	7.2	10	8	0.15	1.5	0.5	-	129	n.d.	n.d.
7	Cisadane 2	Jun. 2006	6.9	14	9	0.2	2	0.35	-	118	n.d.	n.d.
8	Cisadane 3	Jun. 2006	6.1	11	8	0.05	1	0.35	-	90	n.d.	n.d.
9	Cisadane 4	Jun. 2006	6.7	43	50	0.1	1.5	0.2	-	195	n.d.	n.d.
		Sep. 2006	7.2	13	10	1.5	0.0075	0.2	10	67	0.53	n.d.
10	Cikaniki 1	Jun. 2006	7	4	6	0.02	1.5	0.75	-	67	n.d.	n.d.
		Sep. 2006	7.4	5	10	0.075	1	0.2	5	52	0.46	n.d.
11	Cikaniki 2	Sep. 2006	7.4	9	13	0.2	0.2	2	5	-	0.76	61
12	Lake Citatah	Jun. 2006	6.8	10	8	0.5	3.5	0.2	-	128	n.d.	n.d.
		Sep. 2006	8.4	14	50	0.01	1	n.d.	75	40	0.44	191.4
13	Lake Cikaret	Jun. 2006	7.5	11	13	0.1	1.5	0.2	-	17	n.d.	n.d.
		Sep. 2006	8.6	2	50	0.01	1	0.2	110	27	0.42	154.5
14	Lake Cibinong	Jun. 2006	6.7	10	40	0.5	3.5	0.35	-	154	n.d.	n.d.
		Sep. 2006	7.6	9	70	0.05	1	0.2	10	21	0.18	96.6
15	Sunter Lake	Jun. 2006	7.2	52	50	0.02	1	0.2	-	58	n.d.	n.d.
16	Saguling Resevoir	Jun. 2006	7.6	21	20	0.02	1	0.2	-	49	n.d.	n.d.
17	Citarum Bandung	Jun. 2006	6.9	49	55	0.02	1	1	-	304	n.d.	n.d.
Central Kalimantan												
18	Sebangau	Sep. 2006	4.3	3	4	0.05	1	0.5	2	25	0.69	938.3
19	Kahayan 1	Sep. 2006	6.6	2	20	n.d.	n.d.	0.2	2	8	0.27	402.5
20	Kahayan 2	Sep. 2006	7.1	2	40	n.d.	n.d.	0.5	20	13	0.17	n.d.
21	Kahayan 3	Sep. 2006	7	2	16.5	n.d.	n.d.	0.2	2	19	0.18	118.1

(Map number correspond to that in Fig. 1. -: no data, n.d.: not detected)

Table 3. Data for general water quality of water samples in Hokkaido and Tokyo area, Japan.

Map number	sampling point	date	pH	Conductivity (μS/cm)	COD (mg/l)	NO_2^- (mg/l)	NO_3^- (mg/l)	PO_4^{3-} (mg/l)	Cl (mg/l)	E. coli (num./ml)	BPA (μg/l)	APE (μg/l)
Hokkaido												
22	Shiribetsu R.1	Nov. 2005	7.03	3	3	0.02	1	0.2	-	-	n.d.	n.d.
		Nov. 2006	-	4	5	n.d.	n.d.	n.d.	2	9	n.d.	n.d.
23	Shiribetsu R. 2	Nov. 2005	7.25	8	2	0.02	1	0.2	-	-	n.d.	n.d.
		Nov. 2006	8.27	8	5	n.d.	2	n.d.	20	166	n.d.	110.9
24	Shiribetsu R. 3	Nov. 2005	7.09	8	4	0.2	0.23	0.2	-	-	n.d.	n.d.
		Nov. 2006	8.12	11	2	n.d.	2	n.d.	10	9	0.39	169.2
25	Shiribeshitoshibetsu R. 1	Nov. 2006	8	11	2	n.d.	2	n.d.	0	52	0.21	n.d.
26	Shiribeshitoshibetsu R. 2	Nov. 2006	8	9	4	n.d.	n.d.	n.d.	10	12	n.d.	68.2
27	Yoichi R. 1	Oct. 2006	8	7	7	n.d.	n.d.	n.d.	10	2	0.11	n.d.
28	Yoichi R. 2	Oct. 2006	8.08	5	5	0.05	5	n.d.	5	48	n.d.	n.d.
29	Barato	Nov. 2005	6.69	27	8	0.02	1.5	0.2	-	-	n.d.	n.d.
30	Sousei	Nov. 2005	6.7	39	9	0.02	5	0.2	-	-	n.d.	n.d.
		Oct. 2006	7.5	-	6	n.d.	n.d.	0.75	10	0	0.60	96.6
31	Fushiko	Nov. 2005	6.45	33	75	0.3	8.5	0.2	-	-	n.d.	n.d.
32	Toyohira R.	Oct. 2006	7.1	-	6	n.d.	n.d.	n.d.	2	10	0.05	267.2
33	Ishikari R. 1	Oct. 2006	8.27	-	50	0.01	1	0.2	125	-	n.d.	361.8
34	Ishikari R. 2	Oct. 2006	8.12	-	20	0.01	1	n.d.	75	-	0.10	n.d.
35	Chitose R.	Oct. 2006	7.63	-	5	0.01	5	n.d.	75	-	0.30	89.4
36	Tokachi R. 1	Nov. 2006	7.7	11	6	0.01	10	n.d.	2	16	0.22	89.4
37	Tokachi R. 2	Nov. 2006	7.9	7	55	n.d.	n.d.	n.d.	2	15	n.d.	729.0
38	Tokachi R. 3	Nov. 2006	7.4	22	6	0.005	20	n.d.	5	45	0.68	n.d.
39	Tokachi R. 4	Nov. 2006	7.9	8	5	n.d.	n.d.	n.d.	7	10	n.d.	154.5
40	Satsunai R. 1	Nov. 2006	7.9	3	0	n.d.	1	n.d.	n.d.	-	n.d.	n.d.
41	Satsunai R. 2	Nov. 2006	7.4	4	4	1	n.d.	n.d.	n.d.	6	0.22	n.d.
42	Satsunai R. 3	Nov. 2006	7.6	4	5	n.d.	5	n.d.	n.d.	10	0.28	n.d.
Tokyo												
43	Nakagawa R	Oct. 2006	7.2	-	10	0.1	10	0.5	75	4	0.24	402.5
44	Arakawa R.	Oct. 2006	7.3	-	10	0.0125	2	0.5	200	147	0.70	26.3
45	Kanda R. 1	Dec. 2006	7	45	13	0.005	45	2	75	113	n.d.	n.d.
46	Kanda R. 2	Dec. 2006	6.7		13	0.5	45	2	220	47	0.46	n.d.
47	Tama R. 1	Dec. 2006	7.4	8	5	n.d.	2	0.2	2	4	0.00	184.0

48	Tama R. 2	Dec. 2006	7.3	30	5	0.05	20	1	5	28	0.62	47.2
49	Tama R. 3	Dec. 2006	7.3	35	6	6	0.2	45	7.5	16	0.32	n.d.
50	Lake Okutama	Dec. 2006	7.1	7	5	n.d.	1	n.d.	n.d.	1	0.42	n.d.
51	Koayase R 1	Oct. 2006	7.2	-	50	0.1	10	0.5	125	67	1.65	n.d.
52	Ayase R. 1	Oct. 2006	7.2	-	6	0.05	10	0.35	75	-	0.32	n.d.
53	Ayase R. 2	Oct. 2006	7	-	7	0.05	10	0.5	75	16	0.46	314.0

(Map number correspond to that in Fig. 2. -: no data, n.d.: not detected)

Table 4. Data for Hg in the water samples in Indonesia.

(up:upstream, middle:midstream, down:downstream)

	sampling point	Hg (ppb)
1	Ciliwung (up) Puncag	0.30
2	Ciliwung (up)	0.23
3	Ciliwung (mid) Botanic Garden	0.18
4	Ciliwung (down) in Jakarta black water	0.25
8	Cisadane (down)	0.41
10	Cikaniki (up) Cisarua village	0.44
11	Cikaniki (mid)	0.30
12	Lake Citatah	1.06
13	Lake Cikaret	0.16
14	Lake Cibinong	0.17
18	Sebangau (mid)	0.17
19	Kahayan (up)	0.18
20	Kahayan (mid)	0.39
21	Kahayan (down)	0.23

Table 5 Averages of the data sets in each area

		pH		COD (mg/l)		NO_2 (mg/l)		NO_3 (mg/l)		Cl (mg/l)	
	n	Ave	SD	Ave	SD	Ave	SD	Ave	SD	Ave	SD
West Java	9	7.69	0.51	42.28	33.05	0.24	0.50	1.28	1.25	44.44	39.09
Central Kalimantan	4	6.25	1.32	20.13	14.92	0.01	0.03	0.25	0.50	6.50	9.00
Tokyo	10	7.15	0.21	12.40	13.58	0.68	1.88	14.52	17.16	78.45	81.27
Hokkaido	12	7.83	0.34	9.08	14.54	0.01	0.01	3.41	6.01	6.92	5.53