Total mercury contents in plankton collected from Talawaan Watershed, north Sulawesi, Indonesia

OTSUCHI MARINE SCIENCE 28: 80–83 (2003)

Total mercury contents in plankton collected from Talawaan Watershed, north Sulawesi, Indonesia

Inneke F. M. Rumengan[1)] *, Detty Rumampuk[1)], Daniel Limbong[1) 2)], Takaomi Arai[3)] and Nobuyuki Miyazaki[3)]

[1)] *Faculty of Fisheries and Marine Science, Sam Ratulangi University, Manado 95115, Indonesia*
**E-mail: inneke@manado.wasantara.net.id*
[2)] *Yayasan Bina Cipta Aquatech, JL. Krida IX, Malalayang I Timur, Manado 95115, Indonesia*
[3)] *Otsuchi Marine Research Center, Ocean Research Institute, The University of Tokyo, 2–106–1 Akahama, Otsuchi, Iwate 028–1102, Japan*

Received: 10 December 2002
Accepted: 20 February 2003

As a part of the monitoring program on mercury contamination in Talawaan Watershed, north Sulawesi Indonesia, total mercury contents in plankton along the watershed has been determined. The plankton samples were collected three times with two-week interval from 12 sampling sites along the three main rivers (Talawaan River, Kima River and Bailang River). All values ranged from 0.4 to as high as 118 μg mercury per g dry weight of concentrated plankton, not implying content in individuals of plankton. In general, plankton collected from sites around tailing ponds along the three rivers observed contained more Hg than do plankton collected upstream. In upstream area, T1 and B1 (in average of 4.03 and 6.5 μg/g d.w, respectively). Total mercury in plankton collected from downstream of Talawaan River were much higher, 3–13 times than those in upstream (in average of 4.03 μg/g d.w), where the highest levels in sites the sites T2 and T3 where the wastes of most active processing units drained into. Mercury concentrations in sampling sites along Bailang River and Kima River were lower than those in Talawaan River, i.e. in range of 9.2 to 25.5 μg/g d.w. and 3.1 to 10 μg/g d.w., respectively. This fact is a clear evidence for mercury emission from the existing gold processing plants. Gold mining activities in the study area are considered exclusive factor for environmental contamination by mercury, and high levels in plankton suggest that a process of bioaccumulation is occurring, which needs more clarification in the future.

Key words: mercury; watershed, plankton, Indonesia

INTRODUCTION

Mercury emission due to small scale gold mining in study area, Talawaan Watershed situated in northern part of North Sulawesi peninsula, Indonesia, has recently been a big issue, since its impact extends far beyond the immediate sites of the processing units, as previously reported by several authors (Martens 2000, Anonymous 2001, Limbong et al. 2003). Mercury pollution in this area has received international news coverage since 2000, however it is no meaningful without clarification of mercury bioavailability in aquatic system.

Plankton, of their short life cycles, responds quickly to environmental change, and hence their abundance and species composition are strongly influenced by certain non-biological aspects of water quality, including any contaminants that accumulate in the aquatic system. Bioaccumulation is related to food web (Veiga and Meech 1999), where plankton (both phytoplankton and zooplankton) ranks as primary producers. Knowing their level of contamination will provide a strong explanation of the level of contamination in higher tropic levels of the food chain.

Investigation of plankton in relation to the problem of environmental pollution, especially mercury pollution is likely very few. From the available articles on bioaccumulation of mercury in the study area, none record of mercury in plankton from that watershed was provided, except of anonymous (2001) but only taken from a single site, Talawaan River. Study on mercury contents in concentrated plankton along the watershed has therefore been conducted as a part of the monitoring program on mercury contamination in the study area. In order to evaluate how far the degree of mercury contamination has occurred in aquatic system, the plankton has been collected in the watershed from upstream to estuary.

Although only total mercury was analyzed in this study, it is expected that mercury in plankton is largely organic mercury, and therefore can be discussed in addressing to the rate of bioaccumulation in aquatic system. Thought that mercury incorporation in plankton is a function of mercury levels in sediment and water, data obtained is discussed with referring to those previously reported by Limbong et al. (2003).

MATERIALS AND METHODS

Plankton collection was conducted in 12 sampling sites along the three main rivers (Talawaan River, Kima River and Bailang River) (Fig.1). The description of the sampling sites has been reported by Limbong et al. (2003). Selection of these sites was based on variation of landform and land use in the watershed. The sites distributed from the most upstream area of the Talawaan and Bailang Rivers (T1 and B1, respectively), passed through the location of gold processing plants (T2, T3, and K1) to downstream areas (K3 and T5). A remote area, the Poigar River, was also selected for comparison, thought the mercury level in this area

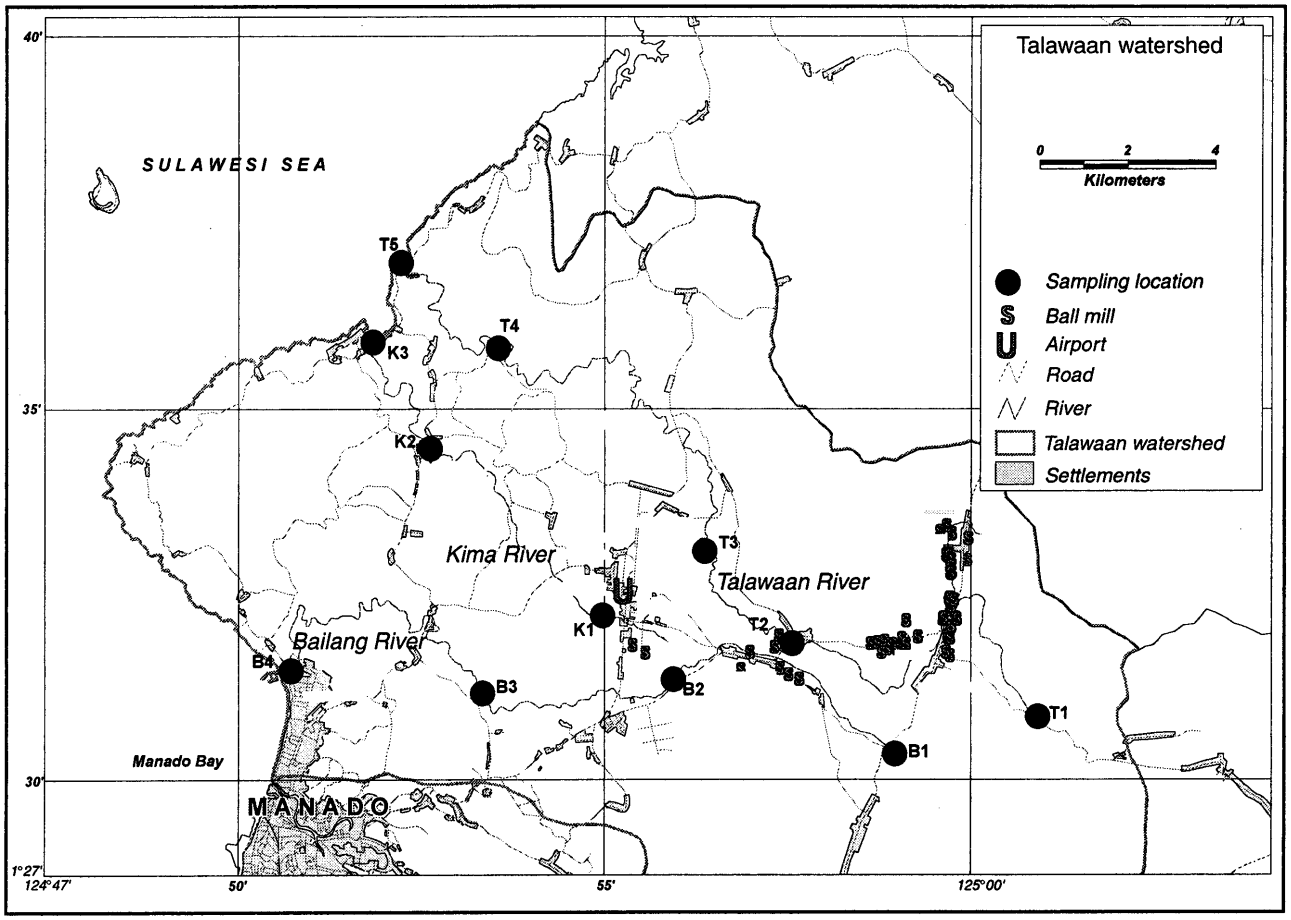

Fig. 1. Sampling sites in Talawaan Watershed, north Sulawesi, Indonesia. T: sampling sites along Talawaan River, B: sampling sites along Bailang River, K: sampling sites along Kima River.

represents the background level.

Sample collections were conducted three times within two weeks interval in order to account any short-term fluctuations within the watershed over May–June, 2001. Concentrated plankton was obtained by filtering 100 liters of water through a plankton net, and then transferred into bottles and immediately kept in a cool box after labeling. The sample was diluted with distilled water to make 400 ml, a 100 ml was sent to the Laboratory of Environmental Analysis, Bogor, Indonesia for mercury analysis.

This study focused on total mercury, in which the concentrated plankton were filtered using a 0.45 m filter to remove the seawater matrix and then washed with 100 ml deionized water. It was observed that the suspension (filtered materials) still contained fine particles that could not be separated prior to digestion and analysis. Following filtration the filter was dried and weighed. Total Hg in filtered materials was analyzed according to the method suggested by Daniel et al. (2003). The procedure involves digestion using nitric acid and hydrogen peroxide along with hotplate heating. Instrumental analysis is also by atomic absorption spectrophotometer (EPA Method 7000) with a detection limit of 1 μg/kg-wet weight.

RESULTS AND DISCUSSION

The watershed drains from the peak of Mount Klabat into western coast of Minahasa District and Manado City, and occupies an area of approximately 34,400 hectares including the drainage basins of the Talawaan River, Kima River, and Bailang River, which flow through the main center of gold mining area using mercury for amalgamation. The mining area is situated in upper part of the watershed in the region of Tatelu and Talawaan Villages, and the gold processing units are widely distributed in surrounding areas including many creeks around (Fig. 1).

Total mercury values of the present study ranged from 0.4 to as high as 118 μg/g d.w., incomparable to those of Anonymous (2001) for plankton samples taken from Talawaan River and ponds around in August 2000 (0.00128 to 0.0805 μg/ml). Theirs are per volume of concentrated plankton not dry weight. Magnitude of mercury level in this study is in μg/g d.w of the concentrated plankton, not implying content in individuals of plankton. As for biomass of one gram plankton may contain from hundreds to millions of individuals.

Figure 2 shows results of three sampling in each site that highly varied, except in upstream area of Talawaan River, T1 and Bailang River, B1 (in average of 4.03 and 6.5 μg/g d.w, respectively). Fluctuations in one site were not regularly according to the period of sampling which within a relative short time interval, only two weeks. The respective environmental conditions and weather at the time of sampling may explain this fact. Comparing the data among different sites, it is clear that mercury levels of the three sampling were highly variable at sampling sites along Talawaan River, where those in the downstream T4 and T5 were

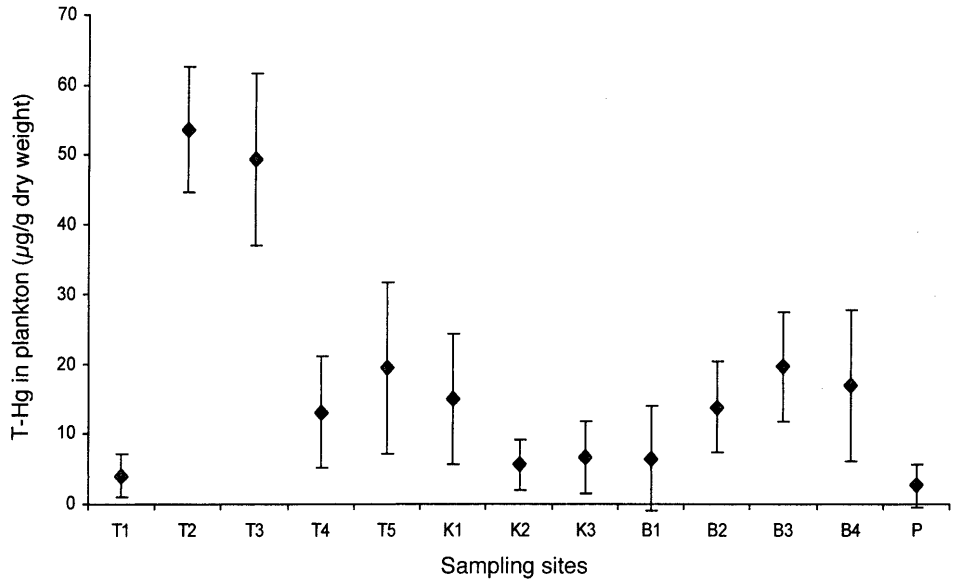

Fig. 2. Total mercury contents in plankton collected from Talawaan Watershed and Poigar River.

much higher, 3–13 times than that in upstream (T1). The highest contents were in the sites T2 and T3 where the wastes of most active processing units drained. It can be seen in Fig. 2 that mercury concentrations in sampling sites along Bailang River (B2 and B3) to the downstream (B4), and along Kima River (K1, K2 and K3) were lower than those in Talawaan River, i.e. in range of 9.2 to 25.5 μg/g d.w and 3.1 to 10 μg/g d.w, respectively. This fact is a clear evidence for mercury emission from the existing gold processing plants, since there are no other potential sources of mercury emission in this area. Gold processing plants are denser along Talawaan River, followed by Bailang River, and Kima River. At Kima River, the gold processing plants are located at the most upstream area of the river, therefore impact of a high mercury level had existed at site K1. The lower concentrations in sites upstream of Talawaan River, T1 and Poigar River, P as well (4.0 and 2.6 μg/g d.w, respectively) than those in other sites indicate the background levels of mercury since almost no direct influence from the processing plants on those areas.

The mercury contents in plankton along the rivers reflect that the emission of mercury has been dispersing to a larger area through river systems. High concentrations of mercury in concentrated plankton from Talawaan River are explainable with regarding to those concentrations in sediments and in water as previously reported by Limbong et al. (2003). Figures 3 and 4 illustrates the relationship between these factors and mercury contents in plankton. Those show the tendency of high accumulation rate of the emitted Hg in the aquatic system, where an increase of mercury levels in both water and sediments along that river occurred synchronizing with the increase in plankton.

The rate of bioaccumulation in the aquatic environment is best indicated by the concentration of mercury at various levels within the food chain (Martens 2000). Mercury biomagnifications along the food chain, increase in concentration from plankton and invertebrates to fish, with usually carnivorous species having the greater load. It is commonly argued that mercury in biota mainly in the form of methyl mercury, and that mercury in organic form is faster assimilated and more slowly eliminated than the inorganic forms. It is therefore reasonable to say that mercury in plankton is more efficiently transferred into the organisms of the higher rank of aquatic chain because of the biomagnifications, process with cumulative effect based on the fact that preys play the role of mercury pre-concentrator for the predator (Carmouze et al. 2001). Because plankton (both phytoplankton and zooplankton) ranks as primary producers in the aquatic food chain, their mercury level provide a strong explanation of the level of contamination in higher tropic levels of the food chain. As reported by Limbong et al. (2003) who examined mercury contents in 47 fish muscle samples of 13 species, in which a highest mercury level (3.14 mg/kg wet weight) was in a relatively small carnivorous species, *Caranx* sp. (a carnivorous species) caught in the Talawaan estuary. Carmouze et al. (2001) argued that 70–100% of mercury in fishes is mainly in the form of methyl mercury. Therefore, high mercury contents in plankton explain the presence of high methyl mercury amounts in higher level of aquatic fauna. The amounts of mercury that exist in methylated form still remain to determine for evaluation of bioaccumulation rate in various compartments of aquatic system. However, total mercury values of the present study have important implications regarding accumulation in the environment, especially in areas affected by mercury pollution from gold mining.

In food chain accumulation (biomagnifications) can be several orders of magnitude higher than in ambient water, and it enhances the probability of long-term toxic effect through the human food sources (Bruggeman 1988). Although the present results show that magnitude of mercury levels (in ppm unit) in fish were lower than in plankton, but it should be realized, as mentioned above, that the values are of concentrated plankton, not individuals, though the effect of other physical factors, such as suspended solid and turbidity should be taken into consideration. It is realized that in the sample contained some fine unseparated particles, which probably contained plankton residue or suspended materials. In addition, due to very limited information on mercury contents in plankton, and acceptable

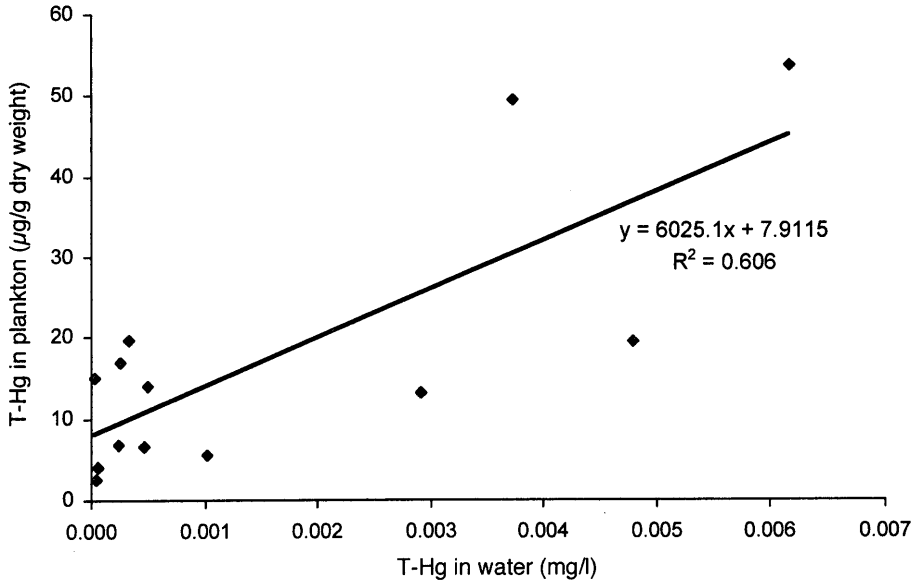

Fig. 3. Relationship between total mercury contents in plankton and in water taken from Talawaan Watershed.

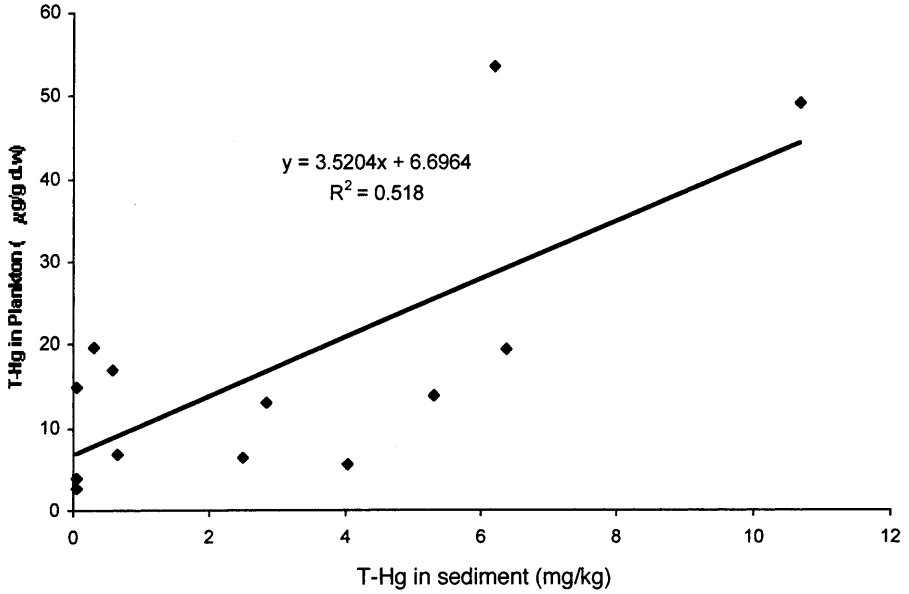

Fig. 4. Relationship between total mercury contents in plankton and sediments taken from Talawaan Watershed.

standard of mercury in plankton is not available yet , the present data in plankton can not explain how far the mercury has affect the biological performances of the plankton. It needs further clarification, with referring other factors such as abundance and species composition. Such information could provide more insight on the ecological impact on the watershed.

ACKNOWLEDGEMENT

We would like to thank US AID Natural Resource Management Program in North Sulawesi who sponsored a monitoring program in the study area implemented by a local nongovernmental organization, Yayasan Bina Cipta Aquatech with some staff of Sam Ratulangi University.

REFERENCES

Anonymous. 2001. Environmental Impact of Illegal Miners at Talawaan, North Sulawesi. Final Report. PT Dames and Moore Indonesia. 159 pp.

Bruggeman, W. A. 1988. Bioaccumulation. *In*: Manual on Aquatic Ecotoxicology. de Kruijf, H. A. M. et al. (eds.), pp. 149–153, Allied Publ. Private Ltd., New Delhi.

Carmouze J.-P., Lucotte, M. and Boudou, A. 2001. Mercury in the Amazon. Importance of human and environment, health hazards. IRD Editions, Paris, 40 pp.

Limbong, D., Kumampung, J., Rimper, J., Arai, T. and Miyazaki, N. 2003. Emission and environmental implications of mercury from artisanal gold mining in North Sulawesi, Indonesia. Sci. Total Environ. 302: 227–236.

Martens, H. 2000. Mercury Pollution Awareness and Control. A case study at small-scale gold mining sites in Ratatotok and Tatelu Sub-districts of North Sulawesi, Indonesia. Collaborative Environmental Project in Indonesia (CEPI).

Veiga, M. M., and Meech, J. A. 1999. A Brief History of Amalgamation Practices in the Americas. Website: briefhi2.htm at www.mining.ubc.ca. pp. 1–9.