Improvement of in situ measurement of mercury transport in the Minamata Bay

AKIHIDE TADA[1], SHINICHIRO YANO[2], HIDEO OSHIKAWA[3], TAKEHIRO NAKAMURA[4], HIROKATSU AKAGI[5], AKITO MATSUYAMA[6], TAKASHI TOMIYASU[7], RUDI RAJAR[8] & MILENA HORVAT[9]

[1]Department of Civil Engineering, Nagasaki University, Nagasaki 852-8521, Japan, E-mail: tada@civil.nagasaki-u.ac.jp
[2]Kyushu University, Japan, E-mail:yano@civil.kyushu-u.ac.jp
[3]Kyushu University, Japan, E-mail: oshikawa@civil.kyushu-u.ac.jp
[4]Nagasaki University, Japan, E-mail: tak-nak@net.nagasaki-u.ac.jp
[5]National Institute of Minamata Disease, Japan, E-mail: hiroakagi@nimd.go.jp
[6]National Institute of Minamata Disease, Japan, E-mail: matuyama@nimd.go.jp
[7]Nagasaki University, Japan, E-mail: tomy@sci.kagoshima-u.ac.jp
[8]University of Ljubljana, Slovenia, E-mail: rrajar@fgg.uni-lj.si
[9]Jozef Stefan Institute, Slovenia, E-mail: milena.horvat@ijs.si

Abstract: In order to realize mercury dynamics in a coastal area YANO ET AL. (2004) have proposed use of acoustic instruments for a measurement of mercury-contaminated suspended sediment transport. Acoustic Doppler Current Profilers (:ADCP) was applied to the first trial to measure mercury transport in the Minamata Bay in winter, 2002. However, mercury concentration was not measured directly. Thus, mercury transport has been estimated roughly. In this study, we attempted to improve the measurement of mercury transport by using depth monitoring water-sampling system to measure vertical profiles of mercury and SS concentration precisely. Both hydrodynamic observations of tidal currents and SS by using ADCP and a measurement of vertical profiles of Total-Hg, Methylmercury were carried out in the Minamata Bay in summer, 2003. From the comparison between measurements in 2002 and 2003 we can see direct measurement of vertical profiles of SS and it is found that mercury is very important for an accurate evaluation of mercury transport.

Key words: mercury transport, Minamata Bay, Acoustic Doppler Current Profilers, vertical profile of mercury

INTRODUCTION

In the Minamata Bay, the remediation project on water and bottom sediment environment has been finished until 1990 by dredging about 0.8 million m^3 of bottom sediment contaminated by mercury. However, recent measurement result (TOMIYASU ET AL., 2000) has shown that mercury is spreading around the center and southern parts of the Yatsushiro Sea from the Minamata Bay. Although the measured concentration of mercury in bottom sediment is a trace of amount (<3 ppm), modelling for accurate prediction of mercury dynamics is necessary.

In order to understand the mercury dynamics accurately in a coastal area, it is necessary to measure mercury transport in an actual sea. Thus, we have been attempting to carry out an oceanographic observation for dynamics of bottom sediment and seawater in the Minamata Bay since 2002, especially a long-term simultaneous measurement of vertical profiles of tidal current velocity and suspended sediment (: SS), by using Acoustic Doppler Current Profilers (: ADCP) (YANO ET AL., 2004). In the first measurement in 2002, annual mercury transport from the Minamata Bay to the Yatsushiro Sea was roughly calculated. However, vertical profile of mercury was not measured directly in the observation's period. In this study, we attempted to improve the measurement as the second stage of development of fundamental method for estimating the mercury transport.

RESULTS AND DISCUSSION

In the same manner as measurement in 2002, one ADCP (Aquadopp Profiler 1000 kHz, Nortek Co.), three Turbidity Meters (Compact-CLW, Alec Electronics Co.) and one wave meter (WaveHunter-99S, IO-Technique Co.) were set on the sea bottom in Minamata Bay from 19 August, 2003 to 4 October, 2003. A height *a* from the lowest turbidity meter to the top of mud layer which was 27 cm on 19 August became to be 30 cm on 4 October. As a result of measurement, time series of vertical profiles (: every 0.5 m layer from 80 cm above the sea bottom) of three velocity components and echo intensity, turbidity at three layers, which are 27, 177, 377 cm layers, and wave conditions (: wave height, wave direction, etc.) were observed. We could estimate time series of vertical profile of SS concentration from calibration between compensated ADCP echo intensity *SV* and SS, which was calibrated versus turbidity by water sampling.

In addition, vertical profiles of SS, Total-Hg and Methylmercury in water body and Total-Hg in SS component were measured by water sampling from five layers between sea surface and bottom as shown in Fig.2. To measure the vertical profiles precisely, water sampling was carried out by a water sampler with water pressure meter (Diver 30 m, Eijkelkamp Co., accuracy: FS0.1 %), which can monitor a sampling position. The measured Total-Hg in SS components is of the same order as an existing data of Total-Hg in bottom sediment in the Minamata Bay

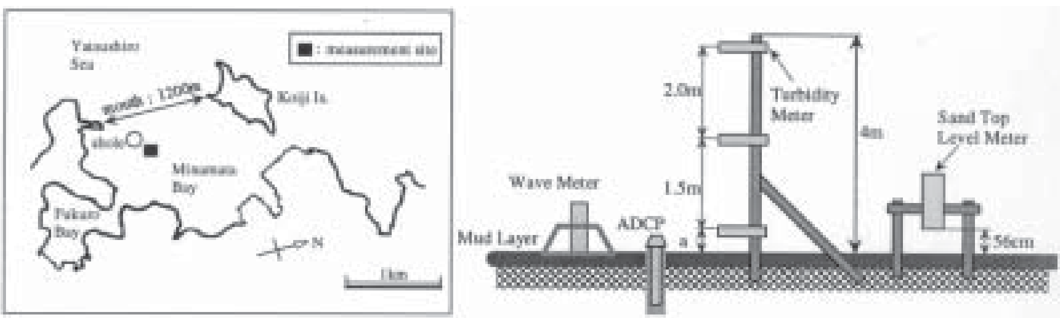

Figure 1. Measurement site and measurement setup

(HARAGUCHI ET AL., 2000), but the former is less than 20 % of the latter. Also, exchange rate of sediment at interface between seawater and bottom sediment was measured by acoustic sand top-level meter (USR-10, Engan Kaiyo Chosa Co.). Moreover, the current observation by using ADCP (RD Instruments WorkhorseADCP 600kHz) was performed on the 29th of July, 2003 in order to realize a three-dimensional structure of tidal currents. In particular, ADCP was mounted over the side of a fishing boat. Fig. 3 shows horizontal distribution of velocity vectors of tidal currents in surface layer at both the maximum ebb tide and the maximum flood tide. Because the northern mouth is very narrow, topographic eddy was generated in the northern part of the Minamata Bay at the maximum ebb tide.

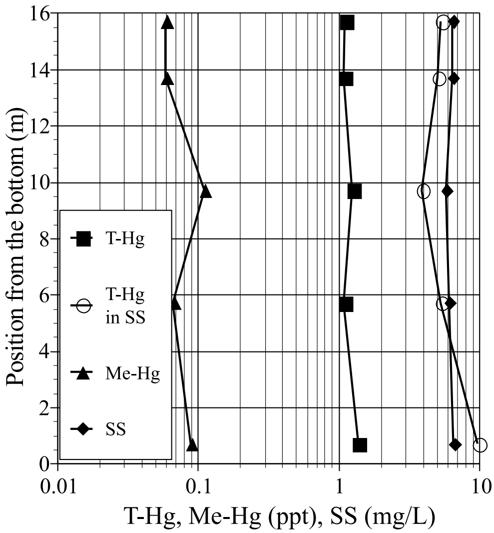

Figure 2. Vertical profiles of SS, concentration of Total-Hg, MM-Hg in water and T-Hg in SS

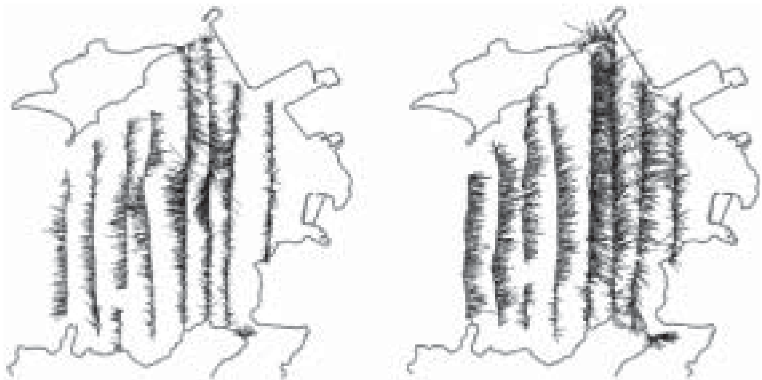

Figure 3. Horizontal distribution of velocity vectors of tidal current in surface layer. (a) at maximum ebb tide and (b) at maximum flood tide

Temporal variation of SS flux at each layer was calculated from the ADCP data of tidal current velocity and SS concentration. Also, Total-Hg flux was calculated from SS flux and measured Total-Hg concentration. Fig. 4 shows directional distribution of net SS transport per unit width for the measurement period and temporal vector variation of Total-Hg flux in layer at 183 cm above the sea bottom in spring tide. The dominant direction of SS flux was N to NW in winter, 2002, while it was scattered in summer, 2003. Magnitude of Total-Hg flux depends on the tidal range apparently.

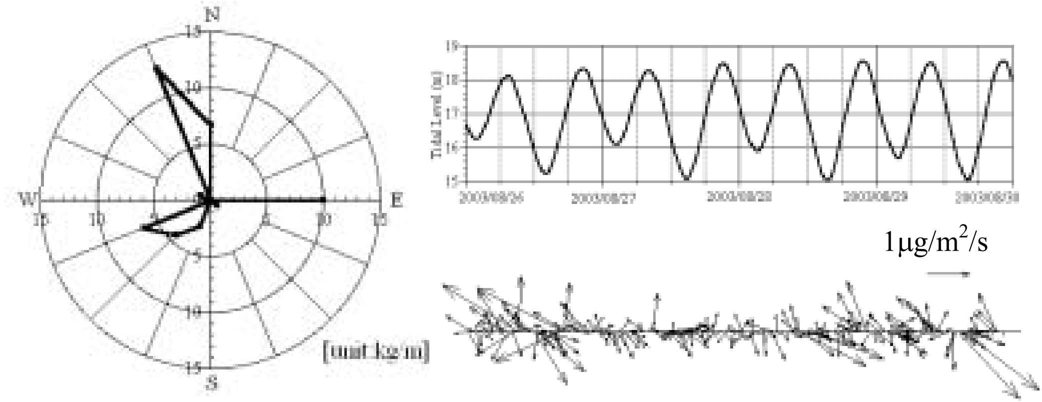

Figure 4. Directional distribution of net SS transport in 183 cm layer, and time series of tidal level and Total-Hg flux vector in spring tide in183 cm layer

CONCLUSIONS

We attempted to improve in situ measurement of mercury transport from the Minamata Bay. As a result of this study, it becomes clear that i) ADCP can measure temporary vertical profile of mercury flux sufficiently, ii) the measurement of vertical profiles of SS and mercury is very important for an accurate estimation of mercury transport.

Acknowledgements

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