MERCURY DYNAMICS IN COASTAL ENVIRONMENT : IN-SITU MEASUREMENT AND NUMERICAL MODELING IN MINAMATA BAY, JAPAN

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論 文 名　：MERCURY DYNAMICS IN COASTAL ENVIRONMENT
– IN-SITU MEASUREMENT AND NUMERICAL MODELING
IN MINAMATA BAY, JAPAN
（沿岸域環境における水銀動態－水俣湾における現地観測と数値モデリング）

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論 文 内 容 の 要 旨

Mercury is a toxic pollutant and can accumulate in ecosystems such as in the marine food web. At the present mercury pollution in the natural environment occurs worldwide. The most well-known health damage associated with mercury pollution is Minamata Disease. It was first detected at the city of Minamata in 1956. Minamata Disease is a very serious disease with symptoms related with central neurological disorder caused by consuming contaminated seafood by methylmercury. In Minamata Bay methylmercury (MeHg) was formed from waste discharged by the chemical plant, which produced acetaldehyde using inorganic mercury as catalysts. In marine sediments, microorganisms can transform the mercury compound into methylmercury substance which is very dangerous to human life. In 1968 the government of Japan officially, for the first time, announced the Minamata Disease after 12 years since the disease was detected.

In order to cope with this environmental pollution disaster, the government of Kumamoto Prefecture conducted an environmental rehabilitation project to remove all contaminated bottom sediment with high levels of mercury (>25ppm, dry wt.). The bottom sediment with lower mercury (<25ppm) was, however, not removed. It is therefore necessary to understand the risk for future generations especially pregnant women who consume seafood contaminated with MeHg from trace mercury in the sediment in the bay. In order to maintain the amount of mercury within safe levels we need to monitor the sea water of Minamata Bay. It is also of great importance to conduct *in-situ* measurement of mercury concentrations in sea water from Minamata Bay to develop a numerical model for mercury dynamics and its fate in the bay. In addition, this numerical model of mercury dynamics can be expected to adapt to other mercury polluted sea areas, for example the Mediterranean Sea, the Pacific Ocean, and the Atlantic Ocean, etc.

The outline of this dissertation is shown as follows.

Chapter 1 introduces the background of the present study of mercury pollution, previous research related to this work, problem identification and the aim and outline of this dissertation.

Chapter 2 describes how two kinds of *in-situ* measurements of mercury transport and transformation have been attempted in Minamata Bay in order to understand a fundamental feature of mercury dynamics. First,

highly-frequent (weekly) water sampling for mercury speciation in sea water with continuous current measurement by bottom mounted ADCP at an observation tower which we built during the summer season. Second, monthly water sampling measuring the vertical profile of grain size distribution of suspended solids (SS) by LISST-100X at three stations in the bay was carried out. As a result of these measurements, the followings were clarified: i) Particulate and dissolved total mercury (T-Hg) in bottom layer was higher than that in both surface and middle layers; ii) Negative correlation between dissolved T-Hg and methylmercury (MeHg) was shown; iii) Annual particulate T-Hg and MeHg transports from Minamata Bay to the outer sea, Yatsushiro Sea were estimated as 6kg and 0.05kg, respectively; iv) Vertical variation of grain size distribution of SS was not shown in winter, but significantly visible in summer; and v) The results indicate the possibility that the source of mercury in the bottom layer and the surface layer is different.

Chapter 3 discusses the relationship between SS grain size distribution and particulate T-Hg concentration from the result of *in-situ* measurement in Minamata Bay. Particulate Hg can in general be considered as attached on the surface of SS particles. It is therefore necessary to understand the relationship between particulate Hg concentration and specific surface area of SS particles before developing a numerical model of particulate Hg transport. Characteristics of the relationship between particulate T-Hg concentration in sea water and SS grain size distribution, at the layer where water was sampled, were analyzed by the entropy method for grouping of dataset of monthly *in-situ* measurement in the bay. The source of SS is discussed from data of core sampling of bottom sediment as well. As a result, the following are clarified: i) There is a significant difference of SS grain size distribution between the upper layer and the lower layer under density stratification; ii) Origin of SS in the upper layer can be estimated to exist in load from rivers; and iii) Relationship among grain size distribution of SS and bottom sediment and particulate T-Hg in the bay was evaluated.

Chapter 4 investigates the effect of baroclinic flows on the bottom sediment transport in the Yatsushiro Sea by numerical simulations in order to develop a numerical model for particulate mercury dynamics dispersed from Minamata Bay. The present numerical model of bottom sediment can express the pattern of spatial distribution of T-Hg concentration in bottom sediment in the Yatsushiro Sea very well. As a result of the numerical research, it is concluded as follows: i) Baroclinic flows can significantly affect the long-term sediment transport in the Yatsushiro Sea around Minamata Bay; ii) The northward transport is generated by the baroclinic flows, while the southward and westward transport is generated by the barotropic flows; and iii) In order to simulate accurate long term mercury distribution from Minamata Bay, both baroclinic flows and barotoropic flows need to be taken into account.

Chapter 5 concludes all chapters and proposes suggestions for further studies.