英文Abstract

Intervention Scenarios and Global Mercury Modeling for Effectiveness Evaluation of the Minamata Convention on Mercury

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For appropriate implementation of the Minamata Convention on Mercury around the world, measures that combine various technologies and systems, such as the conversion of industrial processes and application of advanced emission control technologies, are necessary. The objective of this study was to develop a model that can quantitatively express the behaviors of mercury in natural environments and under the influence of anthropogenic activities for use in future projection and quantitative evaluation of the effectiveness of countermeasures, thereby providing a scientific basis for effectiveness evaluation of the Minamata Convention.

This study introduces a global scenario model for estimating anthropogenic emissions of mercury into the atmosphere. The findings indicate that significant reductions in mercury emissions can be expected with the implementation of various measures compared to the reference scenario without additional measures. In the “Step-wise reduction” scenario, the implemented mercury removal measures only offset the increase in emissions associated with economic growth since 2015. We further analyzed the co-benefit and tradeoff effects of reduced or increased mercury emissions caused by deep decarbonization measures aimed toward the global carbon-neutrality target. Such decarbonization measures will provide a large co-benefit of mercury mitigation. However, bioenergy with carbon capture and storage triggers a tradeoff effect of higher mercury emissions. Thus, mercury removal measures must be implemented to further reduce mercury emissions. In this study, as possible future mercury emission control technologies, we examined mercury behavior in carbon capture devices and developed activated carbon-based high-performance adsorbents.

The mercury emission results were used as input data for a global mercury biogeochemical model. The model calculation results suggest that mercury concentrations in the atmosphere and seawater will not decrease in the “Step-wise reduction” scenario. In the “Maximum reduction by 2050” scenario, mercury concentrations in the environment will decrease after 2032. Global mercury emission to the air is dominated by re-emission and re-mobilization associated with biogeochemical cycles, and thus our results suggest that the timing of environmental mercury reduction can be expected to occur later than the reduction in anthropogenic mercury emission.

We investigated health risks of mercury exposure through the consumption of seafood sold in markets. Model calculations showed that the maximum reduction scenario was expected to prevent economic losses of 27 trillion yen/year compared to the reference scenario without additional measures. However, a time lag exists before the

impact of countermeasures becomes apparent. Measures to reduce mercury emissions must be strengthened and introduced immediately.

From the results of biogeochemical model calculations, we propose new monitoring locations based on comparison of the reference scenario without additional measures with the “Maximum reduction by 2050” scenario.

The largest source of mercury to the air is artisanal small-scale gold mining (ASGM). In this study, data-driven approaches to exposing illegal and informal trade and use of mercury were developed to reduce emissions from ASGM. In addition, application of the retort and cyanidation methods in ASGM was evaluated, suggesting that financial mechanisms must be considered to effectively manage waste mercury. As mercury waste management is essential to the final sink of mercury, we conducted simulated landfill experiments using lab-scale lysimeters and accelerated leaching tests to establish long-term management methods for waste consisting of mercury. The results indicated that the possibility of mercury leaching from solidified mercury waste was low, and therefore mercury waste must be safely stored and disposed of.

Thus, this study produced results that will support effectiveness evaluation of the Minamata Convention. We hope that these results will be effectively used in the future development of domestic and international mercury guidelines.