論文要旨

論文題目: **Assessment of Mercury Pollution and Its Human Health Risk in Myanmar**（ミャンマーにおける水銀汚染とそれに伴うヒトの健康リスクの評価）

氏名: **Pyae Sone Soe**（ピエ ソン ソー）

[Background and objectives]

Myanmar, a developing country in Southeast Asia, has various mineral and natural resources, such as for jade, gold, ruby, and copper (Cu). Recently, population and economic growth in Myanmar has been increasing year by year. Therefore, environmental pollution by chemicals such as metals and pesticide in Myanmar, especially in urban areas is of great concern. For example, mercury (Hg) is listed among the top 10 most harmful metals by the World Health Organization (WHO). However, research conducted on environmental pollution by Hg in Myanmar is very few. Therefore, the objectives of this study were to 1) assess Hg pollution by artisanal and small-scale gold mining (ASGM) in Myanmar in comparison with other Southeast Asian countries, 2) understand contamination status by Hg in urban areas in Myanmar, 3) identify source of Hg in urban areas in Myanmar, and 4) evaluate human health risk by Hg exposure.

[Hg pollution by ASGM in Myanmar and other Southeast Asian countries]

Firstly, the study reviewed studies of Hg pollution by ASGM from Myanmar and other Southeast Asian countries. ASGM is the world's fastest-growing source of Hg and can release Hg into the atmosphere, hydrosphere, and geosphere. Mercury has been widely used in ASGM industries throughout Southeast Asia countries, including Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, and Thailand. Here, 16 relevant studies were systematically searched by performing a PRISMA flow, combining the keywords of "Hg", "ASGM", and relevant study areas. Mercury concentrations exceeding WHO and United States Environmental Protection Agency (US EPA) guideline values were reported in environmental (i.e., air, water, and soil) and biomonitoring samples (i.e., plants, fish, and human hair). The findings indicated severe Hg contamination around the ASGM process, specifically the gold-amalgamation stage, was significantly high. To one point, Hg atmospheric concentrations from all observed studies were shown to be extremely high in the vicinity of gold operating areas. ASGM-related health risks by Hg exposure to miners and nonminers were significant and several health impacts including respiratory disorder and neurological effects were reported. For the review study suggested attentions should be given regarding the public health concern, specifically for the vulnerable groups such as adults, pregnant women, and children who live near the ASGM activity. In the future, more research and assessment will be required to investigate the current and evolving situation in ASGM communities.

[Contamination status by Hg in urban areas in Myanmar]

In recent years, environmental pollution is of great concern in Myanmar due to urbanization and industrialization in urban areas like Yangon and Mandalay. To understand urban pollution by Hg in Myanmar, the study analyzed 39 road dust and 87 sediment samples from urban areas of Yangon and Mandalay and sub-urban areas of Pathein, Chaungtha, Wundwin, and expressway from Yangon to Pathein in Myanmar during 2014 – 2018. Mercury concentration in road dust and sediment from urban areas was significantly higher than that in sub-urban areas. Especially, high pollution was observed in Mandalay. The geo-accumulation index (I_{geo}) for Hg indicated moderately Hg contamination. In addition, the ecological risk index estimated by using Hg concentration in sediment

showed that Mandalay was considerable risk. Those results indicate Hg pollution is severe in Mandalay. Compared with other study results, concentration of Hg in road dust and sediment from Myanmar was moderately lower. However, because population in Myanmar is increasing, significant Hg pollution will be occurred in future.

[Source of Hg in urban areas in Myanmar]

To estimate the source of Hg pollution in urban areas, the principal component analysis (PCA) and positive matrix factorization (PMF) model including other 30 metal concentrations in road dust and sediment were performed. For air dust, Hg was related to aluminum (Al), selenium (Se), cadmium (Cd), cesium (Cs), gadolinium (Gd), and thallium (Tl) and those metals were also significantly higher in urban areas than sub-urban areas, but clear source was not identified. On the other hand, significant correlations of Hg with molybdenum (Mo) and Cd were observed in sediment. Those metals with Cu, tin (Sn), antimony (Sb), and lead (Pb) showed high concentration in urban areas and belonged to same cluster by PCA and PMF, indicating that Hg source in sediment is traffic emission and municipal waste.

[Human health risk by Hg exposure]

As mentioned earlier, Hg pollution was significant in urban areas from Myanmar. Therefore, human health risk in urban areas is of concerened. According to the methods by US EPA, health risk by Hg exposure from road dust in adults and children was estimated. In this study, three routes of ingestion, inhalation, and dermal absorption by skin were considered. For each exposure pathway, Hg exposure levels in adults and children were much lower than the reference dose values. This suggests no harmful effects on human health from Hg exposure up to now.