論文要旨

論文題目　**Health Risk Evaluation and the Investigation of the Potential Human Foetal Subacute Developmental Toxicities upon Exposures to Mercury-Contaminated Food Crops from Artisanal and Small-Scale Gold Mining Communities – A Case Study of Obuasi, Ghana**

小規模金採掘コミュニティーにおける水銀汚染農作物の健康リスク評価ならびに潜在的な亜急性発生毒性に関する研究（ガーナ、オブアシのケーススタディ）

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Mercury (Hg) is one of the potent environmental toxicants with devastating effects on human health and the ecosystem. Its human health effects include cardiotoxicity, hepatotoxicity, nephrotoxicity, neurotoxicity, teratogenicity, gastroenteritis, haematological effects, etc. following short-term and/or long-term repeated exposures. It also affects the health of the ecosystem by destroying ecosystem functions. This study was aimed at evaluating the potential risks of Hg to humans and the entire ecosystem using soil and food crop (plantains and cassava) samples sourced from farms located near artisanal and small-scale gold mining (ASGM) facilities in selected ASGM communities around Obuasi, Ghana. Specifically, the study **1.** Evaluated the contamination levels of soils and the food crops and assessed the potential ecological risks using the Hakanson model, **2.** Evaluated the potential human health risks of long-term repeated exposures to total mercury (THg) and MeHg levels of the soil and the food crop samples using the USEPA risk assessment models, and **3.** Investigated the potential subacute developmental toxicities and genotoxicity of very low MeHg and high InHg levels of Hg-contaminated food crops following repeated prenatal exposures using Japanese medaka embryos bioassay method and gene expression analysis, respectively. Results showed that the Hg levels of the soil samples were above the 500 μg/kg reference value for agricultural soils by the Swiss Environmental Regulation while the edible parts of plantains from Odumase and the edible parts of all cassava samples were above the 100 μg/kg reference value for food by the World Health Organization (WHO). Exactly 50% of plantain peels and the peels of all cassava samples also had Hg levels above the 100 μg/kg reference value for plants used as animal feed by the United Nations Economic Commission for Europe. Assessment of the contamination levels and the ecological risk of samples showed that all samples from the studied communities had some degree of contamination, hence were associated with some levels of ecological risks ranging from low to very high risks. Assessment of the potential human health risks indicated that residents of the studied communities are at risk of the non-carcinogenic human health effects of Hg since the hazard quotient (HQ) for THg of plantains from Odumase and cassavas across the study areas were above 1 while HQ for THg of the soil samples, despite their higher Hg levels were below 1, hence may not pose any non-carcinogenic human health risks to residents. HQ

for MeHg of all the samples were also below 1, hence long-term repeated exposures to MeHg levels of the samples may not cause any non-carcinogenic human health effects. This meant that the health effects associated with plantains from Odumase and all cassava samples would be specific to InHg due to its extremely higher levels (~99.5%) in the food crops. The hazard indices of the selected farms were also above 1, hence long-term repeated exposures to the samples particularly, the food crops may pose potential non-carcinogenic human health effects to residents across the studied communities. The toxicity study also showed that the maternal and cord blood MeHg levels of 0.20 – 1.63 μg/L and 0.33 – 2.77 μg/L, respectively, following repeated prenatal exposures to 0.0035 – 0.029 μg/kg/day of the food crops were below the 5.8, 40 – 50, and the 3.6 μg/L blood MeHg reference values by USEPA, WHO, and other researchers. This indicated that repeated prenatal exposures to MeHg levels of the food crops may not be associated with any subacute developmental toxicities to the foetus or the new-born. For InHg, although very low but significant percentage of the prenatal exposure amount in the range of 1.00 – 5.14 μg/kg/day could reach cord blood and possibly the foetus, it was uncertain whether such low but significant levels could cause subacute developmental toxicities to the foetus or the new-born due to the non-applicability of the one-compartment dose conversion model and the lack of guideline value for blood InHg levels. However, considering the 5.8, 40 – 50, and the 3.6 μg/L blood MeHg reference values by USEPA, WHO and other researchers, and the fact that the body Hg burden is always made with reference to MeHg, it could be concluded that the very low MeHg and high InHg levels of the food crops may not be associated with any subacute developmental toxicities to the foetus or new-born following repeated prenatal exposures. For the gene expression analysis, both MeHg and InHg caused the suppression of cyclin B1. Cyclin B1 suppression leads to disruption in cell cycle and mitotic cell division, which in turn results in cell growth and development and eventual cell death. These deductions meant that the MeHg and InHg levels of the food crops may be toxic to the human foetus at the genetic level. Additionally, the decreased in expression level of cyclin B1 by InHg showed that InHg may be associated with tumorigenesis or may be a potential tumour initiator at the genetic level. Generally, Hg contamination of the samples and the entire ecosystems resulted from ASGM activities. Despite the higher probability of no developmental toxicities to the foetus or the new-born. It is evidently clear from the study, particularly the ecological risks, human health risks and the genotoxicity assessments that Hg releases and its subsequent contaminations have detrimental effects on human health and ecosystem functions, particularly upon long-term repeated exposures. Such detrimental effects can take several years to manifest and when they manifest the aetiology is usually unidentifiable. Therefore, since there are no treatment processes for Hg within the catchment areas and Ghana at large, regular and strict monitoring of ASGM activities, particularly Hg releases from ASGM facilities is required to preserve the integrity of the ecosystem and prevent the future occurrence of any toxic effects of Hg to humans, particularly the younger generation.

Key words: Food crops, MeHg, InHg, Developmental toxicity, Genotoxicity, ASGM