学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

Assessment of heavy metal content in rice and soil samples from rainfed paddy fields in Yangon Division, Myanmar

（ミャンマー・ヤンゴン管区の天水水田から採取した米および土壌試料中の重金属含有量評価）

Despite much research focused on arsenic concentration in rice arising from irrigation water than the rainfed area in Southeast Asia. However, limited information exists on the significant rice-growing area, Ayeyarwaddy, Myanmar. In this study, the heavy metal analysis of rice grains and soil was performed to determine the concentration of rice due to the geological background.

The presence of potentially toxic metal(loid)s (As, Pb, Cd, Cr, Mn, Fe, Zn, Cu, Ni, Mo and Co) in 120 white (polished) rice grains (*Oryza sativa*; 2017 or earlier crop) purchased from farmers in the five most agriculturally active townships near Yangon in the eastern edge on Ayeyarwady Delta was determined by triple quadrupole inductively coupled plasma mass spectrometry (ICP-QQQ). Their total-As and Ni concentrations (0.16 mg/kg, 0.39 mg/kg) were around the worldwide average literature values from a heavy metal non-contaminated area of intermediate to acidic (non-mafic) composition. Their Pb, Cd, and Cr mean concentrations (0.010, 0.0056, and 0.056 mg/kg, respectively) were lower than the maximum allowable levels by over one magnitude, reaching the concentration ranges comparable to the lowest level in the literature values. This study's natural background levels were explained by a negligible influence of human, mining and industrial activities in this area, and probably genotype effect, which remains to be examined by the associated paddy soil analysis.

Health risks associated with rice consumption (ca. 0.5 kg/day) by the inhabitants were estimated, assuming that inorganic arsenic was 30% of the total. Arsenic was the main contributor (30%) to the total value of the non-cancer risk (HI) of each element, which was 4.5 times the reference value (< 1), followed by Mn, Zn, Cu, Mo, Co and Ni (15–7%) and Pb, Cd, Cr and Fe (below 4%). The total cancer risk (TCR) for each element was around 17 times higher than the upper limit of cancer risk for an environmental carcinogen (< 0.0001): Nickel accounts for two-thirds of the contribution (66%), followed by Cd (16%) and As (13%). This study suggests that consumers of Yangon rice from paddy fields without groundwater irrigation may need to be concerned about the

potential risk of Ni intake besides arsenic.

In addition, 200 unpolished rice samples and 82 post-harvest associated soil samples harvested from paddy fields in three townships in the same area in December 2019 were collected. The rice samples were acid-degraded like white rice, and the soil samples were acid-extracted for soluble components with royal water. The above elements were quantified similarly using the ICP-QQQ and ICP emission spectrometer installed in the Open Facility at Hokkaido University. Total As concentrations in unpolished rice grains in the present study ranged from 0.015–0.513 mg/kg. The mean of soil As in TK, DL and KM were 1.14, 4.90, and 5.26 mg/kg. This study's range of As concentration in soil (0.67–8.50 mg/kg) fell into rainfed soil As and Cd range, which can be assumed there are no artificial activities. Total soil As in this study had a significantly straightforward relationship with grain As ($r^2 = 0.8$, $P < 0.05$). Next, a negative correlation was observed for nickel content in soil samples and brown (unpolished) rice. It means brown rice is less likely to absorb nickel from paddy soil. It is assumed that the nickel in brown rice was derived from the nickel in the fertilizer applied to the paddy field, and if this hypothesis is correct, it may be expected to lead to measures to reduce nickel intake.