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Arsenic contamination in rice from Vietnam and Cambodia

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Abstract

Arsenic released from the mining, smelting and industrial sectors is common contaminant of arable soil. It can be accumulated by crop plants from soil and eventually entered into the human body through food consumption. Arsenic is one of the most hazardous elements in this soil-plant system and its uptake by rice became the potential threat to human health especially in Southeast Asia. In this scenario, we initiated the geochemical survey to investigate the distribution of As concentration in soil, water, crop plant including rice in the vicinity of Nui Phao mine in Vietnam which is the second largest production of W after China.

In order to examine the geochemical dispersions of As in Nui Phao mine area, 3 batches of sampling were conducted. The preliminary geochemical survey was carried out in summer 2016 to collect the soil, water and sediment samples. The second batch of sampling was carried out in November 2016, and the third batch of sampling was carried out in June 2017 in targeting the pair of paddy soil and rice samples. Analytical results revealed that As concentrations in paddy soil and rice samples are significantly higher than Vietnamese and Codex standard. The residents in Thai Nguyen province are potentially exposed to the risk of As intake from their daily rice consumption. Therefore, average daily dose should be estimated and the chemical speciation of As in soils will also be determined to evaluate the portions of mobile and/or bioavailable fractions in soil. During the further survey, drinking water samples will be collected and comprehensive risk assessment result will be compared with those in Cambodia.

Keywords: Arsenic, Nui Phao mine, Vietnam, Cambodia, Rice

1. INTRODUCTION

Vietnam is one of the large mineral producing countries in Southeast Asia [1] and approximately 60 minerals from 5000 deposits have been developed with particularly Zn, Ni, Mn, and Al currently being produced in Vietnam [2]. Mining is an important industry in the growth of the Vietnamese economy increase but several environmental issues have been raised. Anh et al. [3] reported the soil and water contamination of Cd, Pb, and As in the northern part of Vietnam (i.e. Thai Nguyen, Bac Kan Province). In addition, Kien et al. [4] reported the soil contamination of Cr, Co, and Ni from the Co Dinh chromite mine.

In order to investigate the dispersion of As in the vicinity of the Nui Phao mine, several batched of soil, water and plant samples including rice were collected from 2016 to 2017. For the interpretation of the analytical results, the correlation between soil and plant samples, Enrichment Factor (EF) and Geoaccumulation Index (Igeo) were calculated to identify the influence of the Nui Phao mine on the As contamination in the surrounding environment. These results will also be used to estimate the average daily dose of As to residents and compared with the previous case studies of As contamination in the mining areas of Cambodia.

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2. MATERIAS AND METHOD

2.1 Site Description

The Nui Phao mine, one of largest tungsten (W) mine in the world, is located in Dai Tu District, Thai Nguyen Province (21º38′49″ N, 105º40′27″ E). The mine deposit is a pyrometasomatic W-F-Cu-Au-Bi with skarn and greisen, which formed by Cretaceous age and Ordovician-Silurian age [5]. The mine deposit is spread over an area of 9.21 km^2 with economically recoverable W, F, Bi, Cu, and Au. In addition, the deposit has proven and probable reserves of 65 million tons of ore [5].

2.2 Soil and Rice Sampling

Soil and rice samples were taken from 19 sites, which are denoted NP01–19, from the vicinity of Nui Phao mine. Bulk soil samples were taken from around the plant root samples in the paddy fields. The depth of all soil samples was 20 cm, which is similar to the depth of plant roots. Soil samples were classified with distance from the Nui Phao mine as being within approximately 1.0 km, 1.5 km, and 2.5 km in order to identify a difference of As dispersion.

3. RESULTS

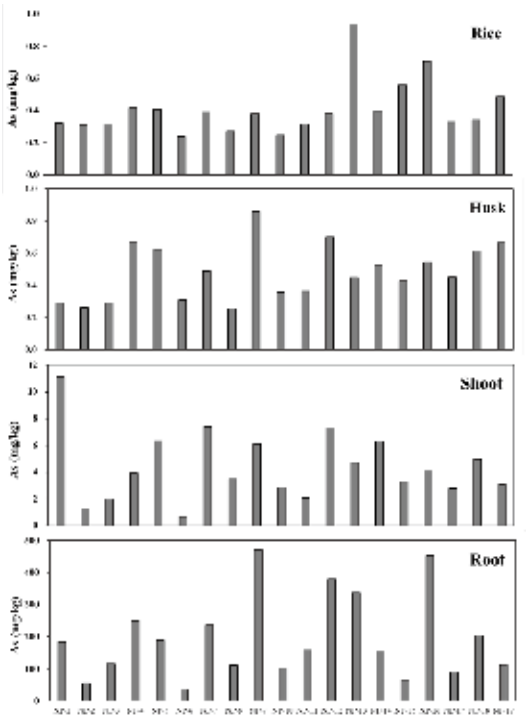

Fig. 1 Arsenic concentrations in root, shoot, husk and rice grain

The concentrations of As in the roots, shoots, husks and rice grain are determined and shown in Fig.1. The first and second highest As concentrations were found in the parts of roots and shoots. Husk and rice grain showed similar concentrations of As in most samples. The As concentrations in roots were in the range of 37.0–470.2 mg/kg dry weight, with a mean of 195.4 mg/kg. The rice grains and husks observed similar As concentration ranges, which are 0.2–0.9 mg/kg. The mean concentration of As in rice grains was 0.4 mg/kg that exceeded the CODEX criteria as 0.2 mg/kg [6]. The influence of contaminated soil and irrigation water on the growing conditions of rice have been reported to cause the elevated levels of As accumulation in the rice [7], [8], [9]. Rice is cultivated under flooded and anaerobic conditions that could enhance the mobilization of the As and its bioavailability. The rice grains contained a range of 0.1–0.6 mg/kg with a mean of 0.3 mg/kg, which exceeds the CODEX criteria of 0.2

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