

## **Distribution of Cadmium in Soil around Zinc Mining Area**

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### **ABSTRACT**

Cadmium distribution was studied in four creeks of Mae Sot district, Tak province. Huai Mae Tao, a reputed creek, was shown to have low cadmium level at the upstream (8.45 mg/kg soil) and increased to 22.5 mg/kg soil at Ban Mae Tao Mai. Huai Mae Ku, the creek on the other side of the mountain with zinc mining, also showed high cadmium levels (7.55-34.95 mg/kg soil). Huai Mae Tao Ngae Sai, a creek in the north-eastern highland of the zinc mining, which was supposed to have no relation to zinc mining area showed cadmium level of 3.05 mg/kg soil. Huai Nong Khiao, a creek of the south-western highland showed cadmium level of only 1.1 mg/kg soil. From the data, it is suggested that cadmium source is at the upstream of Huai Mae Tao then causing the cadmium accumulation downstream. The cadmium source is unclear. Cadmium levels in the creek of two highlands were similar to the EU Maximum Permissible (MP) level of 3.0 mg/kg soil.

**Keywords:** Distribution, cadmium, soil, zinc mining area, Mae Tao, Mae Sot

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## Introduction

Soil is one of the most important natural resources for lives. It provides the four requisites in both direct and indirect ways. Moreover, it also absorbs wastes and pollutants from many sources. In Thailand, the soil contamination problems with chemical substances are still unsolved especially the risk zones such as the industrial and mining area.

Cadmium is a heavy toxic metal that causes an environmental concern. It usually occurs in association with zinc ore and recovered as by-product of zinc mining. Cadmium can be absorbed into human body through respiration and eating then aggregates into liver and kidney causes both acute and chronic symptoms, for example, nausea, abdominal pain, diarrhea, kidney dysfunction and osteomalacia (soft bones).<sup>1</sup>

There are many sources of cadmium pollution in environment, mainly found in fuel combustion, industrial sludge, phosphate fertilizer and mine tailings. The first and important case study occurred at Jinzu river basin, Toyama prefecture, Japan in 1950. Due to Kamioka mine, operated by Mitsui Mining and Smelting Co., Ltd, released contaminated wastewater into the river that generally used within the community and paddy field irrigation causing Itai-itai disease, renal destruction and more than hundred lives were lost. Since then, they have found that the cadmium concentration around the river bank is 4.85 mg/kg soil or around 14 times of unaffected soil (0.34 mg/kg soil).<sup>2</sup>

In Thailand, the biggest reported zinc deposit is situated in Mae Sot district, Tak province which has a mine production capacity up to 214,023 metric tons or costs around 5,550 million baht.<sup>3</sup> There are many mining activities that may influence the cadmium contamination throughout the environment, for instance, drilling, material transfer and removal of mine tailings and drainage as reported in the research of Soil Analysis Division, Department of Land Development, found that the average of cadmium amounts in the sediment which came from the collapsed stacking of cinders around the zinc mining area at Mae Sot was 228.5 mg/kg soil.<sup>4</sup>

In year 2000, Dr. Simmons and team<sup>1</sup> from the International Water Management Institute (IWMI) studied the cadmium concentration in rice field soils at Ban Pha Te, Mae Sot, Tak. The result ranges from 3.4-284 mg/kg soil in 154 samples or 94 times of the European Economic Community Maximum Permissible (MP) in soil (3 mg/kg soil). In the later year, they expanded the sampling sites to the fields along Huai Mae Tao and found 0.5-218 mg/kg soil in 334 samples or 72 times when compare with the EU Maximum Permissible level.

Further, this pollution also affects on many villagers who live around that stream as evidenced by Swaddiwudhipong *et al.*<sup>5</sup> They examined cadmium in urine samples of 15-year-old and older from 12 villages, only 45.6% had cadmium levels less than 2 µg/g creatinine which detected in normal people, 4.9% were found between 5-10 µg/g creatinine for occupational exposure and 2.3% µg/g creatinine had urinary cadmium quantities higher than 10 µg/g creatinine which are renal damage range. Moreover, the people who consumed rice harvested from the defiled place had cadmium within their urine higher than residents who obtained rice from other local markets or other districts.<sup>6</sup>

This study was investigated the ranges of cadmium concentrations in the soil of Mae Sot district, Tak province where zinc mine is located, by using Huai Mae Tao that runs through the mine as a marker, compared with Huai Mae Ku and Huai Nong Khiao which both are parallel flow with that stream.

## Materials and Methods

### Sampling sites

Eight soil samples were collected from 4 different creeks which are Huai Mae Tao Ngae Sai, Huai Mae Tao, Huai Mae Ku and Huai Nong Khiao. The UTM points of each sample are shown in Table 1 and Figure 1.

**Table 1** GPS coordinates of sampling points at Huai Mae Tao Ngae Sai, Huai Mae Tao, Huai Mae Ku and Huai Nong Khiao.

| Creek                 | Samples | UTM position                |
|-----------------------|---------|-----------------------------|
| Huai Mae Tao Ngae Sai | MT1     | x:465447.89<br>y:1843916.34 |
| Huai Mae Tao          | MT2     | x:464619.52<br>y:1842700.85 |
|                       | MT3     | x:461926.60<br>y:1842438.15 |
|                       | MT4     | x:460086.04<br>y:1843409.48 |
|                       | MT5     | x:457339.66<br>y:1843061.42 |
| Huai Nong Khiao       | R1      | x:460993.37<br>y:1840712.88 |
| Huai Mae Ku           | R2      | x:460276.82<br>y:1840885.67 |
|                       | R3      | x:457400.70<br>y:1841002.46 |

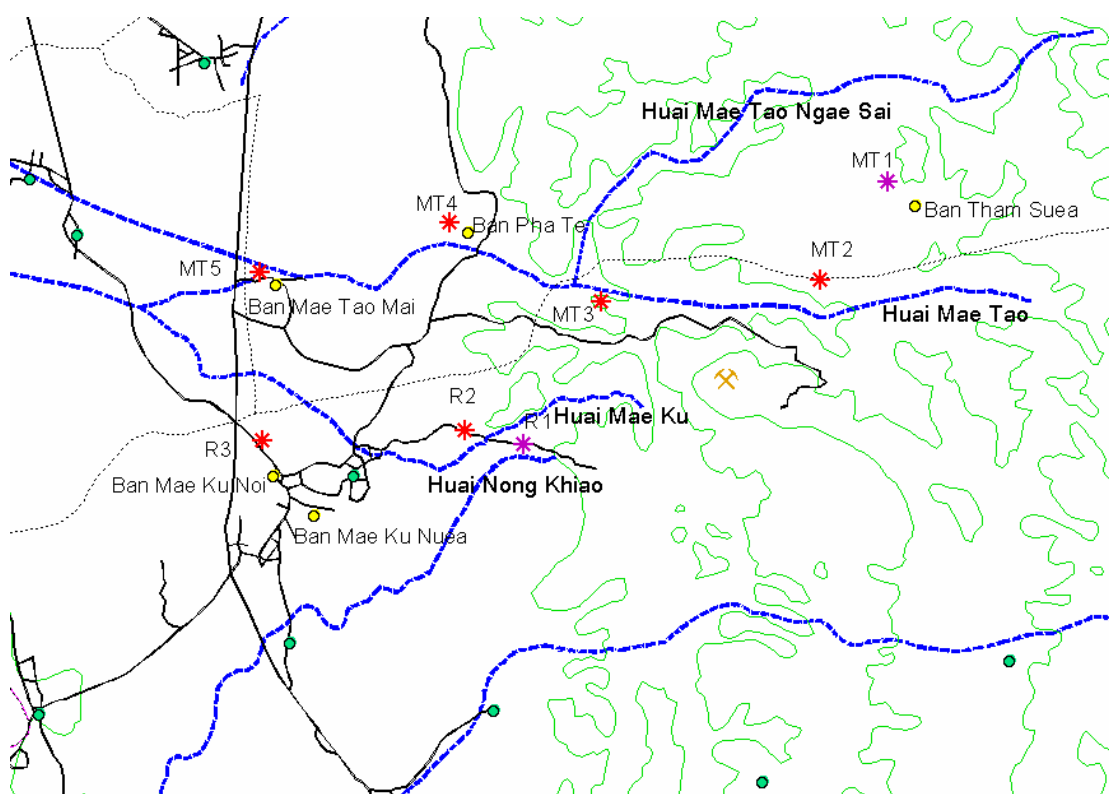


**Figure 1** Map of soil sampling plots investigated in this study.

○ = villages within Mae Sot district

\* = sampling points

### Soil sampling

Eight collecting points were determined by topographical paper map, series L7018 sheet 4742 III scale 1:50,000 from Royal Thai Survey Department and the coordinates were recorded by using the Garmin Nüvi 310. In each soil sample, three 0-10 cm. depth cores were taken with 55 mm. diameter and tightly sealed in zip lock plastic bags. The soils were stored at -20°C until the experiment began.

#### 1. Sample preparation

Three soil cores from individual sampling site were combined to be a composite sample and air dried in the clean room. After plant debris and gravel were removed then sieved through 2 mm mesh.

#### 2. Soil characteristics

Soil texture was determined on hydrometer method. pH was estimated on 1:1 soil:water solution. Organic matter (OM) was investigated according to Walkley and Black method and measured the cation exchange capacity (CEC) with ammonium saturation method.<sup>7</sup>

#### 3. Total cadmium examination

Cadmium was extracted from soil samples with boiling *aqua regia* and detected by atomic absorption spectrophotometer (AAS) at wavelength ( $\lambda$ ) 213.9 nm.<sup>7</sup>

## Results and Discussions

### Soil properties

According to the soil characteristic results (Table 2), pH of all 8 samples were almost neutral while percentage of the organic matter were 4.03-7.98 in range which classified in high level.<sup>7</sup> Almost every sample was coarse-textured soil except MT2 which was medium. In case of cation exchange capacity, there are 5 of them (MT1, MT2, MT3, R1, and R3) that can be categorized into moderate rating and the rest (MT4, MT5 and R2) were rather low.

**Table 2** Characteristics of soil samples

| Creek                 | Samples | pH  | Organic matter (%) | Texture    | Cation exchange capacity (cmol/kg) |
|-----------------------|---------|-----|--------------------|------------|------------------------------------|
| Huai Mae Tao Ngae Sai | MT1     | 6.3 | 4.89               | Sandy Loam | 10.10                              |
| Huai Mae Tao          | MT2     | 6.5 | 7.98               | Loam       | 13.41                              |
| Huai Mae Tao          | MT3     | 6.5 | 5.81               | Sandy Loam | 12.91                              |
| Huai Mae Tao          | MT4     | 6.8 | 5.97               | Sandy Loam | 8.6                                |
| Huai Mae Tao          | MT5     | 6.8 | 4.03               | Sandy Loam | 6.99                               |
| Huai Nong Khiao       | R1      | 6.7 | 6.32               | Sandy Loam | 14.71                              |
| Huai Mae Ku           | R2      | 6.7 | 4.31               | Sandy Loam | 7.39                               |
| Huai Mae Ku           | R3      | 6.8 | 5.39               | Sandy Loam | 14.57                              |

### Total cadmium amounts in samples

Focus on the cadmium amounts, the upriver of Huai Mae Tao (MT2), the creek that flows through the zinc mine, had lower level and expanded into 22.50 mg/kg soil at the downstream (MT3-MT5). The results also showed that the samples of Huai Mae Ku (R2 and R3) which situated on the other side of the mountain had high cadmium concentrations. The R2 site had the highest concentration (34.95 mg/kg soil) perhaps because it contained accumulated cadmium as a dike for the community irrigation. MT1, a sample that was collected from Huai Mae Tao Ngae Sai, the north-eastern highland of zinc mining, was found cadmium at quantity of

3.05 mg/kg soil. Huai Nong Khiao, a creek in the south-western highland had cadmium level only 1.1 mg/kg soil. (Table 3)

**Table 3** Total form of cadmium concentrations found in soils of 4 creeks.

| Creek                 | Samples | Cadmium concentration (mg/kg soil) |
|-----------------------|---------|------------------------------------|
| Huai Mae Tao Ngae Sai | MT1     | 3.05                               |
| Huai Mae Tao          | MT2     | 8.45                               |
| Huai Mae Tao          | MT3     | 16.85                              |
| Huai Mae Tao          | MT4     | 18.80                              |
| Huai Mae Tao          | MT5     | 22.50                              |
| Huai Nong Khiao       | R1      | 1.10                               |
| Huai Mae Ku           | R2      | 34.95                              |
| Huai Mae Ku           | R3      | 7.55                               |

When compared the total cadmium values of soil samples with the EU Maximum Permissible level (3 mg/kg soil), there are the significant difference between the samples which obtained from the creek around zinc mine (MT2-MT5) and the standard value, as the soil samples had much more total cadmium concentrations ( $p < 0.05$ , One-sample T test).

In conclusion, when compared to the Thai investigation level (0.15 mg/kg soil)<sup>8</sup>, all samples contained higher cadmium level. This research suggested that this area is already contained high cadmium concentration. Human activities might accelerate cadmium accumulation to hazardous level.

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