CHAPTER I
INTRODUCTION

1.1 General Statement

Zinc ore has been exploited from Padaeng deposit which locates at the southeast of Mae Sot District in Tak Province for over three decades. Paddy field receiving irrigated water flowed through mine area has been contaminated by cadmium then become an environmental issue since 2003 (Simmons et al., 2005; Wuthichai et al., 2005). Cadmium was determined to be present in some paddy soils for considerable amount and hence uptake above normal quantity by rice plant grown in these areas. The Cd and also Zn existed in paddy fields in this area are presumed to be transported to the field via the irrigation supply (Simmons et al., 2005). Few previous studies revealed that consumption of the contaminated food grown in this area is the main source of excessive cadmium exposure (Simmons et al., 2005; Wimonrat et al.; 2007; Witaya et al., 2007). The government subsequently has requested farmers to suspend their rice cultivation and promoted other non-edible crops instead. Sugarcane has been proposed recently to grow on the contaminated land purposely for ethanol production (Chantana et al., 2002). This practice aimed directly to avoid planting edible crop but still keep villagers to utilize their agricultural land.

Cadmium is a particularly interesting heavy metal (Haroun et al., 2007). It can be accumulated by plants to the levels that can be toxic to humans and animals when consume even in a minor amount (Pinto et al., 2004). Crops grown on Cd-contaminated soils are one of the sources of cadmium transport to humans (Kashem and Singh, 2001a). The Cd uptake and transport have been found effectively by rice plants (Liu et al., 2003) and would inevitably cause adverse health effect among the exposed population.

Since soil is an extremely heterogeneous system, the chemistry of metals has been shown to vary from place to place. The mobility and bioavailability of individual trace metals are metal specific (Lee, 2006). Most important factors influencing the form of available metal species in soil are soil pH, oxidation-reduction potential (ORP) and soil organic matter content (OM) [Manz et al. (1999); He and

Singh (1993); Kashem and Singh (2001)] which in turns determine bioavailability of metals uptake by plants. These factors are interrelated as changing one factor may affect others (John and Leventhal, 1995). Knowledge of the soil properties and interactions between other metals are important to assess the bioavailability of Cd uptake by sugarcane for understanding and reducing the risks associated with the introduction of trace metals into the food chain (Pinto et al., 2004). The association of heavy metals with different soil components in different way determines the bioavailability. Strong binding to soil particles and/or precipitate renders a significant soil metal fraction insoluble, and largely unavailable for plant uptake (Lasat, 2002). The most important chemical processes (specific adsorption, co-precipitation, complexation, cation exchange) affecting the behavior and bioavailability of metals in soils are those concerned with the adsorption of metals. The phrase association and solution of metal changes over time, thereby altering metal availability (Selim and Kingery, 2003). For this purpose, various chemical extractions have been developed to determine element behavior including single and sequential extraction. Sequential extraction is selected in this study to fractionate the metals by using a series of extractions of increasing solvating power. Among the variety of sequential extraction procedures described in the literature, the three-step BCR sequential extraction (proposed by the Standards, Measurements and Testing Programme of the European Union, SM&T) is more preferable here.

As aforementioned, the soil in Mae Sot appears to have been pervaded by cadmium content. The bioavailability, uptake, and level of cadmium in sugarcane is very essential for providing the data for further understanding in protection, remediation and reduction of the adverse impact. Therefore, it is necessary to identify and quantify the forms in which metal is present in soil to gain a more precise understanding of the potential and actual impacts of elevated levels of metals in soil (Singh et al., 2005). Knowledge of individual site factors such as soil properties and the interactions between trace metal ions is also important. These changes can have dramatic effects on the chemical reactions that occur at the soil solution/soil interface and ultimately determine the bioavailability of trace elements to plants.

Thus, this work intends to give a helpful contribution in this field. The cadmium accumulation on the edible parts of sugarcane was determined to compare with the concentration in soil and to evaluate availability of cadmium uptake. The effect of soil pH, organic matter (OM), Oxidation-Reduction Potential (ORP), and of

other metals, copper (Cu), manganese (Mn), iron (Fe), lead (Pb) and zinc (Zn), on Cd uptake by sugarcane were investigated to gain further insight into the risks associated with food chain contamination. In doing so, the procedure of sequential extraction was used as a tool in defining the bioavailability form of Cd, as well as significantly improving an understanding of metal partitioning and mobility in soil (Gobran et al., 2001). In addition, in order to examine the validation of the method, Certified Reference Material (CRM 025-050, RTC) was analyzed.

1.2 Objectives

The main purpose of this study is to determine the availability of cadmium, and thus the uptake by sugarcane grown in Mae Sot District, Tak Province. Two sub-objectives of this study are as the followings:

1.2.1 To determine concentrations of cadmium and other associated metals (Cu, Fe, Mn, Pb and Zn) in soils and sugarcane from the contaminated area.

1.2.2 To investigate the relationship of soil properties (pH, organic matter content (OM) and oxidation-reduction potential (ORP)) and other metals (Cu, Fe, Mn, Pb and Zn) on available cadmium concentration uptake by sugarcane.

1.3 Hypothesis

Soil properties (pH, OM, and ORP) and other metals (Cu, Fe, Mn, Pb and Zn) influence on the availability of cadmium uptake by sugarcane.

1.4 Scope of Work

1. The sampling sites are located in Mae Sot District, Tak Province. Eighty-one soil and eighty-one sugarcane samples were collected in March, July, and October 2007 from selected eighteen sugarcane growing fields.

1.1 During March 2007, the samples (soil and sugarcane) collection was undertaken for 24 sampling sites (M-1 to M-24) from 7 sugarcane growing fields for the sugarcane samples at age 9 to 10 months (one year crop).

1.2 During July 2007, the samples collection was undertaken for another 27 sampling sites (J-25 to J-51) from 5 sugarcane growing fields for sugarcane samples at age 5 to 6 months (half year crop).

1.3 During October 2007, the samples collection was undertaken for 30 sampling sites (O-52 to O-81) from 6 sugarcane growing fields for the sugarcane samples at age 9 to 10 months (one year crop).

2. Soil properties: Soil samples from sampling sites were analyzed for:

2.1 Soil pH (1:2 soil/water suspensions): by pH meter.

2.2 Soil organic matter content (OM): by wet digestion according to the Walkley-Black procedure (Benton Jones, 2001).

2.3 Oxidation-reduction potential (ORP): by Oxidation Reduction Potential Meter.

3. Six metals of interest in this study include:

- Cadmium (Cd)
- Copper (Cu)
- Iron (Fe)
- Manganese (Mn)
- Lead (Pb)
- Zinc (Zn)

4. Metals Analysis: The concentrations of elements (Cd, Cu, Fe, Mn, Pb and Zn) were analyzed by Inductively Coupled Plasma-Optical Emission Spectrometers (ICP-OES).

4.1 Soil samples

Soil samples were subjected to both total digestion according to EPA standard method (EPA-Method 3052, 1996) and the first two step of BCR sequential extraction procedure developed by the Standards, Measurements and Testing programme, SM&M.

4.2 Sugarcane Samples

Root, underground stem, bagasse, top and leaves, were digested with microwave-assisted acid digestion procedure according to the standard method of US EPA 3052 with slightly modification on digestion procedure. Metals in juice were determined by using the tri acid digestion (Jackson, 1973).

5. The accuracy of total digestion for determination of metals in the extracts was verified by using Certified Reference Material, CRM 025-050 (RTC).

6. Statistic Analysis

The concentration data set of the elements (Cd, Cu, Fe, Mn, Pb and Zn) was analyzed by using the principal component analysis (PCA) on the data matrix to determine the correlation of bioavailability of cadmium uptake by sugarcane with the influence of the soil properties (soil pH, organic matter, and oxidation-reduction potential) as well as the presence of other metals (Cu, Fe, Mn, Pb and Zn).

1.5 Benefits of this study

At the end of the study, the selected soil properties (include soil pH, organic matter content (OM) and oxidation-reduction potential (ORP)) and the relationship between Cd and other metals (Cu, Fe, Mn, Pb and Zn) would have been investigated. The total digestion and the first-two step of BCR sequential extraction procedure recommended by the Standards, Measurements and Testing programme of the European Union (SM&T) were employed to determine the metal contents in total and available forms, respectively.

1.5.1 To understand the effects of soil properties (soil pH, organic matter content (OM) and oxidation-reduction potential (ORP)) and other metals (Cu, Fe, Mn, Pb and Zn) on the cadmium uptake of sugarcane.

1.5.2 To apply the knowledge of the distribution among specific forms of heavy metals as a tool for the management and to adjust the practice for site remediation, protection and risk reduction.