# CHAPTER I

# INTRODUCTION

## 1.1 Introduction

At present, countries all over the world rely heavily on industry and concentrate their efforts on becoming more competitive worldwide. People devour modern technology, such as for communication, transportation, and accommodations, which responds to the needs of people. Nowadays, while an economy may be growing well, another part usually ends up deteriorating, and that part is the environment. One of the environmental problems comes from industrial development, which produces industrial waste. This waste is increasing and current industrial waste management practices are not sufficient. This problem has an impact on human health and the environment; therefore, industrial wastes should be suitably managed.

Mostly industrial wastes contain many hazardous metals which can be leached to the environment. Industrial wastes contain high contents of hazardous metals. Because of the increasing quantity of waste sludge and lack of landfill sites due to not-in-my-back-yard (NIMBY) sentiments, the disposal and reuse of sludge is becoming a serious and an immediate concern. From the Notification of the Ministry of Industry No.6, B.E. 2540 (1977) to the new Notification B.E. 2548 (2005), it can be seen that there is a growing concern for the proper disposal of waste, particularly hazardous waste, in Thailand by the Department of Industrial Works (DIW, 1997, and 2005). Toxic waste is of particular importance. It is a major kind of hazardous waste that must follow the requirements of this regulation. Toxic wastes can lead to a long list of problems. For example, once it was accidentally or intentionally released into receiving waters, it can have grave impact on the environment, and cause economic difficulties due to the increased need for industrial waste management. The traditional waste management practice of using a secure landfill is becoming less popular; the stress of limited landfill sites is the main problem. Another waste management method is incineration; however, it is by no means a complete waste management system. It produces a new kind of waste with high concentrations of heavy metals, which require further treatment such as stabilization and/or solidification before it can be dumped in a sanitary landfill or secure landfill. This method makes the process more complicated and troublesome.

Therefore, industrial waste management concentrates on improving the efficiency of every production process in an industrial factory. This can decrease the environmental problems coming from industrial waste, limited natural resources, the reduced quantity of landfills, and energy recovery. From the viewpoint of waste disposal, how to improve the ratio of recycled resources and how to recycle wasted resources have become two very important environmental protection efforts. In recent years, studies have been carried out by various researchers investigating the use of sludge in construction materials. Sewage sludge ash (SSA) retained in filters can be deposited into controlled landfills or used in construction; for example, sludge mixed with clay can be used in the production of bricks for construction use. Incineration residues such as rice husk and municipal solid waste ash have been used successfully in construction. SSA has been used in mortars in concrete mixtures. It has been found that the reuse of waste in cement production mainly depends on the chemical composition of the waste (Long Lin and Yi Li, 2005; Rachakornkij, 2000).

From an industrial ecology point of view, the co-processing of hazardous industrial waste in cement kilns appears capable of reaching a compromise among the interests of environmental protection, resource conservation, and economic incentive. The co-processing technology composes of the partial application of hazardous waste as alternative raw materials in cement production. Several kinds of industrial wastes contain a large amount of the main basic chemical composition of cement products, such as silicates, calcium, and alumina. Thus, the possibility of utilizing such waste as raw material in cement production has been broadly investigated (Shih et al., 2005; Lin K and Lin C, 2005; Pipilikaki et al., 2005; Shih, Chang, and Chiang, 2003) with the intention of addressing the problems related to waste treatment and limited natural resources. Likewise, the utilization of industrial wastes as an alternative fuel in cement production is common in many countries not only as a way to appropriately manage wastes, but also for the economic incentives that are received by preserving non-renewable energy resources.

This research studies the effects of hazardous heavy metals in cement by characterizing the chemical and physical properties of the cement. A series of leaching tests was employed to study fate of the heavy metals in the cement after co-processing using industrial sludge containing petroleum and heavy metals as the alternative fuel. A feasibility test has been conducted to address the suitability of reusing sludge after a burning process such as the one that occurs in an eco-cement process (Taiheiyo, 2001). Thus, the cement produced by the co-processing of industrial sludge containing petroleum and heavy metals as the alternative fuel was tested using a number of analytical instruments and leaching tests; e.g., sequential extraction (Tessier et al., 1979), US EPA SW-846 Method 1311, Waste Extraction Test (WET) from the Notification of the Ministry of Industry B.E. 2548 (2005), leaching test required by the Notification of the Ministry of Industry No.6 B.E. 2540 (1977). This study investigates the behavior of heavy metals in cement for risk management purposes and for a better understanding of the advantages of using industrial sludge containing petroleum and heavy metals as an alternative fuel in co-processing for cement production.

## 1.2 Objectives of the study

The main objective of this research is to study the leachability of heavy metals (Cr, Ni, Zn, and Pb) in cement produced from co-processing industrial sludge containing petroleum and heavy metals. The sub-objectives are as follows:

1. To determine the optimal ratio of industrial sludge containing petroleum and heavy metals for use in co-processing in cement production.

2. To examine the effects of hazardous heavy metals in cement from co-processed industrial sludge containing petroleum and the effects of using heavy metals as alternative fuel on the physical, chemical, and mechanical properties of the cement.

3. To assess the potential environmental risks by applying cement from co-processing of industrial sludge containing petroleum and heavy metals as alternative fuel. This was evaluated by a series of leaching procedures.

## 1.3 Hypotheses

1. Utilizing petroleum sludge and heavy metals in co-processing does not produce negative effects on the chemical, physical, and mechanical properties of cement.

2. Petroleum sludge and heavy metals do not affect the basic chemical compounds in cement products.

3. Short-term leaching test can predict the distribution of heavy metals in cement from co-processed industrial sludge containing petroleum and heavy metals.

## 1.4 Scope of the study

This research looked into the short-term leaching of cement from co-processing using industrial sludge containing petroleum and heavy metals as the alternative fuels within the following scope:

1. Raw meal for the experiment came from Siam City Cement Public Company Limited (SCCC), a cement production facility, in Saraburi Province and the petroleum sludge came from General Environmental Conservation Public Company Limited (GENCO).
2. The raw meal was mixed with petroleum sludge at various mixture ratios of 0%, 5%, 10%, 15%, and 20% by weight.
3. A high temperature furnace was used for co-processing. Raw mix was burned at different high temperatures and various mixture ratios. Afterwards, the clinker was analyzed by X-ray fluorescence (XRF), X-ray diffraction (XRD), and SEM.

4. The type and quantity of heavy metals in the clinker were analyzed using a microwave digester (US EPA. SW-846 Method 3052), after that, the clear solutions from digestion were used to analyze type and quantity of heavy metals using an Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES).
5. The experiments were carried out at the hazardous waste laboratory of the Department of Environmental Engineering, Faculty of Engineering and the central laboratory of the National Center of Excellence for Environmental and Hazardous Waste Management, Chulalongkorn University.
6. To prepare the cement paste, the samples were mixed with 0.485 wt. % of gypsum to make cement. The cement samples were then mixed with water using the water-to-cement ratio (w/c) of 0.485:1, and then cured for 28 days. The sample was examined by the sequential extraction method.
7. The mortar sample casting utilized cement-to-sand-to-water ratio of 1:2.75:0.485 following ASTM C109M-05, and the samples were cured for periods of 3, 7, 14, and 28 days and tested for compressive strength following ASTM C109M-05.
8. Leaching tests of heavy metals; namely, US EPA SW-846 Method 1311, WET of the Notification of the Ministry of Industry B.E. 2548 (2005), and the leaching test as required by the Notification of the Ministry of Industry No.6 B.E. 2540 (1977) were applied on mortar samples cured for 28 days. The heavy metal concentrations from the leaching tests were analyzed by Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES).