Chapter 1

INTRODUCTION

It is obvious that our standard of living is closely related to the availability of energy. Energy is used for almost every aspect of human activity *e.g.* heating, lighting, refrigeration, agriculture, forestry, fisheries, manufacturing, education, communications, transportation, and construction. It is also used in the recovery and processing of minerals and biological resources, food production, processing and distribution, and also increasingly for human leisure activities and entertainment. The use of energy is, therefore, an important indicator to show the level of development. In fact, developed countries consume more energy about 61% of the world's energy with an average energy use per-capita of 4.8 toe (tons of oil equivalent) than developing countries which are 39% and 0.9 toe, respectively (Newson, 1992). In Thailand, energy consumption per capita is 0.56 toe (UNCED, 1992). Energy use is also related to Gross Domestic Product (GDP). This is shown by a fixed proportionality between economic growth and energy consumption. An increase of 1% in GDP requires a 1.5% increase in energy use (Newson, 1992).

The global energy use will increase in the near future. The increase is mainly due to rapid world's population growth (by 2% annually), industrialization, urbanization and increase in standards of living. In 1990 for instance, an average annual energy use per-capita of world's population is 8.7×10^{10} Joules. This will increase to 9.4×10^{10} Joules and 1×10^{11} Joules by the year 2000 and 2020, respectively (Winteringham, 1992). On the global scale, energy consumption is estimated in 1990 at 8,013 x 103 kilotons oil equivalent (KTOE) (Allen, 1992).

Coal is one of the world's most important energy sources. Altogether with oil and natural gas, they supply 90% of world's energy (Fyfe, 1993). These fossil fuels will still supply some 77% of our ever increasing energy demand well into the next century (Newson, 1992). The total world coal resources are estimated at 11,500 billion tons (Griffith and Clarke, 1986) and this will contribute to supply 27-30 % of the world's energy demand over the next three decades (Buchanan and Brenkley, 1994). In 1978, annual world production of coal was estimated to be 2.974 x 10^9 tons (Quenton, 1980). In developing countries, coal production increased at a moderate rate of 2.8 % per year over this period (Chadwick *et al.*, 1987).

Most coal is used for electricity generation. By 1980, 66% of the total quantity of coal consume in planned economies in the Organization for Economic Cooperation and Development (OECD) area was for electricity generation. In the United States, it was 61% of the coal mined (Elseewi *et al.*, 1986). At global scale, the percentage varied between 70% and 90% (Chadwick *et al.*, 1987).

The process of coal combustion for electricity generation in power plants has been frequently held responsible for much damage to the environment. Most of the time, the problem is focused on the emission of acid gases and noxious elements, however, several other particulate matter and heavy metals are also emitted in addition to these pollutants. Naturally present in coal, heavy metals are volatilized during combustion process and expelled through the smoke stacks in association with fly ash. They are released into the atmosphere, transported and deposited on the soil, on the vegetation cover, and in the water basins of the surrounding areas. Elevation of the basal pollutant levels frequently occurs in these systems (Purves, 1985; Nriagu and Pacyna, 1988).

In Thailand, electricity demand has been increased over the past decade as a result of the country's favorable economy. Peak generation was recorded in May 1995 at 12,267,900 kW, representing almost 15 growth from the previous year. Total energy production rose to 79,112 million kW of which about 47% was used by industries, 27% by businesses, 21% residences and 5% by others (Electricity Generating Authority of Thailand, 1996).

The Mae Moh Power Plant is the second largest power plant in Thailand and is located in Mae Moh District, Lampang Province, northern Thailand. This lignite-fired power plant is the biggest in the Southeast Asian region and supports more than 25% (about 2,625 MW) of the country's total capacity. At the present times, it consumes 42,800 tons of lignite per day (Electricity Generating Authority of Thailand, 1994). Lignite is considered as one of the most polluting fossil fuels, producing 4-5 times more SO_2,1.5 times more NO_x, and twice as much as solid particulate matter as coal per unit energy generated (UNCED, 1992). Its use to generate electricity in power plants is often followed by environmental problems due to the emission of heavy metals, solid particulate matter, and gaseous products. Ratanasthien et al., (1993) reported that Mae Moh lignite ash contains more than 0.1 percent of Al, Ca, Fe, Mg, K, Na, Si, and Ti and more than 30 ppm of As, Ba, Mn, Cr, Ni, Co, Rb, Sr, and V.

Heavy metals emitted from the stacks of power plants can contaminate soils of the surrounding areas. This kind of contamination will affect vegetation, animals, and even people. Assessment based on physicochemical parameters is not only time consuming and expensive but also does not express the impact itself. According to Martin and Coughtrey (1982), they also still need to be interpreted in the context of a complex of factors operating within ecosystem. The use of bioindicators is, therefore, particularly important to be applied. The basis of bioindicators is that the mere presence or absence of species tells us something specific about the habitat or general environment.

Arthropods are most abundant among a large groups of soil invertebrates. Densities of 200,000 arthropods per m^2 are common in Canadian soil (Moore *et al.*, 1988) and as many as a million individuals per m^2 has been recorded (Behan *et al.*, 1978), where about 77% of all arthropods lived in the top 3.5 cm, 15% below the humus layer (3.5-7.0 cm), and only 8% in 7.0-14.0 cm depth (Adis *et al.*, 1987). These organisms may not have direct contact with soil and are, therefore, only indirectly affected by soil contamination. They play, however, an important role in the terrestrial ecosystem and are the first to be influenced by pollutants deposited onto soil from the air. Spiegel (1996) stated that patterns in species losses or decline of soil arthropods, for instance, is not a random loss of species, but follows an identifiable pattern.

Studies have been attempted to relate arthropod communities directly to various environmental factors. The structure of arthropod community and its activity are related to local rainfall (Buxton, 1981), soil organic matter and moisture (Curry, 1978), and cropping pattern (Root, 1973). The effect of habitat fragmentation on Amazonian termite communities was also studied (De Souza and Brown, 1994). Likewise, Opler (1976) stated that the conservation of low land and mountain forest to pineapple and sugar cane plantations, as well as to pasture, has probably resulted in the loss of several hundreds species of native insects.

The potential use of arthropod communities as bioindicators for assessment of environmental pollution is based on some advantages. Like other invertebrates, arthropods are often readily available and easily collected throughout the time. They often show a consistent relationship between their metal concentrations and those of other environmental components. Also they are not subject to substantial uptakes of metals from other sources; repeatability between individuals at any one sample site and between sample collections at different times of the year is often good; and the cost of collection and ease of analysis is, with current techniques, acceptable. (Martin and Coughtrey, 1982). Their abundance and often narrow ecological niches are also advantages of using arthropods as bioindicators. They, therefore, can be used to complement physicochemical monitoring (Olive *et al.*, 1988).

Rationale

Transportation, deposition and enrichment of heavy metals (*e.g.* As, Cr, Ni, Co) emitted from the stacks of the Mae Moh Power Plant can contaminate soil in the surrounding area. The contamination of soil by heavy metals will directly or indirectly affect soil-inhabiting arthropods. Sites having different levels of heavy metal contamination are hypothesized to show the different diversity patterns of arthropod communities.

Purpose of the study

The main purpose of this study is to investigate patterns of soil-inhabiting arthropod communities in order to know their potential use as bioindicators for assessment of soil contamination by heavy metals in the area surrounding of the Mae Moh Power Plant. Specifically, this study has the following aims:

1. To determine and compare soil-inhabiting arthropod communities found at different study sites based on their ecological properties (*e.g.* diversity indices, richness indices, evenness indices, similarity coefficients, distance coefficients);

2. To assess effects of heavy metal contamination on soil-inhabiting arthropod communities in the study area; and

3. To investigate some physicochemical parameters of soil including toxic heavy metals emitted from the stacks and contaminate the soil (*e.g.* soil pH, soil organic matter, soil moisture content, soil field capacity, As, Co, Cr, and Ni).