1. INTRODUCTION

Environmental pollution is a natural process and old as the Earth. Nowadays, unnatural pollution is a serious problem which is causing great and growing concern. All around us pollution is increasing: in the air, water, land and in our bodies. Air pollution is one of the most serious problem at Mae Moh.

1.1. Air pollution: Problem

Air pollution is the transfer of harmful amounts of natural and synthetic materials into the atmosphere often as a direct or indirect consequence of human activity. Air pollution is the dust, gas and moist droplets which is dispersed into the air. Air pollutants include gaseous air pollutant and particulate air pollutants. Gaseous air pollutants can be carbon dioxide (CO_2), carbon monoxide (CO) from burning organic fuels; hydrocarbons from incomplete combustion of gasoline (C_xH_y); nitrogen oxide (No_x); fluorides (HF) and sulfur compounds (SO_3, SO_2, H_2S). Particulate air pollutants include viable particles such as pollen grains and microorganisms; and nonviable particles e.g. sand and soil particles, dust and man-made organic and inorganic matter. Air pollution is closely related to our production and use of energy, both in the use of fuels for heat and electric power and in the use of petrol, etc. for motor transport (Dix, 1985, Chiras, 1991). The major air pollutants listed in Table 1.1 are those produced in significant amounts and those having documented health or environmental effects.

1.2. The sources and causes of air pollution

Generally speaking, air pollution has two major origins, natural events and human activities. Natural sources of air pollutants include forest fires started by lighting, pollen dispersal, wind erosion of soil, volcanic eruption, evaporation of volatile organic compound from leaves, bacterial decomposition of organic matter.

But emissions from natural sources are dispersed throughout the world and rarely reach concentrations high enough to cause serious damage. Exceptions include massive injection of sulfur dioxide and solid particulate matter from volcanic eruptions and buildup of radon-222 gas inside buildings. Most potential pollutants are added to the troposphere as a result of human activities. Man-made air pollution sources can be divided into mobile and stationary sources. Mobile sources are automobiles, buses, train, airplanes and other fossil fuel-powered modes of transportation. Stationary sources include factories, incinerators, and other kinds of nonmobile sources. The major contributors of air pollution, in decreasing order, are transportation, electric power generation, industry, forest and agriculture fires, and incineration (Moran *et al.*, 1973, Turk and Turk, 1984, Kypchella and Hyland 1993). Each source of pollution involves the rapid burning of some kind of fuel. A summary of the sources of major pollutants is given in Table 1.1

1.3. Effects of air pollution

1.3.1. Health effects

Air pollutants can cause both acute and chronic health problems. Some of the acute problems such as colds, coughs, rhinitis and other symptoms caused by sulfur dioxide; burning eyes and irritated throats caused by photochemical smog; headaches caused by carbon monoxide from automobile fumes. Long-term exposure to air pollution may result in a number of diseases, including bronchitis, emphysema, and lung cancer (Chiras, 1991).

1.3.1.1 Particulate toxicology

Particulate pollutants enter the human body almost exclusively way of the respiratory system, and their most important immediate effects involve this system. Particle size is probably the most important factor to be considered, for it this factor

Table 1.1. Molecular composition and characteristics and source of major air pollutants

Pollutant	Composition	Characteristics	Source
Sulfur Dioxide	SO_2	Colorless, heavy, water-soluble gas with a pungent, irritating odor	Combustion of coal, oil and other sulfur-containing fuels; petroleum refining, metal smelting, paper making
Particulates	variable	Solid particles or liquid droplets including fumes, smoke, dust, and aerosols	Fuel combustion, industrial processes, construction, forest fires, refuse incineration, automobile traffic
Nitrogen dioxide	NO_2	Reddish brown gas, somewhat water soluble	Produced by combinations of atmospheric nitrogen and oxygen at high temperatures such as those in automobile engines; also a by-product in the manufacturing of fertilizers
Hydrocarbons and other volative organic compounds	variable	Many and varied compounds of hydrogen and carbon	Motor vehicles- evaporation from gasoline tanks and carburators, industrial processes involving solvents
Carbon Monoxide	CO	Colorless, odorless toxic gas, slightly water soluble	Combustion of fuel, e.g., gasoline
Ozone	O_3	Pale blue gas, fairly water soluble, unstable, sweetish odor	Produced by complex photochemical reactions in the atmosphere involving hydrocarbons, nitrogen dioxide, and sunlight
Hydrogen sulfide	H_2S	Colorless gas with a very offensive "rotten egg" odor, slightly water soluble	Various processes in many kinds of chemical industries; oil wells, refineries
Fluorides (e.g., HF)	variable	Pungent, colorless, water-soluble gas (HF)	Fertilizer manufacure, ceramics manufacturing, aluminum smelting
Nitric oxide	NO	Colorless gas, slightly water soluble	Combustion of leaded gasoline; solder, lead-containing paint; lead-smelting operation
Lead	Pb	Metallic, can exist in a variety of chemical compounds with different characteristics	Paper, chemical, paint manufacturing; pesticides, fungicides
Mercury	Hg	Metallic, can exist in a variety of chemical compounds with different characteristics	

Source: Kupchella and Hyland (1993)

which determines the extent of penetration into the respiratory system. There is medical evidence that as a mixture, urban particulate matter is harmful. Of the larger portions of particulate matter that are toxic, black smoke has no acute health effect unless the level of exposure causes the lungs to actually clog up with carbon particles. Black smoke is far from pure carbon. The carbon has adsorbed various products of organic combustion that are harmful. Many of these organic compounds are carcinogens. Particulate can exert an overall toxic effect in overloading our lungs. Moreover, particles can have a harmful effect is by enhancing the effect of harmful gases. Particulate matter greatly increases the effect of sulfur dioxide on the lungs. Moreover, many toxic particles are found in the air in trace amounts that may pose health-hazards in the environment such as nickel, beryllium, boron, germanium, arsenic, selenium, yttrium, mercury, vanadium, cadmium, antimony and lead (Kypchella and Hyland, 1993).

1.3.1.2 Effects of sulfur oxides

Sulfur oxide and the associated sulfuric acid aerosol are not systemic poisons, but are irritant substances causing the respiratory system to react to their presence. The primary effect of SO_2 alone at concentrations of a few ppm is to evoke construction of the bronchi, which is then manifested as increased airways resistance. If the exposure is continuous, these same relatively low levels ultimately produce irreversible degenerative changes and characteristics of aging.

The mechanism of these effects, both acute and chronic, is the stimulation of the goblet cells in the bronchi to overproduce mucus in their resistance to air flow and also tends to over whelm the cilia. If the exposure is long enough, the body tries to cope by producing extra goblet cells to secrete still more mucus. The concentrations of SO_2 alone that have been found to increase airways resistance in humans range down to 1 ppm. At still lower levels, acute sensory effects occur- the taste threshold for SO_2 is

about 0.3 ppm and the odor threshold is 0.5 ppm (Kypchella and Hyland, 1993). In addition, the combined effect of SO_2 and particulate matter seems to be yet more critical, that is, occurring at even lower levels.

1.3.2 The effects of air pollution on other organisms

Studies have shown the harmful effects of air pollution on animals. Fluorides have been shown to cause more worldwide damage to farm animals than other kinds of pollutants. Other air pollutants that have been shown to have adverse effects on farm animals are lead, selenium, molybdenum, and mercury. Ozone, sulfur dioxide, and sulfuric acid are very hazardous to plants as shown in Table 1.2.

1.3.3 The effects of air pollution on ecosystems.

To affect an ecosystem a pollutant must have some effect on the structure and function of the ecosystem. Among some of the things that might be watched for are changes in rates of decomposition, in biogeochemical cycles, in species diversity, in community structure, in primary productivity, and in ecosystem productivity.

1.3.4. The effects of air pollution on materials

Pollutants affect health because they are reactive since they can and do react with almost every living and nonliving thing. Sulfur dioxide can react with aluminum to corrode aluminum surfaces. Dilute acid solutions can etch limestone and even marble. Hydrogen sulfide can combine with silver to form silver sulfide and tarnish silverware. Ozone can cause the oxidation of fabrics directly causing them to degrade rapidly.

1.3.5 The effects of air pollution on climate

Measurements show that the average carbon dioxide content of the atmosphere has risen more than 9 percent since 1958. The current rate of increase is

Table 1.2. Effects of Air Pollutants on Plants

Chemical	Symptom	Sensitive plants	Concentration for sensitivity
Chlorine	Bleaching, leaf tip and margin browing, dropping of leaves, yellow spots	Radish, alfalfa, peach, buckwheat, corn, tobacco, oak, white pine	Radish, 1.3 ppm
Fluorides	Leaf tip and margin yellowing (chlorosis), drarfing, leaf absission, decreased yield	Gladiolus, tulip, apricot, blueberry, corn, grapr, blue spruce,white pine	Gladiuolus, apricot, 0.1 ppb
Nitrogen oxides	Brown spots on leaf, suppression of growth	Azelea, sunflower, mustard, tabacco, pinto bean	Pinto bean, 3 ppm
Sulfure dioxide	Bleachesd spots on leaf, chlorosis, suppression of growth, early abricission, reduced yield	Barley, pumpkin, alfalfa, cotton, wheat, lettuce, apple, oat, aster, zinnia, birch, elm, while pine, penderosa pine	Alfalfa, barley, cotton, 0.3 ppm
Ozone	Reddish brown flecks on upper surface of leaf, bleaching, suppression of growth, early abscission, premature aging	Alfalfa, barley, bean, oat, onion, corn ,tabacco, apple, grape, tomato, spinach, aspen, maple, privet, white pine, ponderosa pine	Tomato, tabacco 0.05 ppm
Other oxidant gases, e.g., peroxyacetyl nitrate	Glazing, silvering, or bronzing of lower surface of leaf	Pinto bean, mustard, oat, tomato, lettuce, petunia, bluegrass	Petunia, lettuce 0.2 ppm
Unsaturated hydrocarbons, e.g., ethylene	Leaf abscission, dropping of flowers, loss of flower buds, chlorosis, suppression of growth	Orchid blossom, carnation blossom, azelea, tomato, cotton, cucumber, peach	Orchird, 0.005 ppm; tomato, 0.1 ppm

Source: Kupchella and Hyland (1993)

The current rate of increase of carbon dioxide is 1 ppm per year, equivalent to $23x10^{15}$ grams of carbon (Kypchella and Hyland, 1993). If this rate continues, there will be some 660 ppm of CO_2 in the earth's atmosphere by the middle of the twenty-first century. This is twice as much as there was in 1990. It is also reported that mathematic models predict the increase of daily temperature by about 2^0 to 5^0 C with the doubling of CO_2. Whatever the relative importance of the sources of increased atmospheric CO_2 levels are increasing, and the levels of other "greenhouse gases" are increasing as well. A World Meteorological Organization panel of "experts" indicates that trace gases such as methane, chlorofluorocarbons (CFCs), nitrous oxide and ozone may have an impact on global warming equal to that of carbon dioxide. The global warming would cause various global changes including the rise of the sea level, the frequent flooding and storm, forest fire and various other change causing uncountable economic loss.

1.4. Energy and air pollution

In our modern world, energy consumption, the quality of life and development are closely related. Developing countries are rapidly expanding their commercial energy to meet demand for development as energy is needed in vast quantities. According to Fyfe *et al.*, (1993), even with a reduction or stabilization of population in the industrial world, the need for energy increases. From 1970 to 1990 world energy demand increased by 50 percent. In 1980, the World Energy Conference predicted a 50 percent increase from 1980 to 2000, and this prediction is on track.

Fossil fuels (oil, natural gas, coal) are the largest source which supplies about 90 percent of world energy. On the other hand, fossil fuels are also the largest source of carbon dioxide which threatens to change world climate, temperature and rainfall distribution. In addition, combustion of fossil fuels creates large amounts of atmospheric trace elements including Hg, Se, Mo, Cd, Pb and others. Coal will soon

become the world's most important source of fossil fuel and associated problems which become a global concern since the nations of the developing world will continue to and increase burning coal. Coal usage increased 90 per cent for 10 years from 1979 to 1989 accounting 71 per cent of total energy production causing serious environmental and ecological problems in India (Fyfe *et al.*, 1993).

In Thailand, as in other developing countries, energy demand is rapidly rising. Thailand's use of primary energy supplies grew at an average rate of 13.4 percent per year in the period 1985 to 1990. The rapid, sustained growth was due to the overall pace of growth in the economy and the expansion of industrial, construction and transportation activities. A major expansion in the electricity sector is underway in order to meet this rapid increase in demand. Energy consumption in Thailand is dominated by fossil fuels which accounted for more than 95 percent of the total energy consumed in 1989. Fuels used in generation of electricity are natural gas (43%), oil (29%) and lignite (22%). At present, power plants emit 56 percent of the country's total SO_2, 16 per cent of NO_x, and 33 per cent of CO_2 emission (Thailand National Report, 1992). Coal and lignite are expected to become much more significant fuel sources in electricity generation, as a result of the policy to make more use of domestic sources of energy. Lignite is readily available in Thailand at competitive prices and its use is expected to increase dramatically over the next 15 years. Lignite is 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. The proportion of coal and lignite use in power stations is estimated to rise from 22 per cent (1990) to 66 per cent in 2006 (Thailand National Report, 1992). Figure 1.1 shows the breakdown of total generating capacity in Thailand by fuel source over the next 15 years. Clearly, this fuel switch could have major implications for the quantities of pollutants emitted to the atmosphere. The sulfurous smoke, fly ash and other by-products of coal combustion can destroy vegetation, corrode metals and affect people

and the surrounding environment. Figure 1.2 shows the production and consumption energy in Thailand from 1970 to 1989.

1.5. Rationale/Hypothesis

The development and use of lignite source to generate electricity by power plants has created environmental pollution by emitting trace elements and gaseous products from the power plant stacks. The dispersion of lignite fly ash depends on distance, wind direction from the source of pollution, and also the topography of the area. There is the probability that soil element concentration is inversely correlated with distance from the power plant.

1.6. Purpose of the study

The overall purpose of this study is to trace the dispersion of lignite fly ash from Mae Moh Power Plant in Lampang Province. Specially, it aims to:

- investigate deposition patterns of lignite fly ash released from the power plant to surrounding areas,

- assess soil concentration and enrichment of some major and trace elements emitted from the power plant, and

- describe and visually evaluate the possible impacts of fly ash on vegetation and ecosystems within the study area.

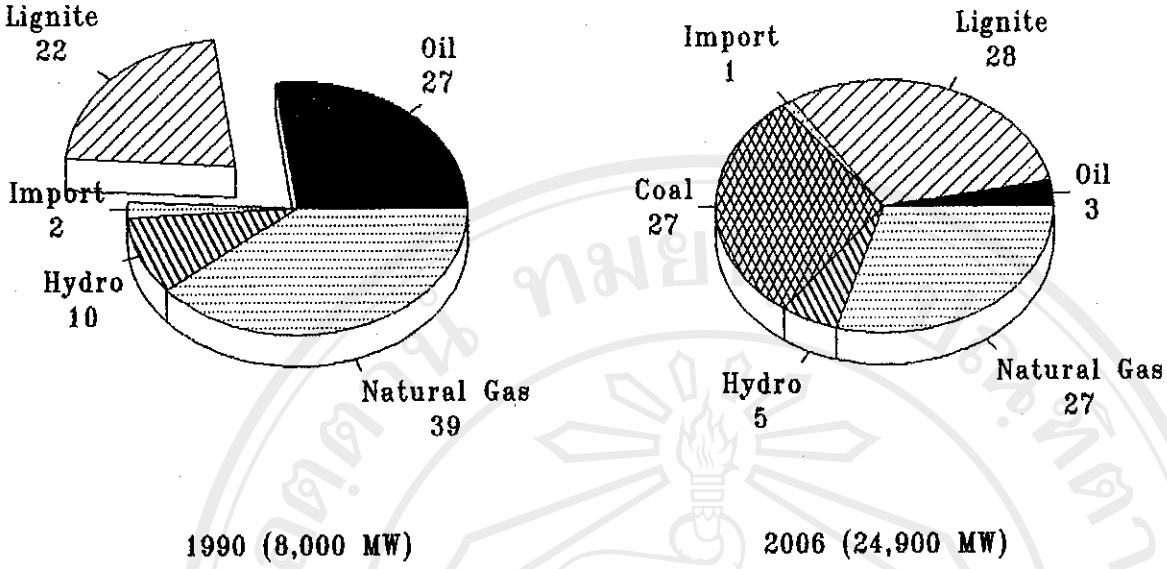

Figure 1.1. Type of fuel source
Source: EGAT

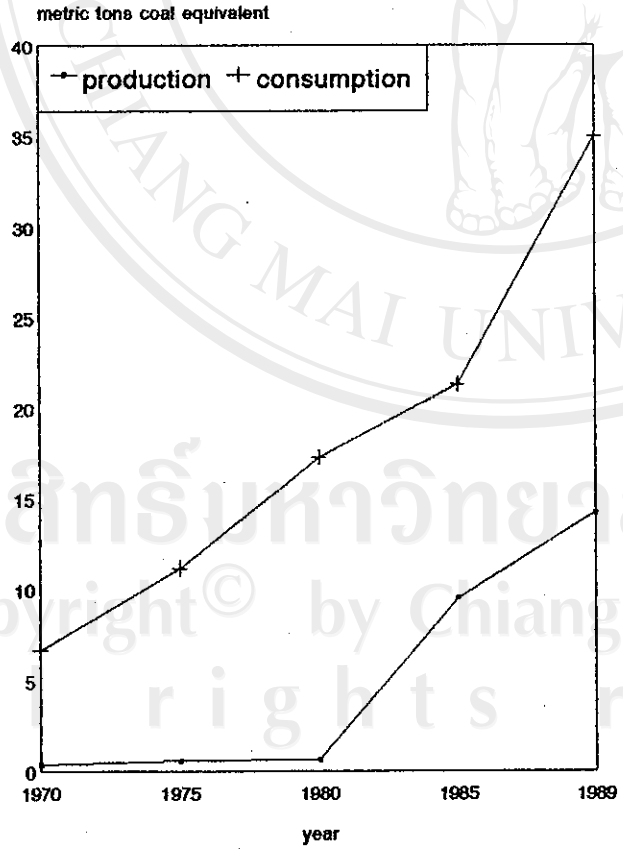

Figure 1.2 Production & consumption energy in Thailand