2. LITERATURE REVIEW

In view of the growing problems caused by environmental pollution in both the industrialized and the developing countries, there is a justified interest in finding appropriate methods for monitoring the environment and detecting the level of atmospheric contamination. Since the 1970s there have been many studies done to determine the extent of contaminants and heavy metals in the air by physical and chemical methods. Because of the limitations imposed on data recorded by individual measurements of physical and chemical parameters as well as practical difficulties associated with performing them, it is worthwhile investigating whether in developing countries biological indicators could be used alternatively or additionally to monitor the environment in tropical and subtropical ecosystems (Ellenberg, 1991).

Ellenberg (1991) states that bioindicators can be usually subdivided into three groups: indicators or pointer species, so-called "biomonitors", and test organisms. Ellenberg (1991) has defined biomonitors as organisms that assimilate certain toxins in the environment over a period of time (plants) or also in different places (mobile animals), possibly accumulating them in their tissues. They can then yield information on the geographical pattern and temporal trend of concentrations of these toxins in the environment. Such biomonitors can be "passively" utilized by observing their natural occurrence. The alternative is to "actively" expose individuals or populations of them to the pollutants under study and to monitor their reactions. Either "passive" or "active" biomonitors have great importance for their practical applications.

It is well documented that certain major and trace metals can accumulate in different plant species through air-borne dust and precipitation. Studies on air pollution monitoring, both active and passive, have been extensively carried out on the accumulation of metal pollution on lichens, bryophytes, pteridophytes, and angiosperms(Burton, 1986).

Wustemann (1983), in an experiment to investigate lead concentration in plants growing in the vicinity of a lead recuperation facility in Venezuela, reported that the grass *Panicum maximum* Jacq. (giant panic grass) can be regarded as a good indicator for the accumulation of lead.

John and Van Larhoven (1972) have also reported a reduction of lead uptake by lettuce and oats from lead-contaminated soil on liming. There is also evidence that the levels of lead in earthworms reflect the lead levels in the soil (Ireland, 1976).

In many Asian countries and areas, such as India, China, and Hong Kong; biological monitoring for lead pollution in the air has already been practiced (Ellenberg, 1991).

In India, Boralkar et al. (Ellenberg, 1991) investigated the increase in atmospheric lead levels caused by automobile emissions in New Delhi during the 11th Asian Games, which lasted from November 19 to December 4, 1982. During the months of October, November and December, they took samples of *Nerium indicum* L. (Apocynaceae, a shrub) and *Eucalyptus rostrata* (Myrtaceae, a tree) at seven selected traffic intersections. At the beginning of the games in November a clear increase in the lead concentrations in the leaves of these two species was recorded. In December the values dropped off again drastically.

Another study from India (EIAS/1/1985-1986) is about lead pollution from automobile exhaust in New Delhi. Once a month, the SO_2, NO_2, dust and lead pollution of the air at traffic intersections with varying traffic densities were measured analytically. At six selected sites, *Cynodon dactylon* (L). Pers. (Gramineae, a grass), *Alstonia scholaris* (L). R. Br (Apocynaceae, a tree), *Nerium indicum* L. (Apocynaceae, a shrub) and *Eugenia jambolana* L. (Myrtaceae, a tree) were exposed. The results showed that the tree *Eugenia jambolana* and the shrub *Nerium indicum*, due to their high accumulation capacity, are effective filters and suitable for planting along roadsides.

Records of accumulations of heavy metal lead from airborne particulate and dust on higher plants have been widely documented during last few decades especially in temperate countries. Alli and Nasralla, who investigated lead in various clover species along roadside in Egypt, revealed that concentrations of lead reached as high as 40 μg/g (Ellenberg, 1991).

There is also research related to the effects of environmental conditions on lead levels. Ho and Tai (1979) determined the extent to which rain affects the levels of lead in roadside plants in Hong Kong. These results indicate that rain causes great and rapid fluctuations in lead levels.

Crump (1982) presented a study of the mechanisms determining lead content of rye grass pastures in both a contaminated roadside environment and at a rural background site. He demonstrated that plant growth processes determine a maximum level of lead in pasture for a given site of deposition.

Bacso (1984) investigated the accumulation of lead in plants growing along roadsides and in the vicinity of a smelter in Hungary. He found that lead concentrations in rye grass are proportional to the level of traffic on the roads. He suggested rye grass to be a suitable indicator plant due to its high lead-accumulating ability and its widespread occurrence.

Similar experiments were done by Wong and Tam, who found that there was high lead accumulation in two species of *Brassica* (leaves, stems, and roots) grown next to roads in Hong Kong (Ellenberg, 1991). At various distances from a major thoroughfare, soil and plants were sampled and atomic absorption spectroscopy was used to determine their lead contents. The plant samples were differentiated into leaves, stems and roots that were unwashed, washed with water and, washed with detergent. The results showed that the closer to the motorway, the higher the content of lead.

Ho and Tai (1979) not only demonstrated the importance of leaf surface characteristics for the ability of plants to trap airborne pollutants, but also established the relationship between meteorological factors, in particular rainfall, and the degree of leaf surface contamination, *Alocasia odorata* (Araceae) for example possesses thick, smooth, leaf blades, leaves, while those of *Mikania glauca* (Compositae) are covered with hairs.

There is some evidence based on experimental work with maize and soybeans, that both photosynthesis and transpiration are inhibited by the presence of high lead levels in plants (Bazzaz *et al.*, 1974).

It has been found that in cereals, extra lead which is taken up by the root system from contaminated soil, is translocated to the leaves, rather than to the grain (Purves, 1985).

Rolfe (1973) stated that most of the lead taken up by plants seems to accumulate in the root system, while appreciable amounts are only translocated to leaves at relatively high soil lead level. He also reported significant increases in levels of lead in leaves, in a study involving eight tree species grown in soils containing lead in the range of 75 to 600 ppm.

No obvious deleterious effects on the growth of oats, clover, radishes, or lettuces were observed by Purves (1985) in greenhouse experiments on adding soluble lead up to a level of 400 ppm to soil, although a significant reduction in yield of perennial rye grass has been observed at this level.

From studying the lead level in ambient air which was surveyed in rural, urban, and suburban areas in several areas in the USA and other countries it was shown that there are variations in leaf pollution levels, but usually these decreased due to distance from sources. The level of lead in ambient air from studies in the USA showed that in urban areas there was a maximum average of 0.36 $\mu g/m^3$ in 1984 (EPA, 1984). A similar study on airborne lead pollution was conducted from 1977 to 1986 in Chiang Mai City (Thavornyutikarn *et al.*, 1988). These results showed that there were high airborne lead contents there.

Rapid increases in motor vehicles has led to increasing levels of lead and is believed to be the major source of lead pollution, especially in a highly congested traffic areas like Chiang Mai City. Monitoring of environmental lead has to be done regularly. The use of plants as monitors of air pollution has several advantages, i.e. plants are cheap and excellent receptors of airborne heavy metals and provide continuous and integrated results (Martin and Coughtrey 1982).

Since there is little report about the determination of lead in plants in Thailand, it is an interesting problem to study the present situation of lead pollution in Chiang Mai City by using five plant species as bioindicators for assessing the extent of this pollution.