1. INTRODUCTION

1.1 The Statement of the Problems

After industrial revolution, the development of human society has always being accompanied by environmental pollution, which can be classified into air, water and soil pollutions. In air pollution, all pollutants can be grouped into three categories: physical, chemical and biological pollutants. The impacts of physical pollutants e.g. noise or heat on environment and human being are terminated immediately when the pollutant sources disappear. The impacts of chemical pollutants remain a long time. Our attention of the environmental pollution has been attracted by physical and chemical pollutants because they may lead to the decrease in life quality and the loss of social wealth. Another reason is that physical and chemical air pollution e.g. noise, black diesel smoke, and dust are easily felt or observed by people. Governments, academic organizations and mass media have focused more attention on these environmental problems than those caused by biological pollutants.

In comparison with physical and chemical pollutants, biological pollutants e.g. airborne bacteria, fungi and viruses are invisible to the naked eye and hardly felt. The main problems of biological pollutants are the acute adverse health effects on human. These effects are sometimes very serious or global health problems e.g. influenza. The condition of biological air pollutants is related to many factors including temperature, humidity, dusts, and smokes etc.

Chiang Mai, a fast developing tropical city, is facing possible air pollution problems with the development of local economy and the improvement of people's life quality e.g. the increase of cars and other automotive vehicles if the proper measures are not adopted. The relatively high air temperature and humidity in Chiang Mai city are favorable to the survival and growth of biological pollutants. Many food stands are just situated on the road side exposing to outdoor air. These specific atmospheric features and eating habit increase the relative importance of biological pollutants to public health. Some airborne fungi are important allergens. Chiang Mai city is an important tourist site in northern Thailand for international tourists, who may be susceptible to some airborne allergens.

The risk of biological pollutants is dependent on (1) the composition and concentration of biological pollutants; (2) the susceptibility of population and (3) the people's opportunity of exposing to air pollution (Seltzer, 1995). In order to reduce the risk of airborne microbes to people's health, it is very necessary to get information on the composition and concentration of airborne microbes in Chiang Mai city. The information on microflora in Chiang Mai city is the basis for designing proper measurements to control the biological pollutants.

1.2 Air Environment

The essential background knowledge about meteorology is indispensable for us to understand the environment of airborne microflora before the problems of biological air pollution are discussed.

The atmosphere consists of a mixture of gases. A gas is composed of an extremely large number of particles moving at high velocities in random directions. The air temperature depends on the average velocity of these particles. The gases making up the atmosphere may be divided into two categories: (1) the constant gases which are relatively constant by volume and (2) the variable gases. Among the constant gases, nitrogen (N_2), oxygen (O_2), and argon (Ar) are most important with 78.09%, 20.95%, and 0.93% by volume respectively. The variable gases of most importance are water vapor (0-4% by volume) and carbon dioxide (CO_2, around 0.03% by volume). Carbon dioxide is sometimes considered as one of the constant gases (Hidore, 1969).

There is a third variable component, apart from the two kinds of gases mentioned previously, including dusts and other solid particles e.g. soil particles, smoke residues, volcanic ash and meteoric residues. It is these dusts and solid particles that act as the carriers of biological pollutants.

The atmosphere is usually recognized as layered. The nomenclature of atmospheric layers is shown in Table 1 (Hidore, 1969).

Table 1 The vertical structure of the atmosphere (Hidore, 1969)

Name of layers	Height* (mile)
Thermosphere	Above 52
Mesosphere	27 - 52
Stratosphere	7 - 27
Troposphere	below 7

* Height varies considerably at the different layers

The characteristics of each zone are very different. The changes in each zone have different effects on the surface weather condition. The higher in the atmosphere a change occurs, the longer it will be before it is reflected in the atmosphere at the surface. The hourly and day to day weather changes are associated with the troposphere. The changes over longer periods of time e.g. weekly or seasonal variations are related to the upper atmosphere. The phenomenon of air motion and a rather uniform decrease in temperature with height are the main characteristics in the troposphere but it is possible to show temperature inversions i.e. the temperature increases with height under some conditions e.g. at night, no wind, and cloudless sky etc. In a temperature inversion, fungal spores and dust particles (the main carriers of airborne bacteria) tend to settle out so the concentration of airborne bacteria and fungi may decrease. However the air above the inversion part may continue to carry a normal spore- load (Gregory, 1973).

The condition of the various atmospheric elements at a particular point in time and space is called weather, which is the primary ingredient of the climate. The climate consists of the regime of weather at a place over a relatively long period of time. The analysis of weather and climate is usually focused on several variable factors of the atmosphere near the surface including solar radiation and temperature, humidity and precipitation as well as air pressure and wind speed. There are many interrelationships among these factors. The weather and climate in an area affect the local airborne microflora i.e. the composition and number of different kind of microbes.

1.3 The Microflora of the Air

The microflora of the air is composed of different species which enter the atmosphere from the soil, plants, and animals. These species include not only spores of fungi, myxomycetes, bryophytes, and pteridophytes but also pollen grains, moss gemmae, propagules of lichens, cells of algae, vegetative cells, bacteria, cysts of protozoan, and virus particles. The largest groups of these particles are the pollens which may range up to 200 μm in diameter, though most are 20-50 μm. Most airborne fungal spores are between 3 and 30 μm in diameter and most bacterial cells are about 1 μm in diameter, and viruses 0.1 μm (Hawker and Linton, 1979).

In a specific area, the composition of the airborne microbes is dependent on (1) the extent to which air is contaminated with mineral and organic suspensions; (2) the temperature, rainfall and humidity; (3) the activities of man and (4) geographical location and features. For example, in the Arctic region the air contained 2-3 microbes per 20 cubic meters but in industrial cities the air contained a large numbers of bacteria per ml of air (Pyatkin and Krivoshein, 1980).

Time is one of the most important factors affecting the concentration of airborne microbes in a specific area. Day and night populations of airborne spores as well as the methods of spore liberation are different. In different seasons, the concentration of airborne spores changes also. These variations in composition and number of air spores depend on the types of airborne microbes and the geographical location.

The vertical profile of spore concentration in many parts of the world generally shows a decrease in concentration with the increase of height. Spores may be undetectable at the heights of 2-6 km with ordinary sampling methods. Nevertheless, very low concentrations of viable fungal and bacterial cells were detected at the heights of 18-27 km if the sampling with very large volume air was adopted (Hawker and Linton, 1979). However, the most numerous members of the airborne spores near the ground level are bacterial and fungal spores.

1.4 Airborne Bacteria and Fungi

About 1200 species of bacteria and actinomycetes in air were recognized and about 40,000 species of fungi and other spore-producing organisms were identified (Gregory, 1973). However, air with little or no nutrition and water is not suitable for the survival of airborne bacteria and fungi if they are in actively metabolizing phase. The common form of them is spore, which is more resistant, metabolically less active, and better adapted to aerial dispersal.

A fungal spore may be single cell, or consists of a few cells. The spore wall is normally made up of resistant material (chitin etc.). The spore color, which is a useful aid in identification, is different in various species from colorless, transparent to yellow, red, brown, and purple. The density of most spores is greater than water (density =1) , commonly 1.1 to 1.2 but lower densities were recorded also (Gregory, 1973). The surface texture of some spores is smooth but others are rough, spiny, or varied textured. The spore shape varies widely according to species. The smallest spores,

such as those of bacteria, tend to spherical while the larger spores of fungi tend to be somewhat cylindrical or elongated forms etc. The size of spores is less than 50μm (Goetz, 1965). However, the color, size, shape, and texture of fungal spores must be looked upon as probably functional adaptations resulting from interplay of tensions in the growth (Savile, 1954).

The airborne bacteria and fungi may come from soil , plants, animals, water, and human activities e.g. talking. When a water film is broken, droplets are produced.

The dispersal of airborne bacteria and fungi involves: (1) liberation and take-off of spores from sources into air; (2) dispersion in air currents; and (3) deposition on a surface at the end of the journey prior to germination and growth of spores. There are various mechanisms in each step. The dispersal process of airborne bacteria and fungi depends on the characters of species, geographical features and location, time i.e. day or night, different seasons, meteorological factors e.g. temperature, humidity, wind, and precipitation etc.

The composition and number of airborne bacteria and fungi are the function of many natural and man-made factors e.g. (1) the geographical location e.g. tropical areas or temperate regions; (2) the season e.g. the rainy and dry season in tropical areas or spring, summer, autumn and winter in temperate zones; (3) the kind and frequency of man's activities (traffic, industry and agriculture); (4) the local condition of temperature, humidity, and wind when air samples are collected; and (5) the most important factor affecting the spectrum of airborne bacteria and fungi is local spore sources, which may dominate the airborne microflora nearby.

The significance of the study on airborne bacteria and fungi is to reduce the economical loss in agriculture and husbandry as well as to decrease harmful impacts on people's health.

1.5 The Purposes of the Study

The purposes of this study were to examine the composition and concentration of airborne bacteria and fungi in Chiang Mai city, to identify common airborne bacteria and fungi, and to assess the risk (or impacts) of airborne bacteria and fungi on human health. This research could provide the baseline information about the airborne bacteria and fungi in Chiang Mai city during the rainy and cool seasons.