Chapter 5 Effect of Air Pollution

5.1 Health effects on human

5.1.1 Introduction

In this section, effects of typical air pollutants upon our health will be described. Chronic damage to respiratory organs is important in many cases. In some cases where the ambient air is frightfully polluted, however, eye and/or airway irritations (involving tears, cough, sore eyes and/or throat, etc.) become additional problems.

5.1.2 Respiratory system

The first target organs attacked by air pollutants are respiratory system. Therefore, let us gain a general understanding of them in advance. Fig.5.1.1 outlines the respiratory system of human. From the nasal cavity to near the bronchi, which constitute the passage of air, mucus covers the mucous epithelium. The airway of trachea and the bronchi are provided with cilia to eliminate foreign substances. Also there are alveolar macrophages for phagocyte in the alveola of the lungs exchanging carbonic dioxide for oxygen.

Of the air pollutants inhaled, the larger particulate matters are caught in the nasal cavity. However, so-called suspended particulate matters, measuring 10 μ m or less in diameter pass through the nasal cavity to reach the trachea and/or the alveola. Of the gaseous substances, sulfur dioxide, which is soluble in water, is absorbed mainly in the upper airway, causing chronic bronchitis or asthma. On the other hand, ozone, nitrogen oxides and other insoluble gaseous substances advance deep in the lungs, causing asthma or chronic bronchitis or possibly pulmonary emphysema. Also, carbon monoxide, when coming into contact with hemoglobin contained in the blood in alveola, disturbs transportation of oxygen by the blood because the substance combines with hemoglobin more easily than oxygen.

5.1.3 What respiratory decease are induced by air pollutants?

In the case where the air is severely polluted, aged persons and patients with certain chronic base diseases in particular are in danger of excess death by suffering from acute bronchitis or so (refer to the section on the history of air pollution). In many cases, however, air pollution causes chronic respiratory decease, especially asthma, chronic bronchitis and lung emphysema. These respiratory diseases are known generally as chronic obstructive pulmonary diseases (COPD). Characteristics of these diseases as revealed by the pulmonary function check include smaller values for the forced expiratory volume % in one second (what percentage of their whole expiration the patients can put out in one second when they breathe out as fast as they can) and lower values for the maximum peak flow, while the vital lung capacities of the patients remain normal.

Definitions of these diseases are given in Table 5.1.1. In the case of chronic bronchitis, patients' illness is characteristically diagnosed based on their subjective symptoms such as continuous coughing and phlegm. Asthma

has come to be defined differently, now being considered to be inflammatory injury to the airway based on recent studies. Incidentally, causes of these diseases are not limited to air pollution.

Other diseases that can be caused by air pollution include lung cancer. It can be caused by asbestos, as is well known. Concerning smoke and soot or exhaust gas from diesel engines, because carcinogens have been found sticking to some particles contained in it, there is a suggested possibility of it causing lung cancer. However, a sequence of cause and effect between them is yet to be established.

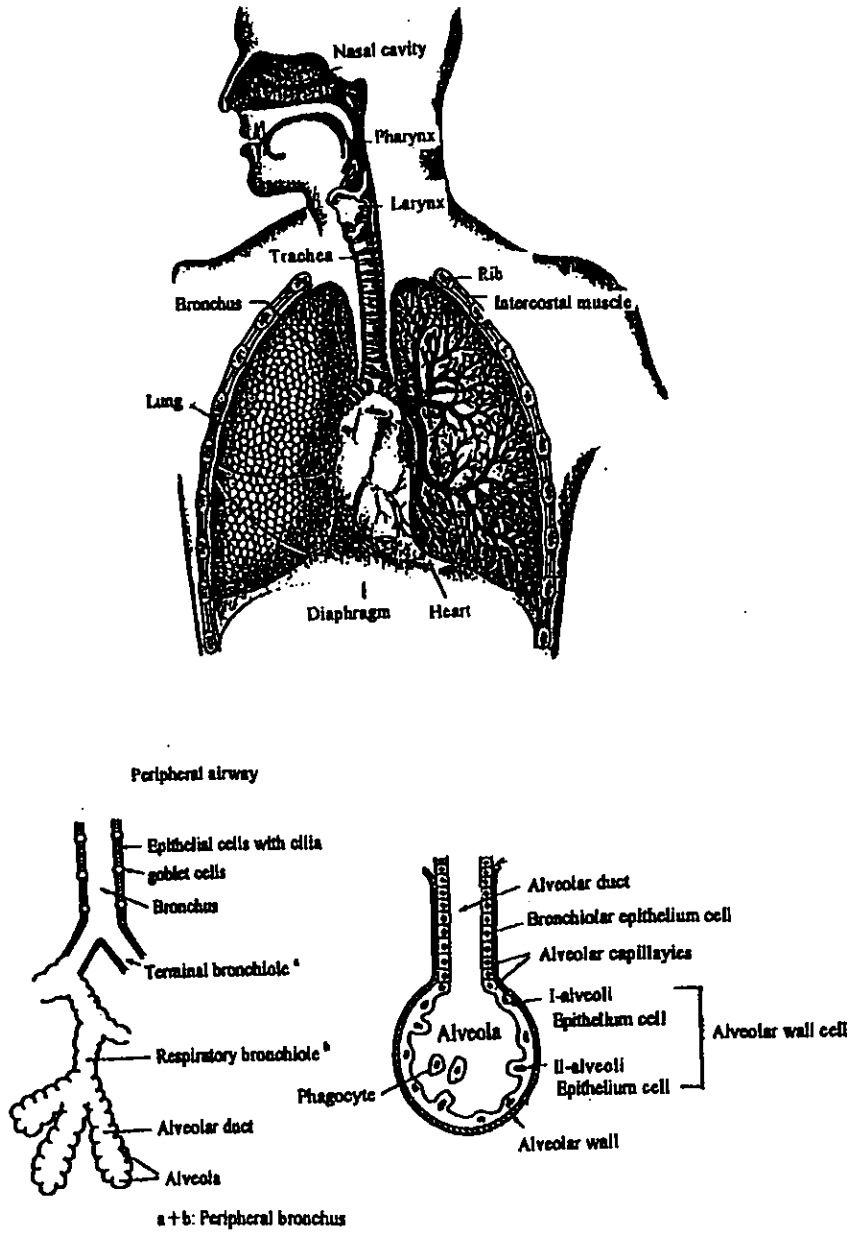


Fig.5.1.1 Respiratory System

Table 5.1.1 Definitions of Chronic Obstructive Lung Diseases

Names of diseases:	Definition
1) Chronic bronchitis	The clinical image of this disease is that excessive mucus is secreted in the bronchus and that phlegm is cough out chronically or repeatedly. In most cases, these symptoms continue almost every day for at least three months each year for at least two consecutive years. (ATS)
2) Asthma	The main characteristic of this disease is exacerbation of reaction to various stimuli of the trachea and the bronchus and its most important symptom is stenosis of extensive parts of the airway, whose intensity change spontaneously or can be changed through treatment. (ATS) The most recent definition of the disease, which recognizes that "the existing definition of asthma is unsatisfactory because it is impossible to fully understand the nature of the disease from its viewpoint of obstructed airway and airway hyperreactivity," is: "chronic inflammatory injury to the airway in which many cells such as mast cells and eosinophils are implicated."
3) Pulmonary emphysema	In this disease, an anatomical change to a morbid state is presented: this disease is mainly characterized by enlargement of air chambers from the ends of the tracheae to the farthest ends of the whole respiratory organ, which is accompanies by destruction of alveolar walls. Only few cases are peculiar clinically. However, the X-ray photos of some cases do not reveal the disease. In many cases, the disease is accompanies by usual coughing, which in turn is accompanied by wheeze. Its patients find it difficult to breathe and feel very much fatigued. (ATS)

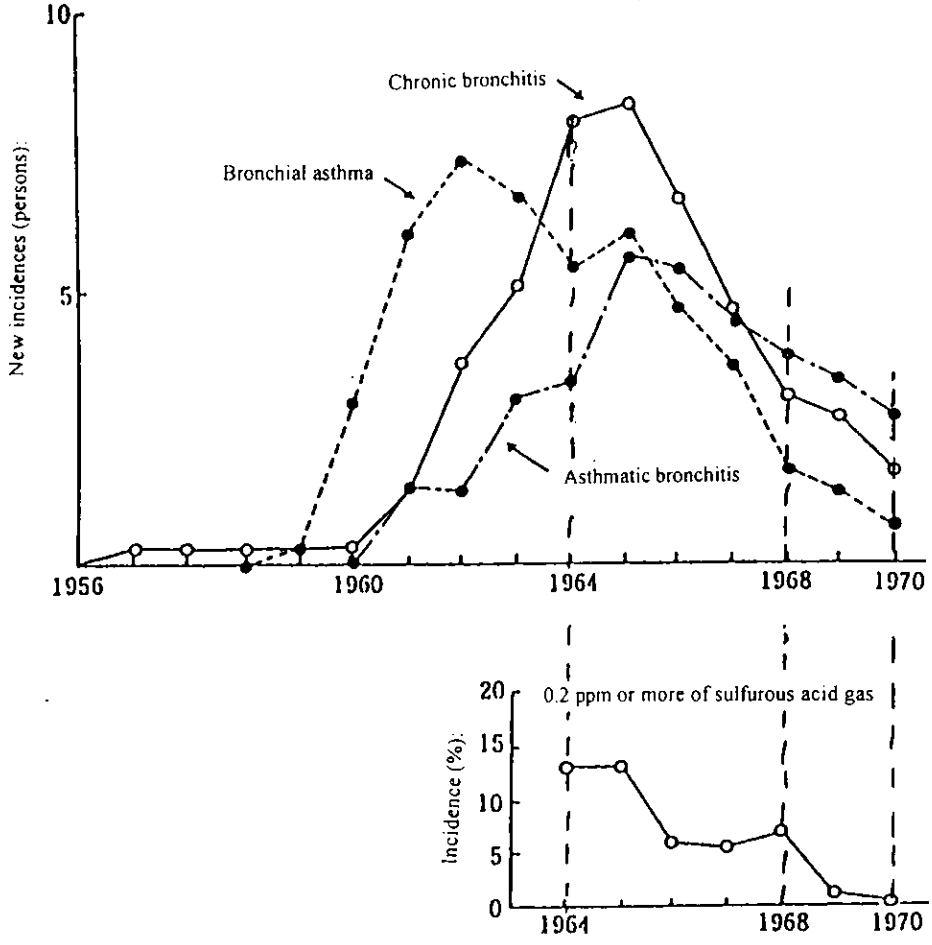
5.1.4 Health effects of typical air pollutants

(1) Sulfur dioxide

Main air pollutants generated when coal is burnt are sulfur dioxide and smoke and soot. In the famous episode of excess deaths due to air pollution in London, many aged people with respiratory or cardiovascular diseases died. Their common symptom was bronchial stenosis accompanied by dyspnea [1]. At that time, the peak concentration of sulfur dioxide was about 1.4 ppm. It is now considered that these acute symptoms occur furiously when particulate matters such as smoke and soot exist together rather than when only sulfur dioxide exists. Later as coal was replaced by oil as fuel, smoke and soot decreased. But concentration of sulfur dioxide has increased inversely, with air pollution having come to occur in more extensive areas.

In Japan, the incidence of "Yokkaichi asthma" is famous. It was characterized by very high peak concentrations of sulfur dioxide, which often reached 1 to 2 ppm, measured in Isozu area, where the maximum amount of air pollutants landed from the chimneys in and around Yokkaichi City. In Isozu area, the rate of consultations with physicians about any of the four diseases related to the air pollution, i.e. common cold syndrome, bronchial asthma and pharyngo-laryngitis (including tonsillitis and angina) and symptoms of eyes (including conjunctivitis, keratitis, trachoma and eye irritation) was obviously higher than in any other area in or around the city [2]. It is considered that the incidence of common cold syndrome included many cases of chronic bronchitis because in those days physicians had not in general made it a practice to use the term, "chronic bronchitis". Fig.5.1.2 shows the trends of the new incidences (three-year moving average) of three diseases of bronchial asthma, chronic bronchitis

and asthmatic bronchitis (children) and frequency rate of the peak concentration (more than 0.2 ppm) of sulfur dioxide in Isozu area from about 1960 through 1970. We can see that, after the start of full-scale operation of the industrial complex in and around Yokkaichi, first the incidence of bronchial asthma, next that of chronic bronchitis and then that of children's asthmatic bronchitis increased and that, since around 1965 when concentration of sulfur dioxide started to be decreased through the adoption of various counter measures, these incidences also started to decline [3].



Upper figures: Their three- year moving averages

Lower figures: Trend of the concentration of SO_2 in the area [1]

Fig.5.1.2 Trends of the New Incidences of Air Pollution-Related Diseases in Isozu Area of Yokkaichi City

(2) Particulate matters

Smoke and soot generated when coal or oil does not attain a complete combustion and diesel exhaust particles whose main component is carbon. Because many of these particles measure less than 2.5 μ m in diameter and can go deep into alveola of the lungs, they may potentially damage to health. On these particles, lots of hazardous substances generated at the same time are stuck. Particularly when these particles exist together with sulfur dioxide, they cause much severe respiratory injury, as described above. Asbestos fibers inhaled induce pneumoconiosis, lung cancer or malignant mesotherioma. In countries where leaded gasoline is consumed, lead in exhaust gas from automobiles has posed problems, causing chronic toxicoses such as anemia, coloring of the gingivae and

neurological diseases. It has been established recently that the concentration of particulated matter has a relationship to the mortality and the number of inpatients with respiratory diseases [4] and that has adjuvant effects on produce of antibodies that take part in allergic diseases.

(3) Photochemical oxidants

The main component of photochemical oxidants is ozone, which accounts for almost all part of the substance. Effects of photochemical oxidants upon human health, therefore, are largely induced by ozone. It is considered, however, eye irritation, of which people often complain as an acute symptom, is not caused by ozone alone but is caused when peroxyacetylnitrate (PAN), formaldehyde and so on are also active. This eye irritation, of which people complain most often, is considered to be the most sensitive indicator of effects of photochemical oxidants. It can rightly be considered that the threshold value of photochemical oxidants for eye irritation is 0.1 (0.08-0.15) ppm [5] [6]. When the hourly average value of concentration of oxidants reaches 0.2 ppm approximately, the respiratory function generally starts to reduce (the forced expiratory volume % in one second decreases, etc.). It has been reported, however, that, even when the value is 0.12 ppm or less, people taking outdoor exercise can present the same symptom [7]. Concerning long-term health effects of photochemical oxidants upon human, there is a suggested possibility of the substances affecting the incidence of respiratory diseases. However, their contribution rates are not yet to be established.

(4) Nitrogen oxides

The current Japanese environmental standards were adopted in 1972 report based on results of the following researches including the respiratory function test also mentioned below: epidemiological surrey that established that the incidence of continuous coughing and phlegm is in direct proportion to concentration of nitrogen oxides and the respiratory function test made at the same time that revealed that, as concentration of nitrogen oxides increases, the forced expiratory volume % in one second and the peak flow described above decrease [8]. In addition, researches conducted recently have discovered that in areas where the annual average value of the concentration of nitrogen oxides exceeds 0.03 ppm (cf. 0.06 ppm as the environmental standard), the new incidence of asthmatic symptoms among children tends to be higher [9]. We must consider that other factors may also work to bring about these research results. However, results of most experiments with animals also support the research results as facts.

As described above, when air pollutants effect our health, many factors are combined to bring about each symptom. Therefore, it should be necessary to grasp which air pollutant affects health most in each area concerned.