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# Air pollution and its health effects in China

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**Abstract - The survey designed to grasp air pollution and to investigate its effects on health is being carried out in three urban cities in the Northeastern districts of China. The results of the survey on atmospheric particulates in Shenyang showed that three surveyed areas in the city showed high concentrations of particulates, which were due to combustion of coal used for heating apparatuses in winter, while there was a slight effect of cars on air pollution in the period when no heating apparatuses are used. The results of pulmonary function test in school-age children showed that the function was slightly decreased in winter.**

## I. Introduction

Air pollution involving particulates deriving from combustion of coal, sulfur oxide, and nitrogen oxide has become a big problem in China, because coal has primarily been used hitherto at factories, thermal power stations, centralized heating system, and so on. Any of countermeasures to remove particles of soot or desulfuration at the source of occurrence does not yet progress even at present.

Recently air pollution due to cars is also being increasingly involved with the problem because of the rapid prevalence of cars in big cities and towns. There has been apprehension about adverse health effects including suffering from respiratory diseases and cardiological diseases and death from these diseases.

In recent years the Chinese Government established the status of improvement in air pollution as the most important task confronting environmental problems. Since 2000, the baseline of atmospheric particulates has been changed from total suspended particles to $PM_{10}$ (particle matter of less than 10 μm in aerodynamic diameter) in China, and the arrangement of air pollution monitoring system is being progressed by confirmation of air pollution index (API) in main towns and cities by INTERNET. Effects of air pollution on health have been investigated by investigators in China and foreign investigators at Chongqing and Taiyuan, where serious air pollution has been induced by smoke discharged from factories, and a number of reports have been published in domestic journals of China. However, there have been only few studies reported in international journals, which include research in Hong Kong [1-3].

In 2001 we started NIES special research, "International cooperative research on health effects of urban air pollution and its preventive measures in China", which was designed to grasp the present situation of air pollution in view of pollution by cars and factories, to determine hazardous components in PM, and to evaluate their effects on health in three urban cities of the Northeastern districts of China, where air pollution by heating gravitated to the cities is serious in winter. The contents of the survey and research are outlined herein, with some results that have been obtained hitherto.

## II. Methods

### *A. Urban cities as the subjects of the survey*

The subjects were three big urban cities in Liaoning Province (Figure 1). The subject of the 2001

and 2004 researches, Shenyang, has 4,800,000 population, and traffic volume in the city is rapidly increasing in recent years. The subject of the 2002 research, Fushun, is an industrial city with a population of 1,300,000. The subject of the 2003 research, Tieling, is a local city with a population of 400,000. Three areas at different levels of air pollution were selected from each city, and research on the following items in these areas is progressing.

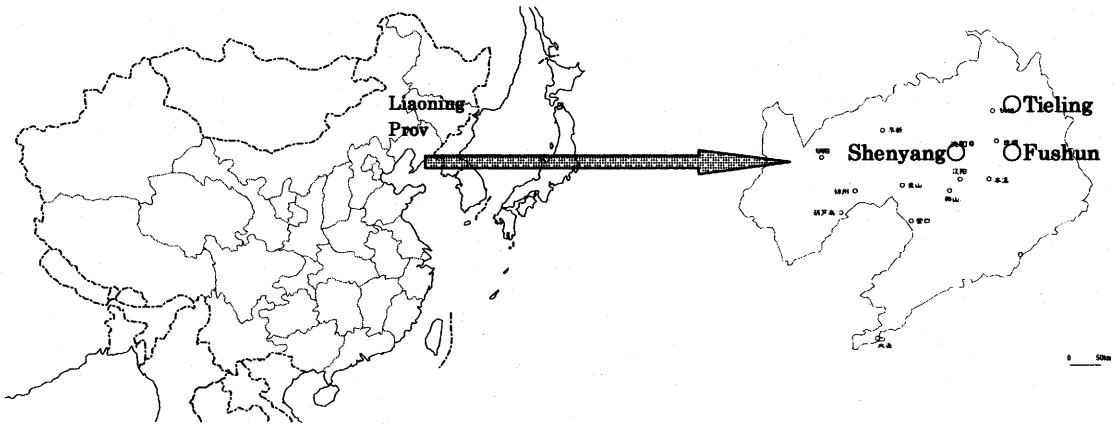


Fig. 1 Study cities in China

*B. Evaluation of air pollution, particularly atmospheric concentrations of particulates and hazardous components*

Atmospheric particulates are measured by particle diameters in each season by means of a low-volume air sampler, Andersen Type (AH-200, Sibata Scientific Technology Inc. Tokyo, Japan) at each elementary school in the three areas. Simultaneously with the measurement, concentrations of nitrogen dioxide ($NO_2$) and of sulfur dioxide ($SO_2$) are also measured by a simple method (using a passive sampler). To compare characteristics of hazardous components of atmospheric particulates, components of polycyclic aromatic hydrocarbon (PAH), nitro-PAH (NPAH), and heavy metals in the particulates collected are also analyzed.

*C. Evaluation of concentrations of air pollution exposed individually by inhabitants*

To clarify the situation of exposure of urban inhabitants to air pollution in their daily life, concentrations of atmospheric particulates, $NO_2$, and $SO_2$ are measured in the periods when heating apparatuses are used and not used by means of a small sampler, which is set up within and out of doors of each of 30 houses in each city, and by means of a personal sampler that is hold by each inhabitant. The personal sampler used was a single-nozzle personal sampler (ATPS-20H, Sibata) equipped with two cascade impactors with 50% cut-off levels of 10μm and 2.5 μm at a flow rate of 1.5 L/min for the size selected for particulate ($PM_{2.5}$, $PM_{10}$) sampling. Prior to sampling, PTFE binding glass fiber filters (TX40HI20, Pallflex Inc. NY. USA) were equilibrated for 24 hours under temperature of $23^0$C and relative humidity of 50% and then weighed. After the sampling process, filters were equilibrated again under the same condition and the particulate mass measured by the gravimetric method using an electric ultra-microbalance (UMT2, Mettler Toledo Inc. OH, USA), with a sensitivity of 0.1 μg.

*D. Evaluation of the effects of air pollution on the respiratory system of school-age children*

*1) Evaluation of changes in pulmonary function*

To evaluate the subacute effects of air pollution on the pulmonary functions of school-age children, pulmonary function test is conducted on the same children repeatedly four times including the period when heating apparatuses are used. The subjects in Shenyang were (approximately 100) third-grade school-age children (aged 8-10 years) of each of three elementary schools. Pulmonary function test

was conducted with a electronic spirometer (HI-701, Chest Inc., Tokyo, Japan) on the same children four times, i.e., in October 2001 (before the start of using heating apparatuses), December 2001 (the period when heating apparatuses are used), April 2002 (immediately after the end of the period when heating apparatuses are used), and June 2002 (the period when no heating apparatuses are used). The test was conducted in a standing position, and a nose clip was applied to each subject. The test was repeated until reproducible flow volume curve was obtained three times. Of these test results, changes in forced vital capacity (FVC), forced expiratory volume in one second ($FEV_{1.0}$), and forced expiratory volume % in one second ($FEV_{1.0}$%) were investigated by paired test in the present study.

*2) Evaluation of the chronic effects of air pollution on the respiratory system*

To evaluate the chronic effects on the respiratory system in children, a questionnaire of Chinese language edition was prepared with some addition to the standard questionnaire on respiratory symptoms, ATS-DLD-78[4], and questionnaires are sent to about 1,500 school-age children in the three areas as subject in each city for the questionnaire survey.

## III. Results and Discussion

Some achievements compiled so far are reported herein.

*A. Atmospheric concentrations of airborne particulates, PAH and NPAH, and distribution of particle diameters in Shenyang*

From the results of the measurements in the periods when heating apparatuses were used and not used, in the three places in Shenyang, the distribution of particle diameters was shown by Hayakari's calculating program (Figure 2) [5-6].

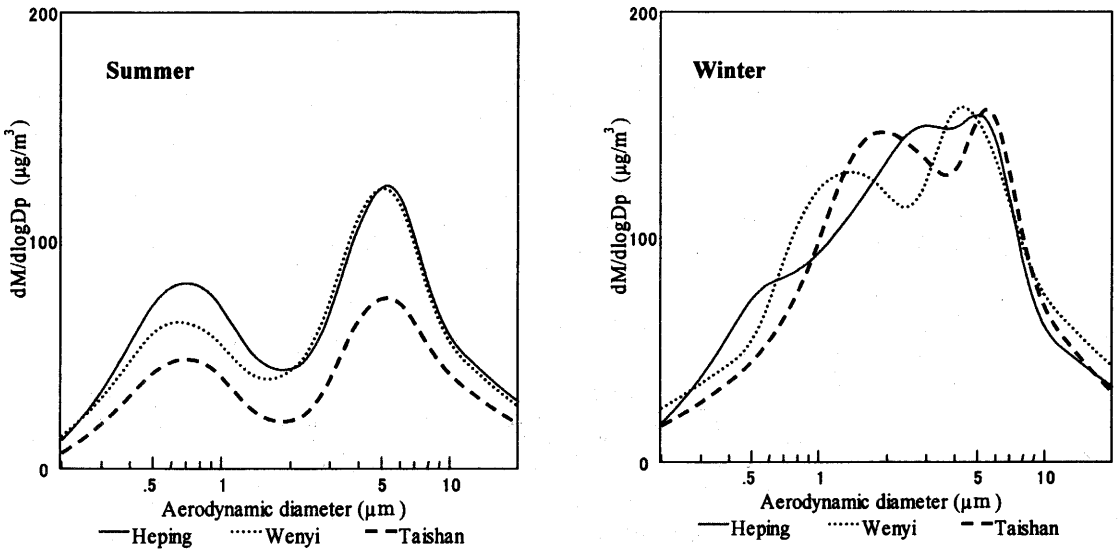


Fig. 2 Size distribution of atmospheric particles in Shenyang

The atmospheric concentration of particulates in summer was highest in Heping with large traffic volume, followed by Wenyi and Taishan, in that order, while atmospheric concentrations of particulates were increased in these three places in winter when heating apparatuses are used, showing that there was slight or no difference among the areas.

Figure 3 shows the total concentration of 9 kinds of PAH in the atmospheric particulates (TPAHC) and the total concentration of 12 kinds of NPAH in the atmospheric particulates (TNPAHC), which

were collected in the three places in Shenyang in summer and winter. In summer, TPAHC was highest in Heping, followed by Wenyi and Taishan, in that order, showing that the results were consistent with traffic volume.

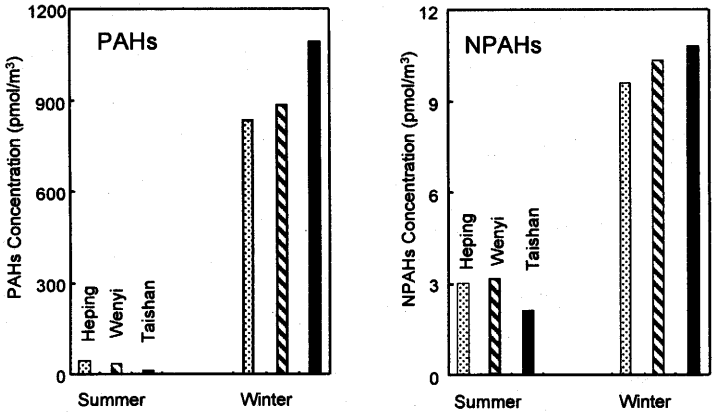


Fig. 3 Total concentration of PAH and NPAH in the atmospheric particulates in Shenyang

As for the concentrations of PAH and NPAH in the atmospheric particulates in winter, the concentration of PAH was 17 to 68 times higher than in summer in some places. The atmospheric concentration of NPAH in winter was also 3 to 10 times higher than in summer, but the degree of the increase in the NPAH concentration was less than that in the PAH concentration. According to areas, these concentrations were highest at Taishan, a residential area, where the large amount of coal is used for heating in winter.

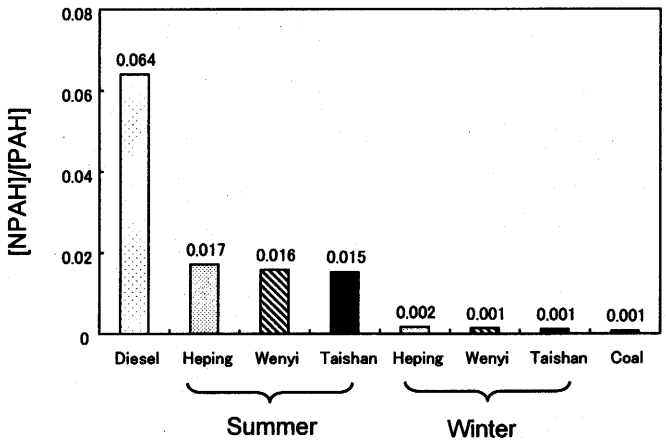


Fig. 4 The ratio of NPAH concentrations to PAH concentrations

The ratio of NPAH concentration in diesel exhaust particles (DEP) collected in Kanazawa of Japan to PAH concentration in DEP was higher than the ratio of NPAH concentration in smoke from coal stoves, which was collected in Shenyang, to PAH concentration in the smoke by times of a number of two figures (Figure 4). The ratio of NPAH concentration to PAH concentration in atmospheric particles in the three places was 0.015 to 0.017 in summer. The level was approximately 10 times as high as that in winter, and intermediate between the DEP level and the level in the smoke by combustion of coal. The atmospheric PAH and NPAH concentrations measured in summer in

Shenyang were contributed to the influence of cars, but combustion of coal was assumed to greatly contribute to these concentrations all the year round in Shenyang.

*B. Concentrations of individual exposure*

The mean indoor concentration of atmospheric particulates ($PM_{2.5}$, $PM_{10}$) over the 24-hour period was slightly lower than the outdoor concentration, but was extremely high in winter in three areas in Shenyang (Table 1). The concentration of individual exposure, which was mostly intermediate between the indoor concentration and the outdoor concentration, was much higher than environmental standards for those in Japan and the U.S.

Table 1 Atmospheric particulate concentration of indoor and outdoor and personal exposure in winter in Shenyang

| Area | Period | Place | n | $PM_{2.5}$ | $PM_{10}$ | $PM_{2.5}/PM_{10}$ |
|---|---|---|---|---|---|---|
| **Heping** | 30 Jan ~ 6 Feb 2002 | **Indoor** | *44* | **126** | **167** | 0.76 |
| | | **Outdoor** | *31* | **139** | **198** | 0.70 |
| | | **Personal** | *42* | **115** | **153** | 0.75 |
| **Wenyi** | 14 Jan ~ 21 Jan 2002 | **Indoor** | *35* | **98** | **138** | 0.71 |
| | | **Outdoor** | *34* | **125** | **194** | 0.64 |
| | | **Personal** | *35* | **117** | **165** | 0.71 |
| **Taishan** | 23 Jan ~ 29 Jan 2002 | **Indoor** | *53* | **123** | **162** | 0.76 |
| | | **Outdoor** | *55* | **148** | **214** | 0.69 |
| | | **Personal** | *52* | **131** | **180** | 0.73 |

*C. Changes in the pulmonary function*

On the determinations in Shenyang, the mean value of $FEV_{1.0}$ in males were 1.89 L, 1.90 L, 1.84 L, and 1.88 L in four tests respectively. The value on the second determination significantly declined on the third determination, and the value on the third determination significantly increased on the fourth determination (Figure 5).

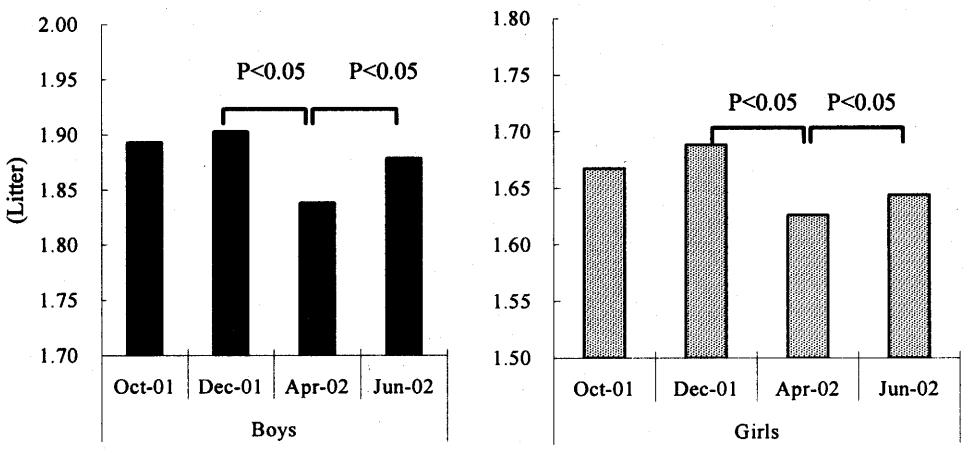


Fig. 5 Change of forced expiratory volume in 1 second ($FEV_{1.0}$)

The mean values of $FEV_{1.0}$ in females were 1.67 L, 1.69 L, 1.63 L, and 1.64 L in four tests, respectively. The same as in the males, the value on the second determination significantly declined on the third determination. The value on the third determination increased on the fourth determination in some areas, but the changes were not significant.

In the future, further studies are needed to the results or tendency shown by the survey in Shenyang in view of some factors including the presence or absence of respiratory symptoms at the time of survey in school-age children and past histories of respiratory diseases, such as asthma and pneumonia, and of allergy diseases. The results in other cities will be comprehensively considered, and the involvement of air pollution with the results needs to be evaluated.

Many small tasks confronting the present survey and research remain unsolved. It is hoped that the results will be compiled and arranged as soon as possible, and the results of the survey of final fiscal year in Shenyang must be added for suggestion to comprehensive evaluation of and countermeasures against the effects of air pollution on health.

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