Effects of Exposure to Air Pollution on Community Health

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PREFACE

During the last 8 years (1950～1958) deposited atmospheric impurities in Ube city amounted to 48 tons/km^2/month, which is the largest quantity in this country. In analysing the composition an extremely large quantity of insoluble matter (59%) was elucidated. That a great portion of the matter consisted of ash (80%) was a characteristic of the phenomenon.

The major causes of this phenomenon were ascribed to the following:

a) In the leading factories of the city, 70,000 or 80,000 tons of fuel coals of inferior quality, the calorific value of which ranges from 3,000 cal to 5,000 cal only, were monthly consumed for generating electricity by means of the pulverizing combustion system.

b) The factories were improperly located to the principal directions of wind throughout the year.

c) Not a few grit arresters (electrostatic precipitators and cyclone dust-separators) in the electricity generating stations were still imperfectly equipped in their installations.

In conformity with counsel and advice of the Air Pollution Control Committee in Ube city, therefore, a plan was devised with a view to raising the efficiency of grit removal of electrostatic precipitator to 97% or more and to decreasing the quantity of dust from flue gases to 1.2g and less per m^3. As fifty percent of the plan was so far brought to completion, the amount of monthly fuel consumption increased 12%, while the amount of monthly deposited atmospheric impurity decreased 15%.

The remaining fifty percent of the grit arresters is to be completed in the year of 1960. To complete these grit arresters will necessitate an expense of some £ 400,000. An enormous cost of construction will, therefore, be required to raise the efficiency of grit removal to a higher effect of 98% or 99%. Such a financial problem as stated leads the construction work into a difficult corner, though the technical viewpoint makes the work achievable.

An urgent problem presented itself for the elucidation of the influence of air pollution upon the citizen's health. An investigation concerning the measure for the elucidation of this problem has been undertaken by the author from an epidemiological standpoint, and the results of which so far are now stated in the following

sheets. They are as follows:

a) An epidemiological investigation has been made on the morbidity and the mortality by selected causes among Ube citizens with the view to clarifying the relation of the characteristics of geographical, historical and biological phenomena to air pollution.

b) Special attention as stated in the following has been paid to the study of geographical phenomena. Besides air pollution the influence of such factors as the density of population, the dwelling places, the economical conditions, the educational levels and the susceptibility may play their parts in the geographical distribution of morbidity and mortality. It may not, accordingly, be considered that air pollution alone has influence on the distribution of morbidity and mortality.

c) The following are noteworthy in the investigation of historical phenomena. Together with air pollution, such meteorological factors as air temperature and rainfall have strong influences upon the yearly and monthly trends of morbidity and mortality. The prevalence of an infectious disease has its own trend, cyclic and seasonal variation. It is, consequently, necessary to make an investigation on the correlation between the quantity of deposited atmospheric impurity and the meteorological elements through the following time series of the yearly and monthly trends of morbidity and mortality.

i. e. 1- Original monthly time series,

2- Time series that eliminates 'trend' and 'seasonal variation'.

d) In the biological phenomena the following are especially taken into consideration. A phenomenon of adaptation to air pollution is sometimes observed in the morbidity. Such elements as the age group and the problem of anamnesis usually control the power of resistance to air pollution, which is supposed to have influence upon the fluctuation of mortality. The phenomenon of adaptation is observed conspicuously among the children of school age. Of the power of resistance to air pollution it is elucidated that the aged people with anamnesis the weakest, followed by the ordinary aged people and the infants.

I

ON THE RELATIONSHIP BETWEEN THE MORTALITY BY SELECTED CAUSES AND DEPOSITED ATMOSPHERIC IMPURITY IN UBE CITY

A characteristic of health problem of Ube citizens observed on the base of mortality by selected causes is the high mortality rate on diseases of the respiratory and the circulatory systems. The phenomenon that in the mining and industrial area this characteristic becomes conspicuous has led the writer to observe statistically the relationship between the yearly and monthly trends of mortality from those diseases and air pollution plus the meteorological elements, and the results of which

are to the following effects.

1. As a control area of the city of Ube, an investigation has been made on the city of Hofu which resembles strikingly to the city of Ube, in respect of the urban character and of the geographical and the meteorological conditions. The city of Hofu, however, is not exposed to such intensive atmospheric pollution as the city of Ube, which always suffers from a heavy concentration of air pollution.

Now, a comparative study of the yearly mortality by selected causes (1948～1953) in these two cities showed ① that in Ube city the high mortality rate of the infant and the aged was found; ② that the death-rate on such diseases of the respiratory system as diphtheria, bronchitis, asthma, tuberculosis and lung cancer was high and ③ that the death-rate on diseases of the circulatory system such as heart disease was especially intense. In Ube city, for example, the author observed the mortality rate from diphtheria 7.8 times as high as in Hofu city; lung cancer was 2.4 times as high, heart disease 1.2 times (Table 1).

Table 1. Comparison of mortality rates by selected causes in the cities of Ube and Hofu (control city).

(1948～1953)

	Causes of death \ Cities		Ube	Hofu
I	Infectious diseases of respiratory system	(B7～9, 14)	**16.2 (157)**	10.3 (100)
	(Repeat) Diphtheria	(B 8)	**4.7 (783)**	0.6 (100)
	Pneumonia	(B 31)	**52.3 (89)**	58.7 (100)
	Bronchitis	(B 32)	**23.7 (105)**	22.5 (100)
	Asthma	(241)	**13.7 (110)**	12.4 (100)
	Meningitis, except meningococcal and tuberculous	(B 23)	9.5 (339)	2.8 (100)
	Infectious diseases of digestive system	(B4, 6)	17.2 (83)	20.7 (100)
	Gastritis, duodenitis, enteritis and colitis	(B 36)	59.4 (125)	47.5 (100)
	Infant death (under 1 year)		45.2 (102)	44.1 (100)
II	Tuberculosis	(B1～2)	155.2 (112)	139.0 (100)
	Malignant neoplasms	(B 18)	85.9 (133)	64.7 (100)
	(Repeat) Lung cancer	(162)	2.2 (244)	0.9 (100)
	Vascular lesions affecting central nervous system	(B 22)	104.2 (102)	102.3 (100)
	Heart disease	(B25～27)	**51.3 (117)**	43.8 (100)
	Nephritis and nephrosis	(B 38)	33.0 (70)	47.3 (100)
	Senility, ill-defined and unknown causes	(B 45)	68.1 (116)	58.5 (100)
	All causes		970.8 (101)	962.6 (100)

Notes: 1) Group I: Crude death rates (per 100,000 population), but infant death rate only: per 1,000 live birth.
Group II: Age-adjusted death rate based on the population of Japan in 1950.

2) Infectious diseases of the respiratory system: Diphtheria, Whooping cough, Scaret fever and Measles.

3) Infectious diseases of the digestive system: Dysentery, all forms and Typhoid fever.

4) Brackets after causes of death show the international abbreviated list number or the international detailed list number.

Table 2. Community health of the mining and industrial area in Ube city from the viewpoint of age group mortality by selected causes, 1953～1957.
(per 100,000 population in each age-group)

Causes of death \ Age groups / Areas	Infantile (0～4 years)		Senile (over 60 years)	
	Mining & ind.	Other area	Mining & ind.	Other area
Pneumonia (B 31)	**144.3**	**129.2**	**522.4**	**191.2**
Bronchitis (B 32)	**22.2**	**11.8**	**149.3**	**73.0**
Tuberculosis (B1～2)	11.1	21.8	373.1	188.7
Heart disease (B25～27)	**66.1**	**20.0**	**1119.4**	**686.9**
Malignant neoplasms (B 18)	—	4.6	1044.8	634.0
Vascular lesions affecting central nervous system (B 22)	—	—	2014.9	1295.8
Senility, ill-defined and unknown causes (B 45)	—	—	**2089.6**	**1046.7**
Gastritis, duodenitis, enteritis and colitis (B 36)	11.1	41.9	149.3	62.9
Nephritis and nephrosis (B 38)	—	13.7	298.5	319.5
Accidents (BE 48)	33.3	30.5	—	91.8
All Causes	**627.1**	**595.7**	**10410.3**	**5774.3**

Causes of death \ Age groups / Areas	Childhood (5～14 years)		Young adult (15～39 years)		Later maturity (40～59 years)	
	Mining & ind.	Other area	Mining & ind.	Other area	Mining & ind.	Other area
Pneumonia (B 31)	—	6.4	**16.7**	**6.5**	12.2	20.0
Bronchitis (B 32)	—	—	—	—	**12.2**	**1.7**
Tuberculosis (B1～2)	—	6.4	50.2	90.5	18.3	142.1
Heart disease (B25～27)	8.7	14.1	22.3	28.0	**109.8**	**103.4**
Malignant neoplasms (B 18)	—	0.7	11.2	17.4	158.6	207.7
Vascular lesions affecting central nervous system (B 22)	—	—	8.4	6.3	85.4	156.4
Gastritis, duodenitis, enteritis and colitis (B 36)	—	5.6	—	2.0	—	5.2
Nephritis and nephrosis (B 38)	—	5.6	11.2	12.0	24.4	36.5
Accidents (BE 48)	61.1	27.9	55.8	46.1	61.0	71.7
All Causes	100.4	116.5	345.9	322.0	756.6	1023.8

Notes: 1) ( ) is an international abbreviated list number.
2) The amount of deposited atmospheric impurity in each area are:
mining & ind. area……105.0 tons/km²/month
other area…… 33.0 tons/km²/month (1950～1958)

2. A comparative study on the death-rate by selected causes was made. It was made concerning the age groups both in the mining and industrial area that always suffers from a heavy concentration of air pollution and in all the other areas of the city, and the result is shown in Table 2. In the mining and industrial area the high death-rate was found for the infant and the aged and the mortality from pneumonia, bronchitis and heart disease was twice, sometimes thrice, as high as the other areas. It may, however, be noteworthy, on the contrary, that among the children of the

mining and industrial area the low death-rate was observed. As there are such elements involved in the factors that control the distribution of mortality as the density of population, the susceptibility of inhabitants, the occupations, the economical conditions, the cultural levels and the medical facilities, etc., the phenomena mentioned so far could not wholly be attributed to the influence of atmospheric pollution.

3. In accordance with the following three items of A_0, A_1 and A_2, therefore, the author has analysed and investigated the correlation of the yearly and monthly trends of pneumonia and bronchitis mortality with the amount of deposited atmospheric impurity (soluble matter)/rainfall (the amount of deposited atmospheric impurity excluding the influence of rainfall), the result of which is seen in Figs. 1 and 2.

(A_0) Original monthly time series.

(A_1) Time series that eliminates 'trend' from original monthly time series.

(A_2) Time series that eliminates 'trend' and 'seasonal variation' from original monthly time series.

A significant correlation between pneumonia and bronchitis mortality and the soluble matter/rainfall is investigated in each time series of these three items mentioned above. Here, when the death-rate from pneumonia and bronchitis is examined a month later as compared with the corresponding amount of deposited atmospheric impurity of the current month, the degree of correlation will reach

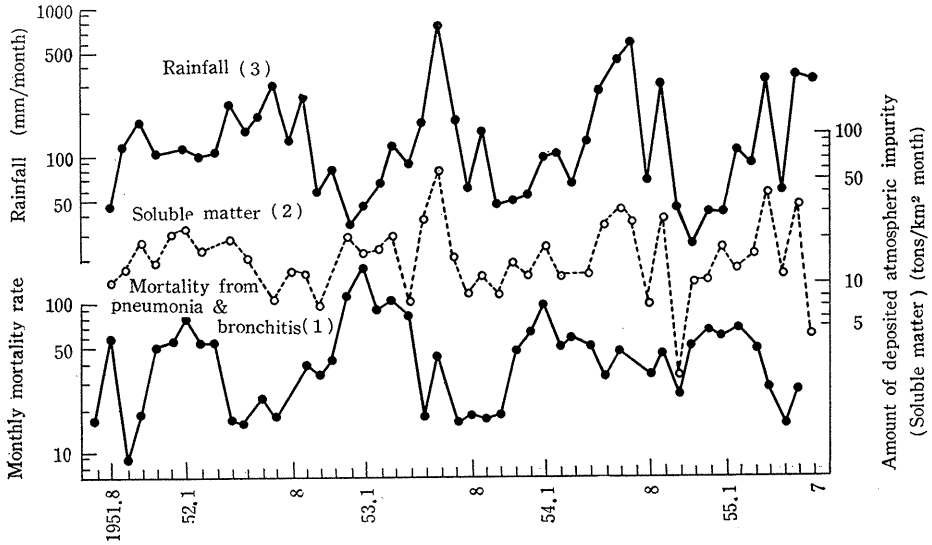

Fig. 1. Relationship between the variation of monthly mortality rate from pneumonia, bronchitis and amount of deposited atmospheric impurity with meteorological condition in Ube city.

Note: Monthly mortality rate $= \frac{\text{Deaths in one month}}{\text{Population in the year}} \times \frac{\text{days in the year}}{\text{days in the month}} \times 100{,}000$

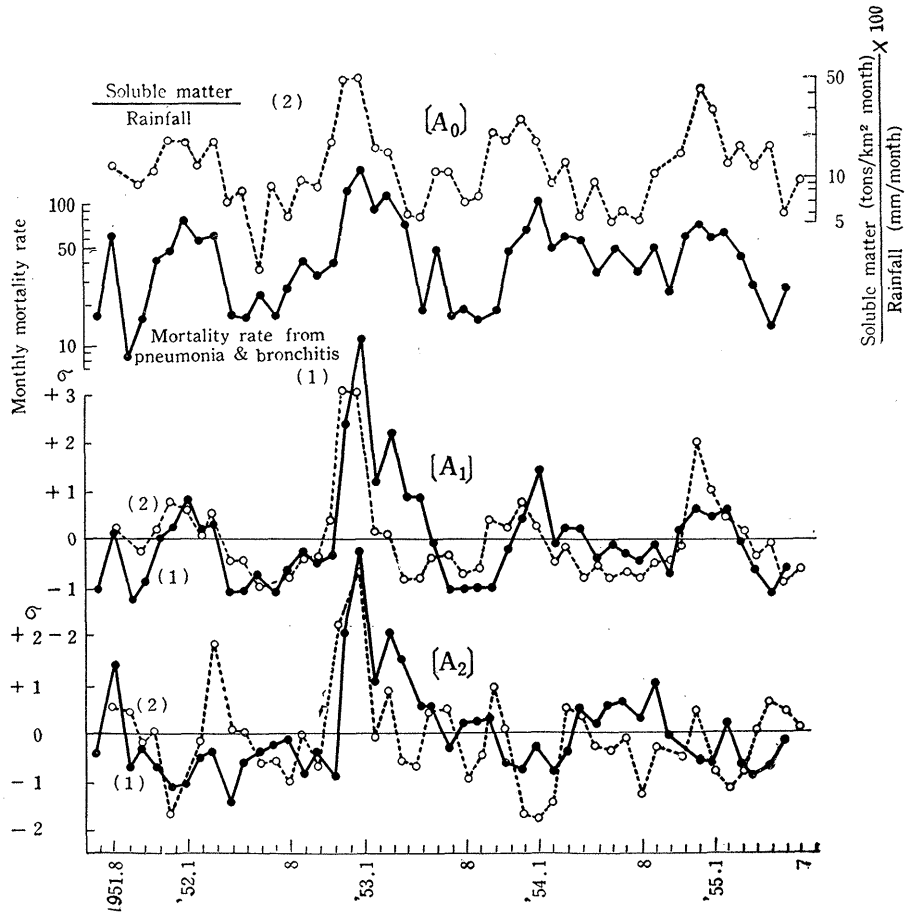

Fig. 2. Relationship between the variation of monthly mortality rate from pneumonia, bronchitis and amount of deposited atmospheric impurity, in Ube city, are analyzed to the following three time series:

[A_0] : Original monthly time series,

[A_1] : Time series that eliminates 'trend' from the original monthly time series,

[A_2] : Time series that eliminates 'trend' and 'seasonal variation' from the monthly time series.

Note: Fig. 2 is figured the mortality which is to occur a month later.

higher. The highest death-rate was observed in the month after January, 1953, when the amount of deposited atmospheric impurity reached a maximum.

Examination of these phenomena clarified the existence of close connection of atmospheric pollution with the death-rate. As to the tendency and the degree of correlation both in Ube city and in its control city, an investigation was made, and the correlation of the meteorological elements (air temperature, rainfall) with the death-rate in each case of three items of A_0, A_1 and A_2 showed disparity, which may

be understood as an influence of air pollution plus the meteorological elements.

4. The daily trend of total death toll of patients among the citizens of Ube city, moreover, is closely related with the amount of suspended atmospheric impurity. It is noticeable that a great many deaths usually take place on the day, sometimes a day or two later, when the amount of suspended atmospheric impurity increases. An observation of this phenomenon on the viewpoint of the relationship between the meteorological elements and the patient death toll elucidates that on the day, or a day or two later, when the velocity of wind is slow and the minimum air temperature in the city is higher than that in the suburbs, a rate of death toll highly increases (Fig. 3). On the day when the velocity of wind in this city is slow the

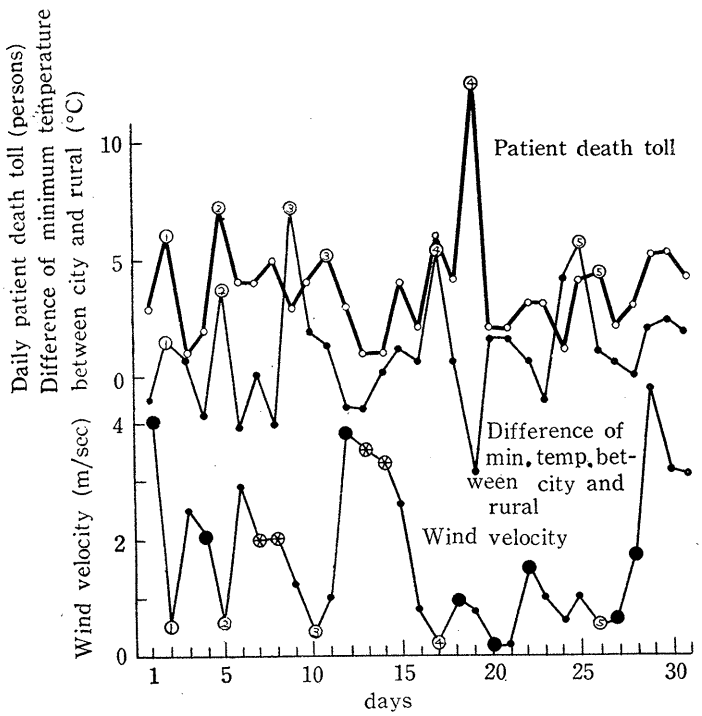

Fig. 3. Relationship of daily patient death toll with the meteorological elements in Ube city, January 1953.

Notes: 1) Circled numbers show the daily relation in the correlation between the death toll and the meteorological conditions.

2) ●: Rain, ⊛: Snow.

amount of suspended atmospheric impurity, especially SO_2, becomes dense. This fact may suggest that air pollution hastens the death of patients.

5. The conclusion is that the correlation between the death-rate by selected causes and atmospheric pollution as stated above does not always mean the causality

between these two subjects, but it is not too much to say that air pollution has influence directly or indirectly, on hastening death of the weak and the feeble citizens of lower vitality, e. g. infant, especially the aged, or patients suffering from pneumonia, bronchitis and heart disease.

II

ON THE RELATIONSHIP BETWEEN THE MORBIDITY FROM DIPHTHERIA AND DEPOSITED ATMOSPHERIC IMPURITIES IN UBE CITY

The following phenomena were observed in the statistic and the epidemiological investigations of the relation between the yearly and monthly variations of diphtheria morbidity including its geographical distribution and the amount of deposited atmospheric impurities plus the meteorological elements in Ube city for the past 10 years (1947～1956).

1. The relation between the yearly and monthly variations of diphtheria morbidity and rainfall in this city is in more significant negative correlation than the relation with air temperature in each of the following cases, i.e.

(A_1) Time series that eliminates 'trend' from original monthly time series,

(A_2) Time series that eliminates not only 'trend' but 'seasonal variation' from original monthly time series.

2. Between the yearly and monthly variations of diphtheria morbidity and the amount of deposited atmospheric impurities(insoluble matter/$\sqrt{\text{rainfall}}$, SO_3/rainfall), there is a significant positive correlation in each of the following three cases, i.e.

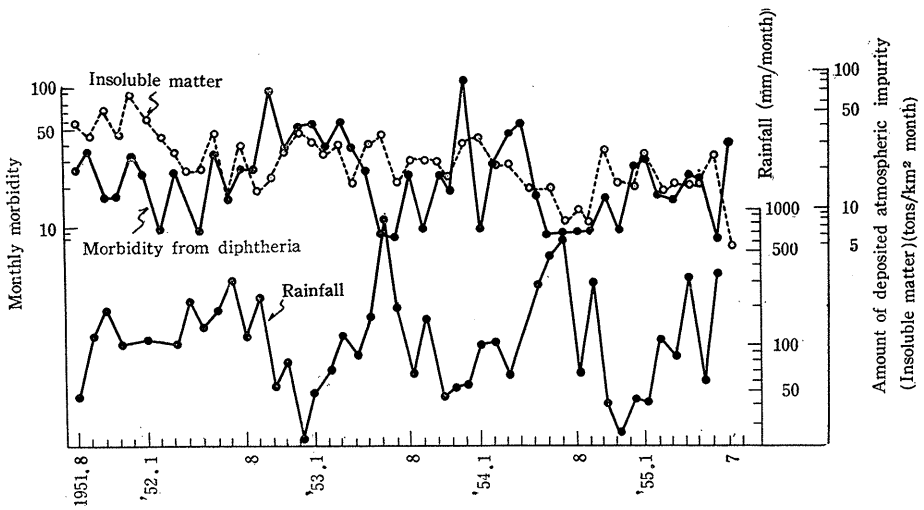

Fig. 4. Relationship between the variation of monthly morbidity from diphtheria and deposited atmospheric impurity with the meteorological condition in Ube city.

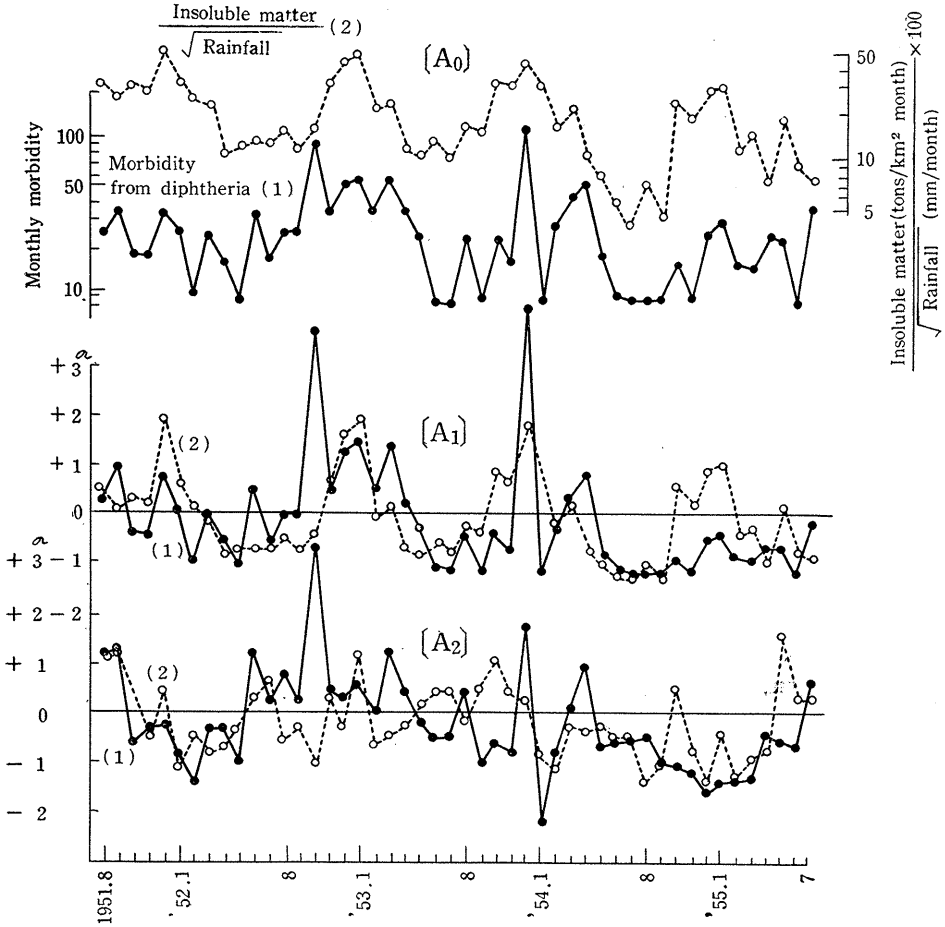

Fig. 5. Relationship between the variation of monthly morbidity from diphtheria and deposited atmospheric impurity in Ube city are analyzed in three items of 〔A_0〕, 〔A_1〕 and 〔A_2〕.
Note: 〔A_0〕, 〔A_1〕 and 〔A_2〕: See the note on Fig. 2.

(A_0) Original monthly time series,
(A_1) Time series that eliminates 'trend' from original monthly time series,
(A_2) Time series that eliminates not only 'trend' but 'seasonal variation' also from original monthly time series.

That the correlation with the amount of deposited atmospheric impurity/rainfall is greater than the correlation with rainfall itself is a characteristic in the case of time series that eliminates not only trend but seasonal variation also (Figs. 4 and 5).

3. The above-mentioned facts may prove that the yearly and monthly variations of morbidity from diphtheria in this city is in a closer relation with a synthesis of meteorological elements plus deposited atmospheric impurity than with such me-

teorological elements as temperature or rainfall etc.

4. The geographical distribution of morbidity from diphtheria in this city, moreover, is generally in accord with the distribution of deposited atmospheric impurity. The rate of diphtheria morbidity in the mining and industrial area was high a few years ago, but the rate has shown a tendency of rapid lowering in recent years. As the geographical distribution of morbidity is variously affected by such factors as the density of population, or the susceptibility of inhabitants, the distribution may not totally be regarded as the influence of air pollution. But when the above-mentioned facts are taken into consideration, it may be understood that there is an important connection between the distribution and the influence of air pollution.

5. The conclusion is that such an extraordinary high morbidity from diphtheria in this city may have its source in an unusually great amount of air impurities emitted into this city.

III

ON THE RELATIONSHIP BETWEEN THE TRACHOMA MORBIDITY AMONG THE PUPILS AND ATMOSPHERIC IMPURITY IN UBE CITY

The trachoma morbidity among all school children in Ube city (ca. 20, 000) gradually decreased year by year through the good effects of the mass treatment (medicines used: 10% homosulfaminum ointment and 0.5% terramycin ointment), during the last 8 years (1950～1957). In a study of the relationship between biolog-

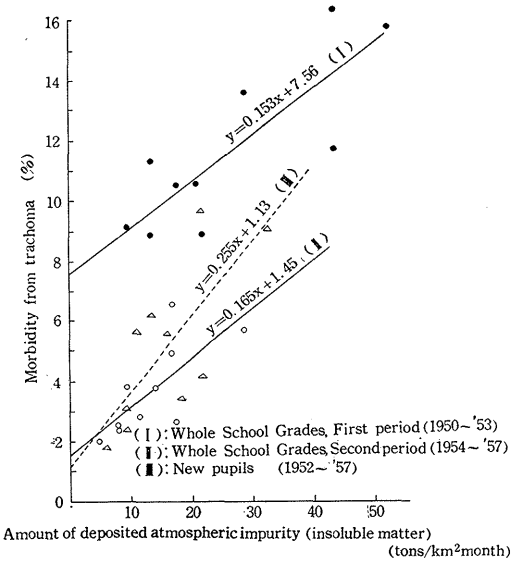

Fig. 6. Relationship between the localization of geographical distribution of morbidity from trachoma among primary school children and deposited atmospheric impurities in Ube city.

ical, historical and geographical elements in this epidemiological phenomenon and the amount of deposited atmospheric impurity, the author has elucidated the following results.

1. The trachoma morbidity of the city pupils, regardless of sex, is higher than the other cities. It is a characteristic of the phenomenon that the geographical distribution is especially distinct and the areas of high morbidity and low morbidity

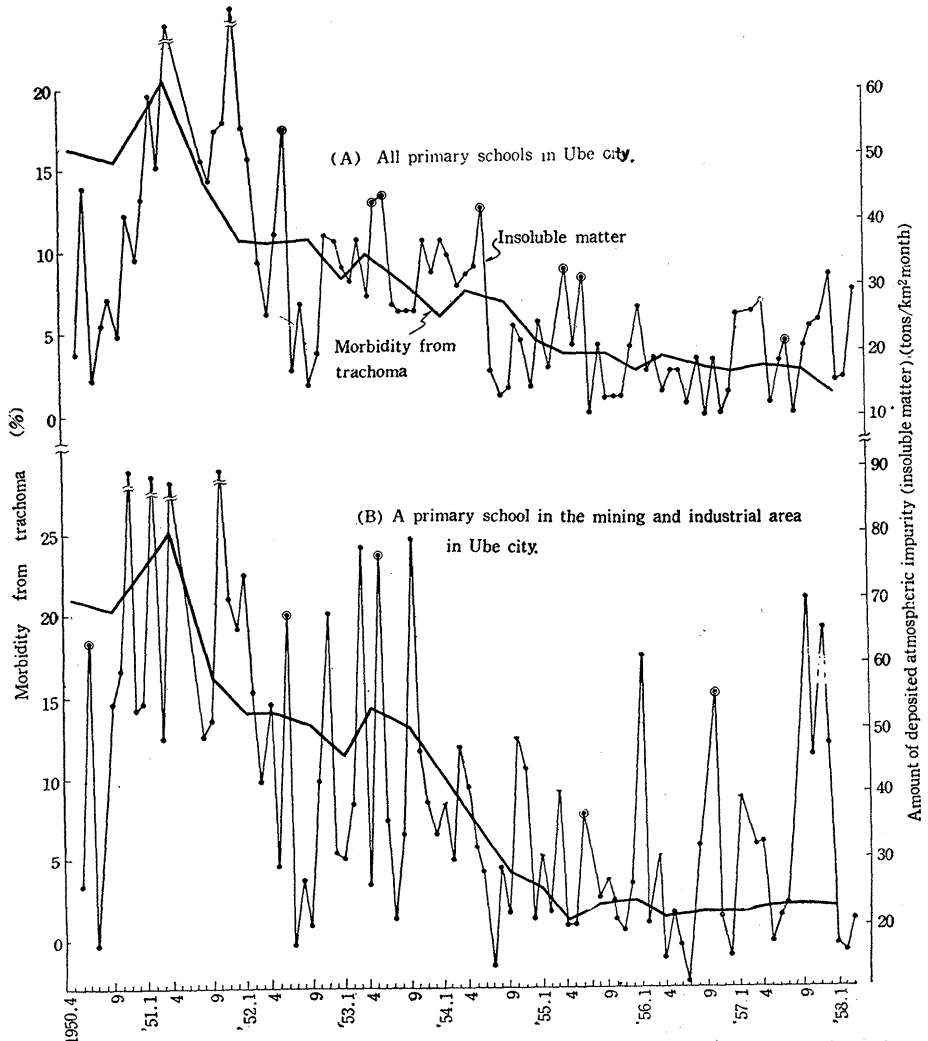

Fig. 7. Relationship between the yearly and monthly trend of primary school children's morbidity from trachoma and the amount of deposited atmospheric impurity in Ube city.

Note: ◉ Shows the month when deposited atmospheric impurity reached a large amount because there had been a large amount of monthly rainfall (over 300 mm).

are always localized and they are never changing.

2. The geographical distribution of trachoma morbidtiy among the pupils in the city is in positive correlation with the density of population. It is also a characteristic that in the area where atmospheric impurity reaches a large amount, the yearly rate of decrease is slow, while the recurrence rate of disease and the incidence rate of new patients are high.

3. The yearly trend of trachoma morbidity among the pupils in the city investigated by area groups shifts in direct proportion to the yearly trend of the amount of deposited atmospheric impurities in the area. This phenomenon is more remarkable in the yearly trend of trachoma morbidity among new pupils (six years old) who have not received any the mass treatment than the upper grade pupils already receiving the mass treatment (Fig. 6～7).

4. Notwithstanding the mass treatment available for the pupils in Ube city, the trachoma morbidity is remarkably high, and the recurrence of disease and the outbreak of new patients reach a considerable number. It is now concluded that as a cause of the phenomenon environmental uncleanliness accompanied by urban air pollution affects deeply.

IV

ON THE RELATIONSHIP BETWEEN THE RATE OF ABSENCE OF SICK PUPILS AND DEPOSITED ATMOSPHERIC IMPURITY IN UBE CITY

Through the statistic and the epidemiological study on the correlation of the geographical distribution and the yearly and monthly trends of morbidity with the amount of deposited atmospheric impurity plus the meteorological elements, the following facts were observed in all primary school pupils of Ube city during the last two years (1954～1955).

1. In direct proportion to the amount of deposited atmospheric impurity, the geographical distribution of morbidity of whole grade pupils in Ube city observed by industrial area groups, excepting the area of mining and industry by the sea where the amount of deposited atmospheric impurity is in the lowest rate, becomes gradually low in accordance with the following order of location: i.e. the business sections in the city center; the residential quarters on the environs of the city, and the rural districts of the suburbs. The distribution, however, is not always clear and distinct.

2. In any district, the rate of morbidity of the first grade pupils is the highest, while the rate becomes lower as the grade advances. In the business quarters, the morbidity of the first grade pupils is the highest and as the grade advances the rate of lowering is slow. The most striking fluctuation of lowering rate as the grade advances is seen in the mining and industrial districts where the morbidity of the first grade pupils is in the second highest.

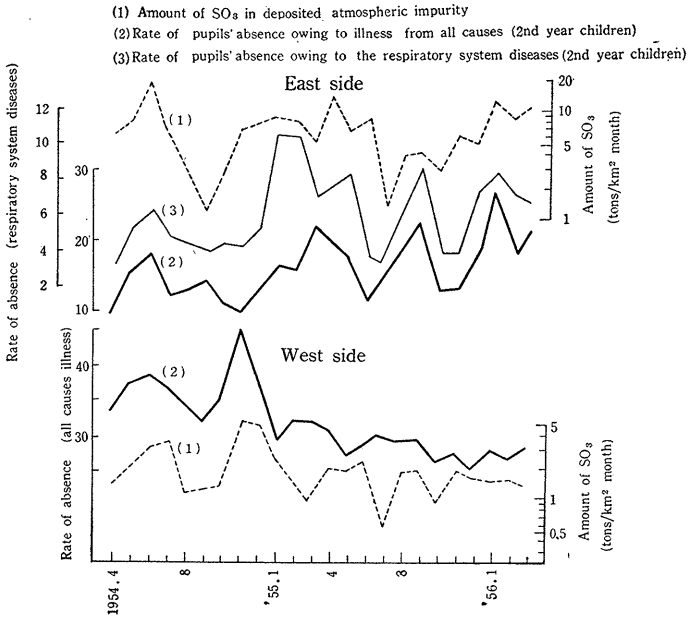

Fig. 8 Relationship between the rate of pupils' absence owing to illness in each primary school in the east-side and the west-side of smoke emitting locale and deposited atmospheric impurity in Ube city.

3. In the mining and industrial area, diseases of the respiratory system decrease and those of the digestive system relatively increase as the school-grade advances. The phenomenon contrary to this holds true in the rural districts of the suburbs.

4. The east-side of smoke emitting locale differs from the west-side in respect of the yearly and monthly variations of morbidity, which occurs in direct proportion to deposited atmospheric impurity, SO_3 especially, of each area. The east-side, moreover, opposes to the west-side so far as the direction of correlation between the morbidity and the meteorological elements (temperature and humidity) is concerned (Fig. 8).

This phenomenon tells that the direct influence of meteorological elements can not wholly control the variation of morbidity but the variation is considerably susceptible to the influences from the pollution of air. Such facts are strongly in evidence among the lower grade pupils; among the upper grade, however, they are not particularly remarkable.

5. Together with the fact in the mining and industrial area where air pollution is in higher concentrations death occurs frequently to the infant and the aged, whereas the death-rate of children is low. These facts as have been stated in the preceding four items (items 1～4) elucidate a close relation between the children's morbidity and air pollution. It may, hence, be possible to approve the phenomena of

'adaptation' and 'selection' to air pollution in the upper grade pupils, in contrast to the lower grade pupils who are under the influence of strong concentration of suspended air pollution.

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