

Relationship of Sulphur Content in Tree Leaves to SO₂ Concentration in Air

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Trees are perennial plants, and continuedly exert a great influence on the nearby environment. In the aspect of environment protection, trees assimilate and accumulate pollutants through the stomas in the leaves, and purify environment. Although its assimilation & accumulation amount and the concentration of the pollutants in air are not in rigid proportion, there is a certain correlation between them. As to the study of their correlation and the analysis of the pollutant contents in the leaves, as a way to understand air pollution, there are few reports at present in our country. This paper makes a preliminary examination of the relationship between S content in tree leaves and SO₂ concentration in air, in order to supply the basis for the development of biological supervision and assessment of the environmental quality.

MATERIALS AND METHODS

Tree species selection is very important for the study of the correlation between S content in tree leaves and air pollution. In order to prevent, under high SO₂ concentrations, the leaf assimilation from decreasing, we selected the following tree species, which contain high resistance to SO₂: Chinese juniper, Tree of heaven, Dryland willow and Chinese white poplar.

Samples were collected during the later period of tree growth in 1983.9 and 1984.9, and before leaves fall in mid-September when leaves with the accumulated pollutants were in their largest numbers. Three 3-4 m trees of each species were selected, which were respectively set from four directions in the middle part of the tree's canopy (The height must be the same). It is according to the trees of the same species in great numbers that S content in leaves was tested.

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The supervision value of SO₂ concentration in air of each collection region was supplied by the local environmental supervision station. Its determined test value is the average value of SO₂ concentration in air during the periods of plant growth (May-September).

The test of S content in tree leaves was done by inflammation, using BaCl₂ to titrate S content in its absorbents. Each sample test was repeated at least three times to estimate the average value of S content in leaves.

RESULTS AND DISCUSSION

1. Analysis of the correlation between S content in tree leaves and SO₂ concentration in air
The relationship of analytical results of S content in tree leaves and SO₂ concentration in air is shown in Table 1 and Figure 1.

Table 1. S content in tree leaves

Samples	SO ₂	S content in tree leaves(m.g ⁻³)				
	concentration in air(μg.m ⁻³)	Chinese juniper	Tree of heaven	Dryland willow	Chinese white poplar	
1983.9	1	6.8		1.96	3.36	2.07
	2	7.8	1.78	1.94	4.85	2.39
	3	9.0	1.66	1.95	4.83	2.92
	4	9.3	1.77	1.99	5.58	
	5	14.0		2.32	8.27	2.41
	6	15.0	2.63	3.10	6.76	3.15
	7	15.8	2.64	3.40	7.44	3.34
1984.9	1	6.2	2.06	1.91	3.61	
	2	6.2	2.01	2.09	4.37	
	3	7.6	2.23	2.73	4.72	2.00
	4	8.4		2.25	6.64	2.65
	5	9.0	2.38	2.31	6.70	2.62
	6	9.8	2.44	2.67	6.99	3.09
	7	10.4	2.41	2.80	6.79	3.68
	8	10.8	2.37	2.73	5.77	3.33
	9	14.0	3.01	3.21	6.79	3.44
	10	14.6	3.44	3.65	7.45	3.85

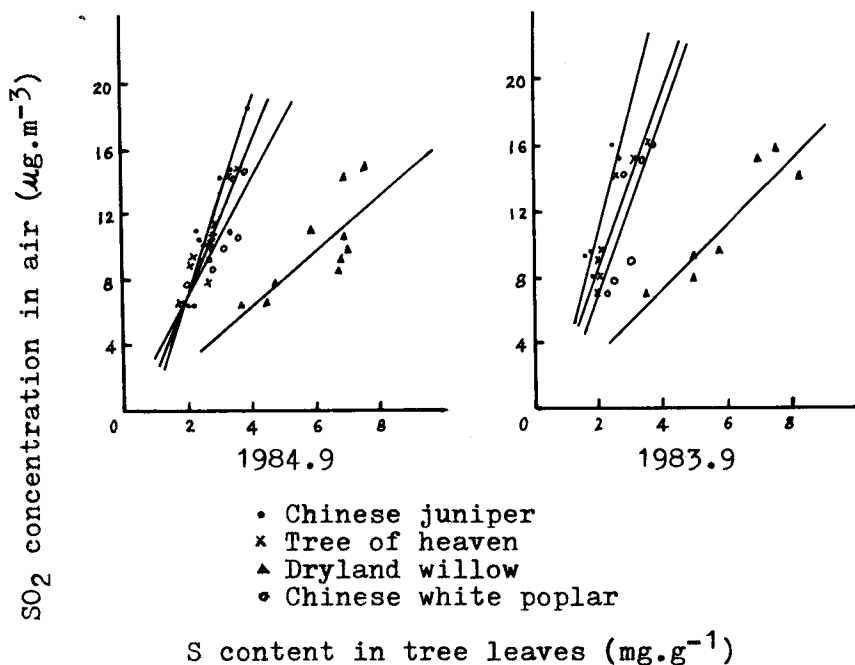


Figure 1. Relationship between S content in tree leaves and SO_2 concentration in air

According to the analysis of the experimental data of Table 1 and Figure 1, SO_2 concentration (y) in air and S content (x) in tree leaves are in direct proportion, which can be considered as the function of x, that is, $y=f(x)+\varepsilon$, ε is certain-existing chance error interference, which is taken into consideration. x is an amount which can be controlled and tested by the precise of the tree leaves. Mathematical statistics demonstrates that there is a correlation of monolinear regression between y and x, so as to get an equation of monolinear regression as shown in Table 2.

If we use reliability $\alpha=0.05$ to test correlation coefficients and F test, the other tree species correlation was remarkable in the above tested tree species except that Chinese white poplar correlation was not remarkable in 1983.9. The test of F test also shows that there is a linear relationship between S content in the leaves of the above tree species and SO_2 concentration in air, that is to say, the height of linear regression is remarkable.

Table 2. Correlation analysis of tree species

Tree species	Sampling time	Sample number	Regression equation	Correlation coefficient	F test
Chinese juniper	1983.9	5	$\hat{y} = -4.92 + 7.91x$	0.955*	36.0**
	1984.9	9	$\hat{y} = -5.60 + 6.22x$	0.944**	57.0**
Tree of heaven	1983.9	7	$\hat{y} = -1.79 + 5.42x$	0.879**	21.0**
	1984.9	10	$\hat{y} = -3.71 + 5.09x$	0.925**	48**
Dryland willow	1983.9	7	$\hat{y} = -0.52 + 1.98x$	0.911**	24**
	1984.9	10	$\hat{y} = -0.61 + 1.72x$	0.776**	12**
Chinese white poplar	1983.9	6	$\hat{y} = -4.33 + 5.80x$	0.725	4.5
	1984.9	8	$\hat{y} = 0.61 + 3.38x$	0.832*	14.0**

** reliability $\alpha=0.01$ remarkable

* reliability $\alpha=0.05$ remarkable

2. Reliability analysis using S content in tree leaves to estimate SO_2 concentration in air

From the above analysis of correlation, we know that the correlation of S content in leaves of Tree of heaven is more remarkable than that of other tree species. Tree of heaven is an ideal tree species to monitor and indicate the air quality using S content in leaves of woody plants. The linear regression equation of Tree of heaven is used to estimate SO_2 concentration in air in one region and analyze its reliability. The results are shown in Table 3 and Figure 2.

In Table 3 and Figure 2 we find that by using the linear regression equation of Tree of heaven to estimate the SO_2 concentration of pollution in air; the greatest correlation error (i.e. $\hat{y}-y$ value) of its correlation estimation value and the determined test value of SO_2 concentration in air is not over $|1.37| \mu g/m^3$, except some points, and regression line of both is nearer to each other. Therefore, if we use the linear regression equation, which is established by use of S content in leaves of Tree of heaven, to estimate SO_2 concentration in air, its test value of the estimated area can be defined in the reliability area 99% or 95% and is tried in this reliability area.

Table 3. Estimation of SO₂ concentration range in air using regression equation on Tree of heaven

Samples	1983.9 determined SO ₂ value	$\hat{y} = -1.79 + 5.42x$		
		x	\hat{y}	Estimated value range
1	6.8	1.96	8.83	3.75-13.91
2	7.8	1.94	8.72	3.62-13.82
3	9.0	1.95	8.78	3.69-13.87
4	9.3	1.99	9.00	3.94-14.06
5	14.0	2.32	10.78	5.86-15.70
6	15.0	3.10	13.68	8.29-19.07
7	15.8	3.40	16.64	10.82-22.46

	1984.9 determined SO ₂ value	$\hat{y} = -3.71 + 5.09x$		
		x	\hat{y}	Estimated value range
1	6.2	1.91	6.01	2.94- 9.08
2	6.2	2.09	6.93	3.97- 9.89
3	7.6	2.73	10.18	7.37-12.99
4	8.4	2.25	7.74	4.86-10.62
5	9.0	2.31	8.05	5.19-10.91
6	9.8	2.67	9.88	7.07-12.69
7	10.4	2.80	10.54	7.72-13.36
8	11.4	2.73	10.18	7.37-12.99
9	14.0	3.21	12.63	9.66-15.60
10	14.6	3.65	14.87	11.58-18.16

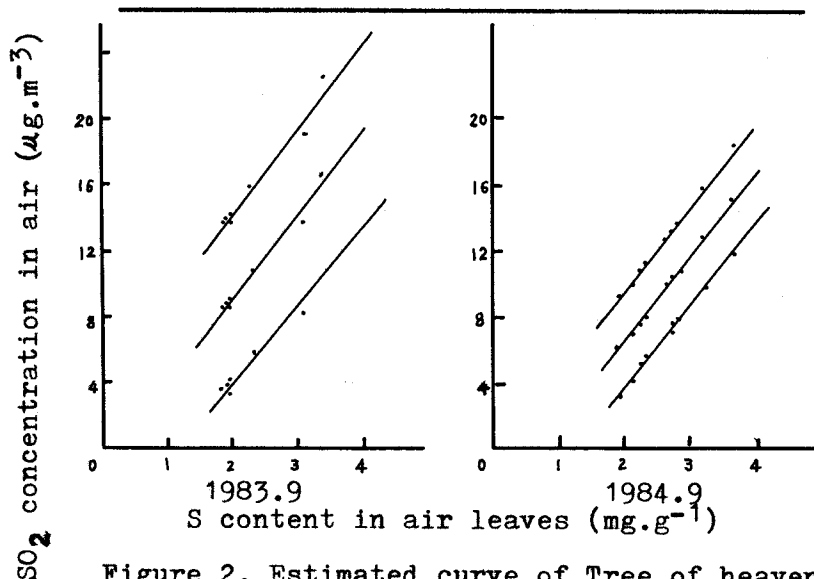


Figure 2. Estimated curve of Tree of heaven

There is a clearer correlation between S content in woody plant leaves and SO_2 concentration in air, and what is more, the correlation of Tree of heaven is the most remarkable. Tree of heaven can be considered as biological supervision tree species in "Yanized" region in Beijing.

When it is easy to test x value, using the linear regression equation of Tree of heaven to estimate SO_2 concentration in air, its estimated value can be defined in the reliability area 99% or 95%, the estimate value is tried in the reliability area.

When the content of pollutants in tree leaves is used to estimate air quality, the pollutant-resistant tree species should pay attention to the great identity of height of sample collection. Because of the change of environmental factors, it is good to establish the linear regression equation of this year, and connect the chemical supervision with the biological supervision, so as to raise the supervision level of regional environmental quality.

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