

OBSERVATIONS ON THE EFFECT OF SULPHUR DIOXIDE ON NATIVE AND INTRODUCED VEGETATION

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An opportunity to observe the harmful effects of sulphur dioxide on native and introduced vegetation was presented during August, 1926. The writer spent a part of this month in the vicinity of Rhinelander, Oneida County, Wisconsin, where a large paper mill was the source of the escaping sulphur dioxide. Although the region has been visited many times during previous years no damage of significance had been noted previously. An unusual combination of weather condition seems to have been responsible for the damage hereinafter described.

The presence of sulphur dioxide as a by-product of this paper mill is always evident if one is on the leeward side of the mill in the path of the smoke. If the atmosphere is clear, the gas is likely to be much less concentrated than when the atmosphere is heavy and the smoke and gas is held close to the ground.

Often the amount of sulphur dioxide in the air as far as two miles from the plant is sufficient to make it very disagreeable. No effort was made to determine the amount of sulphur dioxide present since equipment was not available to do so. The effects, however, of its presence in the air were everywhere apparent upon the vegetation in the path over which it was carried by the wind. The leaves of many plants exhibited the usual characteristic spotting and in numerous instances had been killed completely. Those leaves which were not already dead showed large areas either yellowed or browned. In some cases the edge of the leaf had been completely killed and had rolled up in characteristic fashion.

An interesting feature of the situation is that it was correlated directly with high precipitation. During previous years when the region has been visited at the corresponding time no damage of any consequence had ever been evident. During these visits the weather had been dry and thus very different from the unusual conditions of moisture which existed in 1926.

It is generally recognized that the damage done by sulphur dioxide is the result of its entry directly into the leaf through stomata or of the direct injury of epidermal cells. Injury is also known to be more severe during moist wet weather (1). This was the situation encountered and was apparently the cause of the damage noted. During August the rainfall was recorded as 7.91 inches all of which fell previous to August 22. The heaviest rainfall was 4.06 inches on August 21.

The heavy rainfall and high humidity during the week previous to August 22, together with the fact that the wind blew continuously from one direction, south to southwest, much of the time, resulted in subjecting the same vegetation to the fumes for several days. The records of precipitation, temperature and wind direction for August, as furnished by the U. S. Weather Bureau, are as follows:

August	Inches of Rain	Temperature		Dir. of Wind
		Max.	Min.	
1	.21	84	54	Southeast
2		85	56	Southwest
3		82	61	Northeast
4	.94	61	65	Southeast
5	1.27	67	54	Southwest
6		69	59	Northwest
7	.02	70	52	Southwest
8		72	46	Southeast
9	.13	71	49	Southwest
10		75	56	West
11		73	55	Southeast
12		68	57	Southwest
13		75	53	Southeast
14		78	54	Southwest
15		79	54	Southwest
16	.10	75	52	Southeast
17		69	46	Northeast
18		63	46	Northeast
19	.35	64	49	Southeast
20	.83	61	58	Southeast

21	4.06	78	57	Southeast
22		81	52	Southwest
23		75	53	Southwest
24		73	48	Southwest
25		76	55	Southwest
26		82	45	Southeast
27		84	49	Southeast
28		87	62	Northwest
29		86	44	Southeast
30		76	45	Southeast
31		76	52	Southeast

In the table below a number of the outstanding plants with regard to degree of susceptibility to the noxious fumes of sulphur dioxide are given. Those recorded as very resistant showed no injury or only such slight amount as to be doubtful; the very susceptible were entirely without leaves or with all leaves damaged and in some cases the plants dead.

Very Resistant	Very Susceptible
Acer negundo	Alnus incana
Acer saccharinum	Betula lutea
Amaranthus retroflexus	Cosmos bipinnatus
Beta vulgaris	Dahlia spp.
Brassica celeracea var. capitata	Nasturtium spp.
Echinochloa crusgalli	Pinus Strobus
Syringa vulgaris	Populus tremuloides
Solidago recemosa	Pyrus malus
Paeonia Brownii	Ribes vulgare
Zea Mays	Rosa spp.
	Taraxacum officinale
	Vitus labrusca

The silver maple is extremely resistant to amounts of sulphur dioxide which are fatal to many other plants. In one instance where a birch and a silver maple stood beside each other the contrast was very striking; all the leaves of the birch had been killed while not a trace of damage could be found on any of the leaves of the maple. Roses, apples, cosmos, and quaking aspens were extremely sensitive to the amounts of gas being discharged.

Below is listed a number of plants with an indication of the degree of susceptibility in each case. Very susceptible plants showed more than half of the leaves damaged, and in many cases, were leafless or dead. Generally the stem was yet green indicating that the trouble was of recent occurrence. Medium plants showed only a moderate amount of damage with less than half of the leaves injured. Those recorded as resistant showed very slight or no damage at all from the gas.

	Very susceptible	Medium	Resistant
Achillea Millefolium		X	
Agropyron repens	X		
Agrostemma Githago	X		
Allium cepa	X		
Arctium Lappa	X		
Artemisia spp.			X
Asplenium Felix-femina	X		
Avena sativa	X		
Betula alba var. papyrifera	X		
Bidens vulgata		X	
Bromus inermis		X	
Chenopodium album	X		
Cicuta maculata	X		
Crataegus spp.	X		
Daucus carota			X
Echinocystis lobata	X		
Eupatorium purpureum		X	
Gladiolus spp.	X		
Hydrangea spp.		X	
Lactuca scariola	X		
Lactuca sativa	X		
Lappula virginiana	X		
Lycopersicum esculentum		X	
Papaver spp.		X	
Pentstemon spp.			X
Phaseolus vulgaris		X	
Phleum pratense	X		

	Very susceptible	Medium	Resistant
Poa pratensis		X	
Phlox Drummondii		X	
Pisum sativum	X		
Pteris aquilina	X		
Radicula armoracia	X		
Rheum rhaponticum		X	
Rubus spp.		X	
Rumex crispus			X
Salix amygdaloides	X		
Salix longifolia			X
Solanum tuberosum		X	
Sophia incisa	X		
Trifolium repens			X
Trifolium pratense	X		
Tropaeolum spp.	X		
Typha latifolia	X		
Ulmus americana		X	
Verbascum Thapsus	X		
Xanthium commune			X

The area covered by such escaping gases extended in an ever widening wedge-shaped fashion away from the paper mill. The effects of the gas were discernable at points from five to six miles distant. The damage at such distant points was far less than at points nearer to the source of the sulphur dioxide. Within a mile of the offending paper mill, vegetation susceptible to the fumes took on the aspect of having been badly scorched by fire. Many trees as well as herbaceous plants had dropped much of their foliage. Those leaves that remained were in many cases brown and dead.

The path of the fumes was such that it traversed many large gardens as well as tracts of natural vegetation. This permitted a study of the effect of the fumes on economic as well as native vegetation. A list of all plants identified in the area was made, together with the degree of injury suffered. Most of the records were made within a mile of the paper mill where injury was maximum. There, errors of judgment in interpreting the cause of damage was less likely to occur.

DISCUSSION

Sulphur dioxide in the quantities discharged from factories is injurious to vegetation. That plants vary in their response to different amounts of sulphur dioxide in the air there can be no question. Many plants suffer complete defoliation under such weather conditions as prevailed in the area studied and with such amounts of sulphur dioxide present in the air as prevailed at Rhinelander, Wisconsin when the studies were made. Other plants suffered little under the same conditions and still others gave no response whatever. It must not be assumed, however, that even those plants which showed no damage from the effects of the sulphur dioxide present would not be damaged by greater amounts. The term resistant as here used is only a relative term and does not mean that the plants so designated would withstand greater amounts of sulphur dioxide gas were it present.

Summary

1. Sulphur dioxide is more effective in causing damage to susceptible vegetation during periods of moisture and high humidity.
2. Many plants are tolerant of quantities of sulphur dioxide which are injurious to other plants.
3. Continuous subjection of a plant over several days to fumes of sulphur dioxide is effective in its destruction.

Literature Cited

1. Selby Smelter Commission Report. U. S. Bureau of Mines Bulletin 96, pp. 383. 1915.