Fluorine Levels in Crops of The Dalles Area in 1962 and 1963

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Fluorine Levels in Crops of The Dalles Area in 1962 and 1963

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Summary

The fluorine contents of seven crops grown in The Dalles fruit area in 1962 and of three crops in 1963 are reported. These results are compared to similar data obtained from time to time since 1953.

Leaf samples collected in The Dalles area July 16-20, 1962, ranged from 4 to 362 ppm fluorine and averaged 31 ppm, while those taken October 10-15 ranged from 17 to 474 ppm and averaged 92 ppm. Similar samples from Corvallis had less than 15 ppm. Alfalfa forages from The Dalles area averaged 31 ppm in July and 81 ppm in October with maximums of 84 and 166 ppm, respectively.

Leaf scorch on apricot trees was observed in 1962 in many of The Dalles orchards, being more severe on the weaker trees.

In 1963 the June 16-18 sweet cherry leaf samples ranged from 4 to 34 ppm, averaging 13 ppm fluorine, while those collected September 19-20 contained from 9 to 72 ppm, averaging 22 ppm. Similar samples taken in July and October, 1962, contained an average of 32 and 95 ppm, respectively. The data for peach trees were similar to those for cherry trees.

Fluorine in the air was determined on a few samples in 1963. The amounts found varied from none to 12.9 μg F/M^3, (micrograms fluorine per cubic meter of air) varying with location and season.

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Introduction

Previous reports (1,4) in this series presented data on the concentration of fluorine in foliage of seven crops grown in The Dalles area before and after operation of an aluminum reduction factory in the vicinity. The concentrations of fluorine and the amount of "ponderosa pine blight" in needles of pine trees growing in the same area were reported in 1961 (3). Samples of forage or foliage of alfalfa, apricot, sweet and sour cherry, grape, peach, and prune plantings were again collected in 1962 for determination of their fluorine contents. Only alfalfa herbage, cherry and peach foliage were sampled in 1963. A limited number of air samples were collected in 1963. The results of analyses of these samples for fluorine content and the observations made are presented in this report.

Methods

Methods of sample collection and preparation and the method of analysis for fluorine contents used in 1962 and 1963 were similar to those reported previously (1). The orchards and portions of fields sampled in past years were sampled again in 1962 and 1963 with only slight modifications. The locations of the sampling sites are shown on the map in Figure 1.

Foliage and forage samples were collected July 16-20 and October 10-15, 1962. In 1963 samples of only sweet cherry and peach foliage were collected throughout the area. Alfalfa forage samples were collected from April 12 to June 20 at five locations only, and the cherry and peach leaves were collected July 16-18 and September 19-20, 1963.

Between March 28 and July 8, 1963, air samples were collected daily at

the Hendrix (No. 12), Elton (No. 43), and Gilbert (No. 51) orchards Impinger-type fluoride absorbers (5) and long-cycle automatic impingers (8) were used, the absorbing solution being 0.01 N sodium hydroxide.

Plant samples similar to those from The Dalles area were collected near Corvallis in 1962.

Results and Discussion

1962 Data

Fluorine content of forage and foliage samples

Data on fluorine contents of alfalfa herbage and leaf samples of trees and vines from the 57 sampling stations are presented in Table 1. In Table 2 the averages for the crops are shown. All samples from The Dalles area averaged 31.2 ppm fluorine in mid-July and 91.9 ppm in mid-October. The Corvallis control samples contained less than 10 ppm fluorine in July and 15 ppm in October. The Dalles samples ranged from 4.2 to 362 ppm in July and from 16.5 to 474 ppm in October. The October average was almost three times that of mid-July.

In contrast to the results for 1961 (4) there was a marked seasonal increase in fluorine concentration from July to October in 1962, the concentration in many samples increasing more than four times. At the Daniels orchard (Station 7) 2¼ miles west of the factory, fluorine in prune foliage increased over six times, from 25.8 ppm on July 16 to 162.0 ppm on October 10. Fluorine content of cherry leaves at the nearby Hertel orchard (Station 8) increased only 3.8 times during this period. These increases, often marked, occurred in all sectors of The Dalles area. Other examples are given in Text Table 1.

Text Table 1. The increase in the fluorine content of foliage from certain fruit crops sampled in July and October 1962, The Dalles area

Station No.	Farm	Distance and direction from aluminum factory	Crop	Fluorine content, dry weight basis		Ratio of fluorine content, Oct. 10/July 16
		miles		July 16 ppm	Oct. 10 ppm	
7	Daniels	2¼ W	Prune	25.8	162.	6.3
8	Hertel	2½ W	Cherry	30.4	116.	3.8
10	The Dalles Expt. Farm	2 S	Apricot	44.0	115.	2.6
			Cherry	84.0	223.	2.7
			Sour cherry	23.9	108.	4.5
			Peach	23.8	80.2	3.4
11	Fleck, J.	1 3/4 S	Cherry	59.0	230.	3.9
			Peach	23.7	168.	7.1
13	Hendrix	2 S	Cherry	19.4	180.	9.3
20	Williams	2½ S	Cherry	18.2	96.8	5.3
24	Curtiss Bros.	3½ S	Peach	14.8	68.9	4.7
27	Ranslam, Ed	4 SW	Cherry	16.3	55.5	3.4
33	High Rolls Ranch	3 S	Cherry	16.2	71.6	4.4
37	Roberts	3¼ SE	Sour cherry	24.2	125.	5.2
38	Cooper, Geo.	3½ S	Cherry	8.7	64.7	7.4
42	Sander Bros.	5¼ S	Cherry	8.6	52.6	6.1
48	Kaufman	4½ SE	Cherry	11.2	70.2	6.3
50	Geiger	4 SE	Apricot	29.6	119.	4.0
			Cherry	64.4	176.	2.7
53	Thompson	5½ SE	Apricot	10.1	96.7	9.6
			Cherry	34.5	101.	2.9

Alfalfa forages were collected from 11 farms in July and 10 in October. The fluorine contents of these samples (Table 3) averaged 31.2 ppm fluorine in July and 80.9 ppm in October. Maximum concentrations were 83.6 ppm in July and 166 ppm in October. Some of these forages contained considerably more fluorine than the safe levels of 30-50 ppm in the ration for the lactating dairy cow as reported by the National Research Council (6).

The fluorine contents of foliage samples collected at different distances and directions from the aluminum factory in 1962 are presented in Table 5 and graphically in Figures 2, 3, and 4. The pattern of distribution of fluorine was similar to that of the previous year except that the increase from July to October was considerably greater in 1962. The data in October for all crops in the SW - S sector, especially, show a progressive decrease with distance from the factory, 145 ppm at 1-2 miles to 28 ppm at 5-6 miles (Figure 2). A similar decrease was found in the data for the S - SE sector. These distribution patterns were primarily a reflection of concentrations found in leaves of sweet cherry trees, the most abundant crop. The data presented in Figure 3 support this view.

The effects of distance and direction from the aluminum reduction factory and year of sampling on the fluorine contents of leaf samples from six Royal Ann sweet cherry orchards are clearly evident from the data tabulated in Text Table 2. The fluorine concentrations in samples from the Kroon (Station 5), Malcom (Station 16), and John Martin (Station 30) orchards at 1¼, 2, and 6 miles to the SW, respectively, decreased abruptly in July 1962 from 1¼ miles to 2 miles, but less markedly from 2

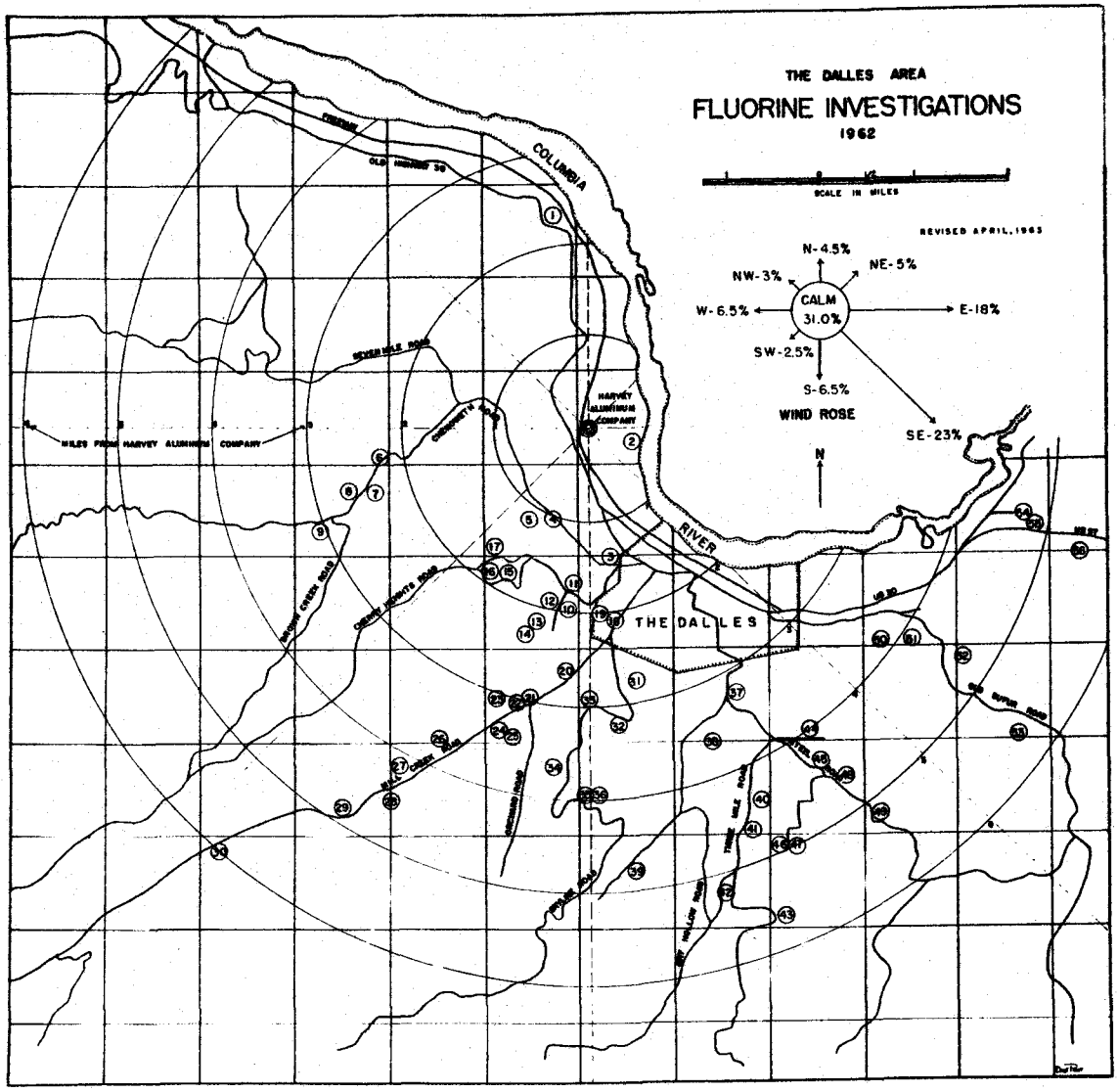

Figure 1. Map of sampling locations.

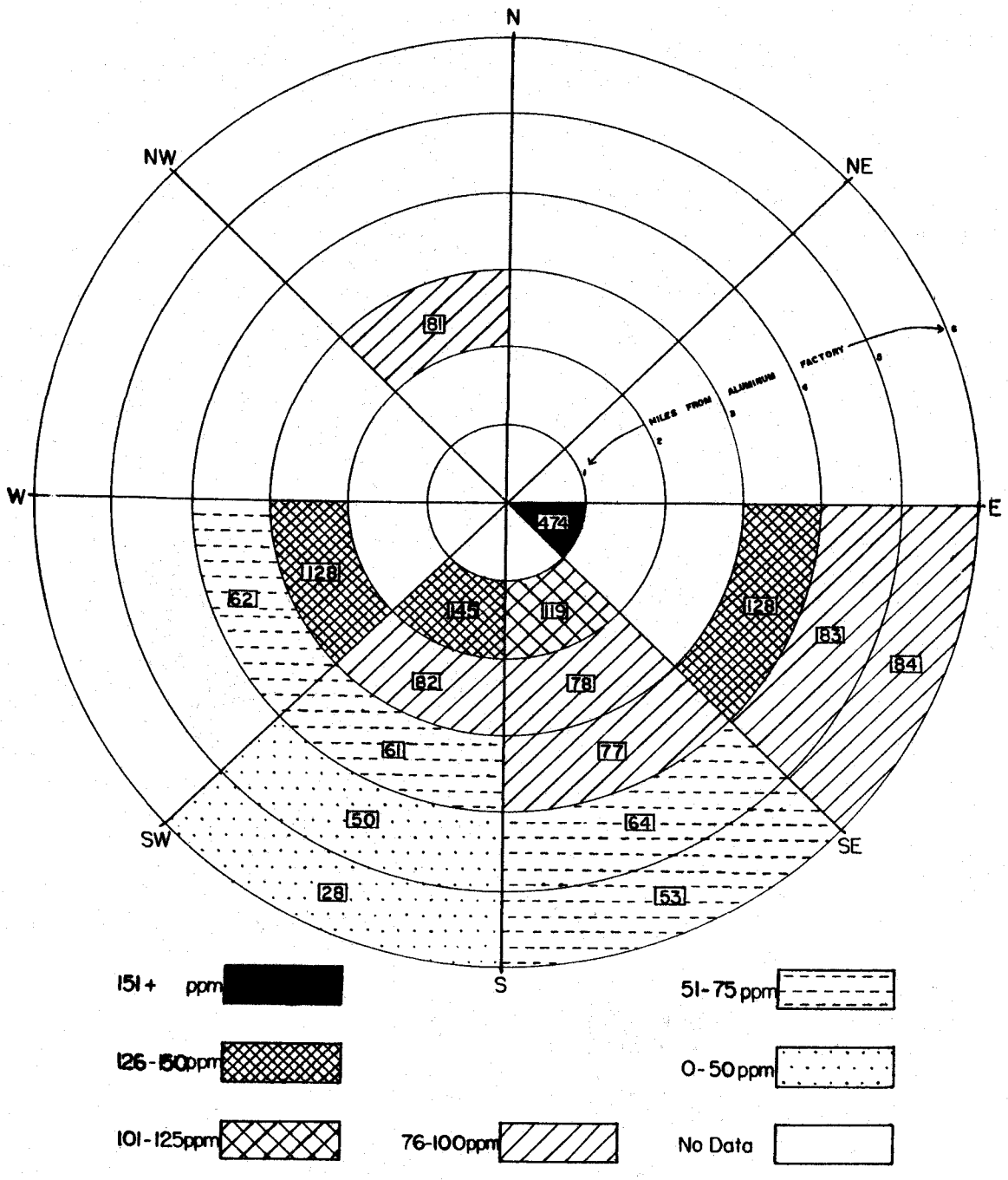

Figure 2. Average concentration of fluorine in parts per million in foliage of seven crops of The Dalles area, October 10-15, 1962.

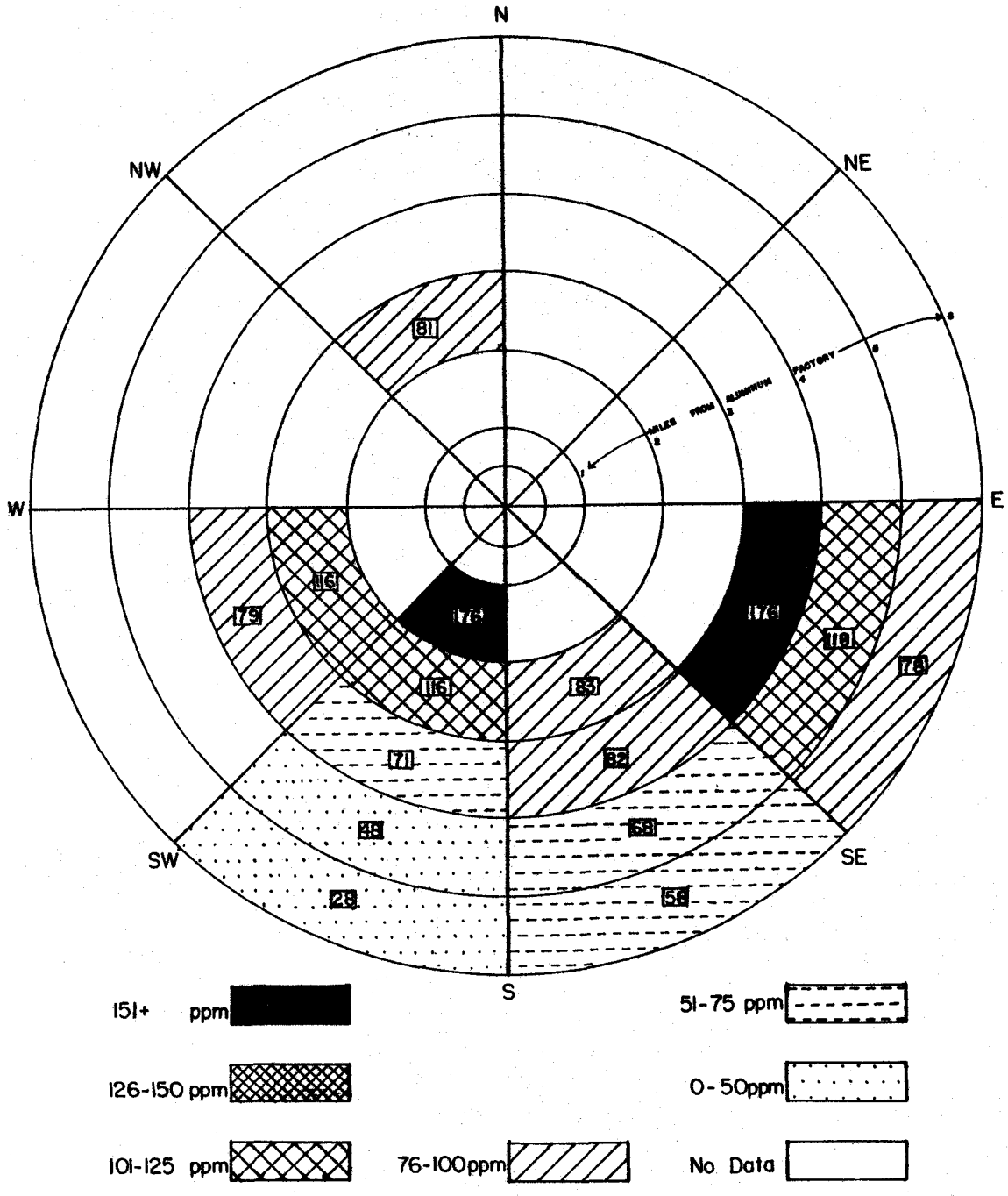

Figure 3. Average concentration of fluorine in parts per million in foliage of sweet cherry trees, The Dalles area, October 10-15, 1962.

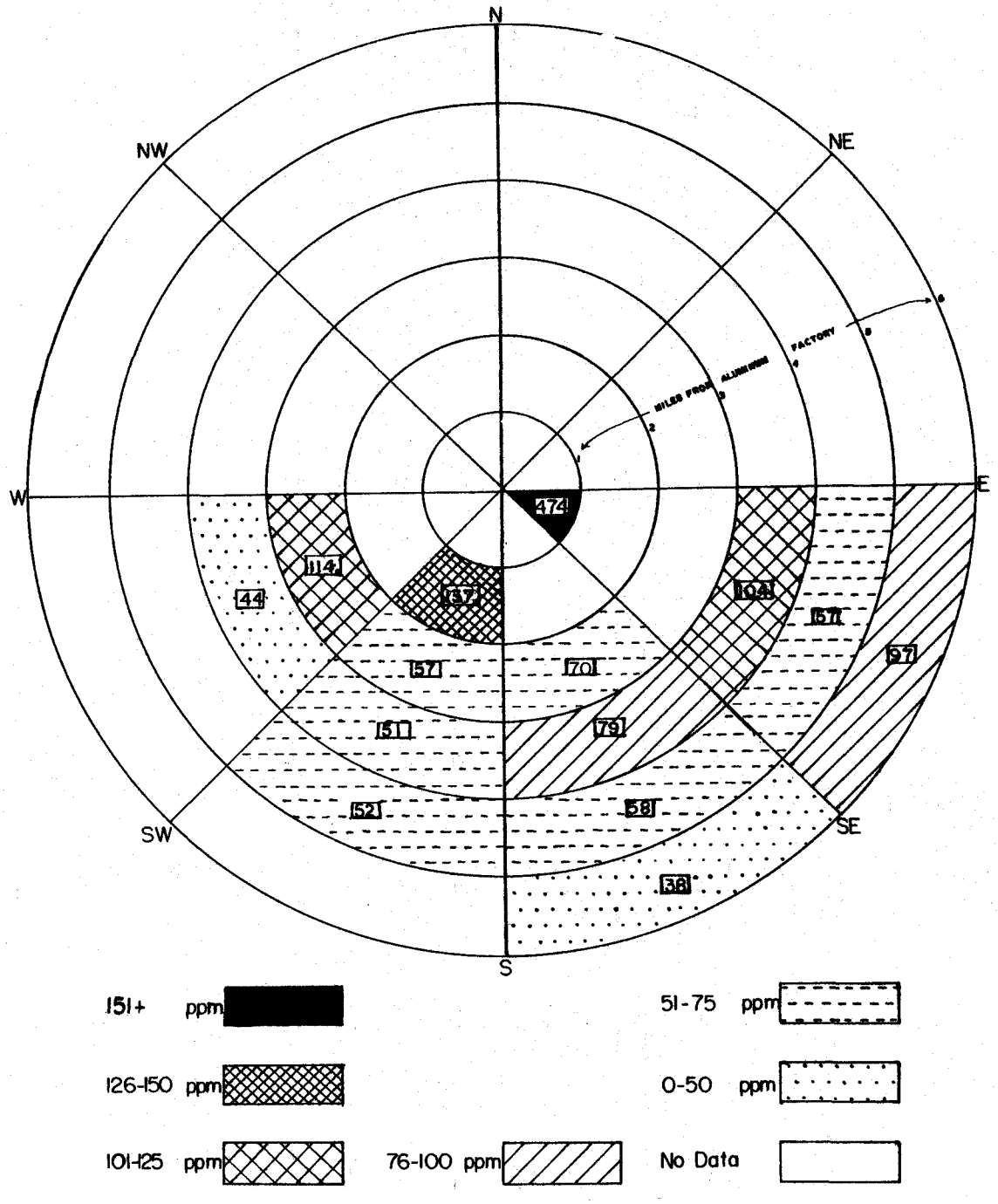

Figure 4. Average concentration of fluorine in parts per million in foliage of apricot, peach, prune, and sour cherry trees, The Dalles area, October 10-15, 1962.

Text Table 2. Fluorine content of leaves from certain sweet cherry orchards in The Dalles area from 1960 - 1963

Station No.	Distance and direction from factory		Fluorine content, dry weight basis							
			July 8 1960	July 12 1961	July 16 1962	July 16 1963	Sept. 20 1960	Sept. 7 1961	Oct. 10 1962	Sept. 19 1963
	miles		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
5	1¼	SW	248	202	111	34	326	141	232	52
16	2	SW	99	93	46	19	173	93	224	36
30	6	SW	30	33	12	6	98	30	28	14
50	3 3/4	ESE	143	84	64	30	265	111	176	41
52	4½	ESE	151	98	44	15	256	105	118	29
53	5½	ESE	131	75	10	18	256	90	97	23

miles to 6 miles. A different condition prevailed that fall. Cherry leaves from the Kroon and Malcom orchards contained 232 and 224 ppm fluorine, respectively, while similar leaves from the John Martin orchard, six miles to the SW, contained only 28 ppm. The fluorine content of samples from Stations 50, 52, and 53 to the ESE of the factory showed the usual fall increase.

The average fluorine contents of all samples collected at approximately one-mile intervals from one to six miles from the factory are presented in Table 6; for sweet cherries only in Tables 4 and 7; and for apricot, peach, prune, and sour cherry trees in Table 8. As in previous years (1,4), these data reflect the imperfect distribution of sampling locations within the area. These average fluorine contents generally decrease with distance from the factory. It has already been shown (1) that there was no discernible effect of location within The Dalles area on the fluorine content of plant samples prior to operation of the factory.

Leaf scorch

A marginal necrosis characteristic of fluoride injury was found on apricot leaves in seven of the fourteen orchards sampled in July. This injury was rated as slight. The average fluorine content of the leaves showing the injury in mid-July was 35.4 ppm while the leaves showing no injury averaged 20.1 ppm. There was considerable overlapping shown by the following ranges in concentration: no injury, 7-33 ppm fluorine; injured, 22-47 ppm fluorine. As was reported previously (2), there was extreme variability in the severity of leaf injury from tree to tree within an orchard, the weaker trees showing the most severe injury.

In the Thompson orchard (Station 53) there was very slight injury on weak trees and none on vigorous trees. At the October sampling only three of the fourteen orchards showed no leaf injury. The injured leaves averaged 105 ppm fluorine while non-injured leaves averaged 52.8 ppm fluorine. The injury was still rated slight at this sampling.

Fluorine in spur and shoot leaves of Royal Ann cherry trees

Leaves from the middle portion of current season's growth (shoots) are normally collected for fluorine analyses. Under certain circumstances, such as low tree vigor, it may be necessary to collect leaf samples from fruit spurs rather than from shoots. It is thus desirable to have information on fluorine in leaves from spurs and shoots. Single samples of spur and of shoot leaves were collected from six cherry orchards at the July 16-20, 1962, sampling. There were 250 leaves per sample, 25 leaves collected from each of 10 trees and composited into a single sample. Normal healthy leaves from the mid-portion of spurs and of shoots were selected. The fluorine contents of these two kinds of leaves are presented in Table 9. The spur leaves contained about twice as much fluorine as the shoot leaves. This difference probably reflects the difference in the age of the leaves. Although the data are limited, they do suggest that sampling be confined to only one kind of leaf. Mid-shoot leaves have been used in this and previous reports of this series.

1963 Data

Data on fluorine contents of leaf samples of cherry and peach trees are presented in Tables 11 and 12 and of alfalfa herbage in Table 13. Forty cherry orchards and 16 peach orchards supplied 57 samples in July and 55

samples in September. The average fluorine contents (Table 12) of Royal Ann cherry leaves were 12.6 ppm in July and 21.6 ppm in September, while leaves of black cherries (Bing and Lambert) averaged 12.7 ppm in July and 18.5 ppm in September. Peach leaves contained about the same amount, 11.1 ppm in July and 16.5 ppm in September. The highest fluorine content found, 71.9 ppm, (Table 11) was in the September sample of Royal Ann cherry leaves from Station 11 which is 1 3/4 miles south of the aluminum reduction factory. In 1962, samples from these same trees contained 230 ppm fluorine in early October. It should be noted that the average fluorine contents of leaves of Royal Ann and black cherries and of peaches were only slightly higher in July 1963, than in August 1953, July 1, 1957, and June 20, 1958, before the aluminum factory started operating (see Tables 19 and 20).

The marked seasonal increase in the fluorine contents of the various crops noted in 1962 did not develop in 1963. In most instances the September concentrations were less than twice those of July. Many of the samples taken in September from the SW-S and S-SE sectors were essentially similar to check values already reported.

Alfalfa collected five times between April 12 and June 20 at The Dalles contained from 17 to 66 ppm fluorine (Table 13). The highest average content of 48 ppm was found at the first sampling on April 12 when the alfalfa was from 3 to 8 inches tall. The fluorine contents varied considerably at subsequent collections but tended to decrease. Sampling stopped at the first cutting.

The fluorine contents of cherry and peach leaves collected in 1963 at different distances and directions from the aluminum factory are presented in Tables 14 and 15. Tables 16 and 17 show the average contents

at various distances from the factory. Some of the fluorine contents are very low and do not differ appreciably from those found prior to 1958 and operation of the factory, and those from the Corvallis area. More detailed additional information on six sweet cherry orchards is shown in Text Table 2. Even though the fluorine levels in 1963 were much lower than in each of the previous three years, the effect of distance and direction from the aluminum reduction factory on the fluorine contents of these leaf samples is evident. There was no discernible trend in fluorine values because of location within The Dalles area prior to the operation of the factory (1).

Fluorine content of air samples

The data on the fluorine contents of air samples are presented in Table 18. Air sampling was started at the Elton (Station 43) and Gilbert (Station 51) orchards on March 28, 1963, with impinger fluoride absorbers, and at the Hendrix (Station 13) orchard on May 17 with a long-cycle automatic impinger. Samples were collected daily through July 8. The highest average fluorine concentration was 12.9 μg F/M^3 (micrograms fluorine per cubic meter of air) at the Gilbert Orchard on March 28. Concentrations at this orchard did not drop below 3.1 μg F/M^3 until April 15. From then until July 8 when sampling was stopped there were only 5 days when the average per day exceeded 2 μg F/M^3. The data are summarized by 15-day intervals at the end of Table 18.

Air fluorine concentrations at the Elton orchard, 5½ miles SSE of the factory, did not exceed 1 μg F/M^3 and many times the concentrations were too low to measure.

Fluorine in the air at the Hendrix orchard, 2¼ miles SSW of the factory, exceeded 6 μg F/M^3 on May 17-20 but from then until July 8 the

concentrations were less than 1 µg F/M^3 with one exception of 1.2 µg F/M^3 on May 21. From June 17 to 25 there was no detectable fluorine in the air at this orchard.

The data are insufficient to relate air and foliage fluorine at these three orchards. However, Royal Ann sweet cherry leaf fluorine contents for July 16, 1963, were 4.0 ppm and 29.6 ppm respectively, for the Elton and Geiger orchards (Geiger orchard ½ mile west of Gilbert) while the total cumulative air fluoride content from March 28 to June 6 was 7.8 and 151.4 µg F/M^3 respectively, for the Elton and Gilbert orchards. The data obtained at the Hendrix orchard were not sufficient to be included in this comparison.

Range and average fluorine levels, 1953 - 1963

The data obtained since 1953 in The Dalles area are summarized in Tables 10, 19, and 20. Prior to the operation of the aluminum reduction factory[1] near The Dalles, the average fluorine content of all samples collected in 1953, 1957, and 1958 varied from 6 to 11 ppm fluorine. Samples collected after start of factory operation averaged from 26 to 77 ppm fluorine at the June or July (1959 - 1962) sampling and from 68 to 140 ppm fluorine at the second sampling (1958 - 1962) in late summer or fall. In 1963 the average for both crops sampled, cherry and peach, was 12 ppm in July and 20 ppm in September.

[1] Aluminum factory started operating July 26, 1958.

Literature Cited

1. Compton, O. C., L. F. Remmert, and W. M. Mellenthin. 1960. Comparison of fluorine levels in crops before and after aluminum factory operations in The Dalles area. Ore. Agr. Exp. Sta. Misc. Paper 95.

2. Compton, O. C., L. F. Remmert, and W. M. Mellenthin. 1961. Fluorine levels in 1960 crops of The Dalles area. Ore. Agr. Exp. Sta. Misc. Paper 119.

3. Compton, O. C., L. F. Remmert, J. A. Rudinsky, L. L. McDowell, F. E. Ellertson, W. M. Mellenthin, and P. O. Ritcher. 1961. Needle scorch and condition of Ponderosa pine trees in The Dalles area. Ore. Agr. Exp. Sta. Misc. Paper 120.

4. Compton, O. C., L. F. Remmert, and W. M. Mellenthin. 1963. Fluorine levels in 1961 crops of The Dalles area. Ore. Agr. Exp. Sta. Spec. Report 153.

5. Pack, M. R., A. C. Hill, M. D. Thomas, and L. G. Transtrum. 1959. Determination of gaseous and particulate inorganic fluorides in the atmosphere. Spec. Tech. Publ. No. 281., Amer. Soc. Testing Mat.

6. Phillips, P. H., D. A. Greenwood, C. S. Hobbs, C. F. Huffman, G. R. Spencer. 1960. The fluorosis problem in livestock production. Nat. Acad. Sci., Nat. Res. Coun. Pub. 824.

7. Rochon, C. A., Chief Chemist, Harvey Aluminum Inc., The Dalles, April 27, 1959. Private communication.

8. Whitsell, W. J. 1957. Multi-cycle and long-cycle automatic impinger sampling. Jour. Air Pollution Control Assn. 7: 120-122.

Table 1. Fluorine content of foliage and forage samples, The Dalles area, 1962

Station No.	Farm	Crop	Fluorine content, dry weight basis	
			July 16-20	Oct. 10-15
			ppm	ppm
1	Weeks	Cherry[1/]	14.3	80.7
	Wetle	Alfalfa	35.6	---
2	Klindt	Gingko[2/]	970.	1450.
		Ornamental maple[2/] (unwashed)	2278.	1035.
		Peach	362.	474.
3	Stadelman	Alfalfa	53.6	119.
4	Fleck, K.	Apricot	33.2	114.
		Peach	40.8	98.0
	Foster	Cherry (Bing)	27.8	58.7
5	Kroon	Cherry	111.	232.
		Peach	63.3	196.
6	Sinsabaugh	Alfalfa	58.3	166.
7	Daniels	Prune	25.8	162.
8	Hertel	Cherry	30.4	116.
		Peach	14.7	65.3
9	Fleck, K.	Cherry	68.0	79.4
		Peach	32.4	43.8
10	T. D. Exp. Sta.	Apricot	44.0	115.
		Cherry (Lambert)	84.0	223.
		Sour cherry	23.9	108.
		Peach	23.8	80.2
		Prune	28.7	89.9
11	Fleck, J.	Cherry (Bing)	41.0	---
		Cherry	59.0	230.
		Peach	23.7	168.
12	Myer, W.	Apricot	46.5	178.
		Grape	22.3	89.9
13	Hendrix	Cherry	19.4	180.
14	Meyer, W. (Mill Creek Orchard, upper end)	Cherry	33.5	---
		Peach	17.0	---
15	Ellett	Cherry	85.0	136.
16	Malcom	Cherry	46.1	224.
17	Anderson	Alfalfa	83.6	86.3
		Apricot	32.9	159.
		Cherry	31.3	128.
		Peach	31.0	134.
		Prune	46.1	200.

1/ "Cherry" refers to Royal Ann cherry unless another variety is specified.
2/ The values obtained for ginkgo and maple leaves are not included in the ranges and averages for crop samples.

Table 1. (Continued)

Station No.	Farm	Crop	Fluorine content, dry weight basis	
			July 16-20	Oct. 10-15
			ppm	ppm
18	Meyer, W. (1st Orchard Mill Cr. Rd.)	Cherry (Lambert)	37.8	79.5
19	Meyer-Erickson	Apricot	22.3	69.7
		Cherry	--	85.3
		Peach	--	57.3
20	Williams	Cherry (Bing)	18.2	96.8
21	Francois	Peach	11.8	29.7
22	Curtiss Bros.	Sour cherry	12.3	54.3
23	Meyer, W. (Mill Creek Orchard, lower end)	Cherry (Bing)	37.9	168.
24	Curtiss Bros.	Cherry (Lambert)	19.0	82.2
		Peach	14.8	68.9
25	Davis	Apricot	14.8	51.9
		Cherry	18.2	43.4
26	Barrett	Cherry	21.6	43.5
27	Ranslam, Edward	Alfalfa	6.5	53.4
		Apricot	13.6	63.3
		Cherry	16.3	55.5
		Grape	11.8	42.9
		Peach	14.3	37.1
28	The Pines Dairy	Cherry	13.0	41.3
		Sour cherry	19.7	54.7
		Peach	5.5	--
29	Kortage	Alfalfa	11.2	--
30	Martin, John	Cherry	12.0	27.7
		Peach	--	16.5
31	Meyer, W. (Skyline)	Cherry	28.4	86.1
32	Ranslam, Earl	Cherry	19.2	82.5
33	High Rolls Ranch	Apricot	32.6	66.1
		Cherry	16.2	71.6
		Peach	11.3	53.5
		Prune	16.4	77.2
34	Bailey	Cherry	21.4	43.4
		Sour cherry	9.9	57.5
35	Curtiss Bros. (Skyline)	Apricot	7.0	43.4
		Cherry	14.9	48.1
		Peach	10.3	30.4
36	O. V. Orchards	Peach	7.9	38.3
37	Roberts	Cherry (Lambert)	87.9	106.
		Cherry	21.2	73.2
		Sour cherry	24.2	125.
		Peach	22.0	64.4

Station No.	Farm	Crop	Fluorine content, dry weight basis	
			July 16-20	Oct. 10-15
			ppm	ppm
38	Cooper, George	Alfalfa	16.9	53.0
		Apricot	17.3	88.7
		Cherry	8.7	64.7
39	Thienes	Cherry	16.6	58.3
40	Martin, Jack	Alfalfa	--	56.6
		Cherry	21.8	49.5
		Sour cherry	37.5	30.5
41	Renkin	Alfalfa	11.5	63.6
		Cherry	6.9	59.9
		Peach	12.3	46.7
42	Sander Bros.	Cherry	8.6	52.6
		Sour cherry	4.2	38.2
43	Elton	Cherry	10.9	55.9
44	Cooper, Glen	Cherry	42.5	88.1
45	Wagonblast	Alfalfa	12.1	55.4
46	Haner	Cherry	9.9	71.5
47	Jones	Cherry	16.8	77.8
48	Kaufman	Apricot	26.2	95.6
		Cherry	11.2	70.2
		Peach	13.2	60.0
49	Thompson	Cherry	12.8	63.9
50	Geiger	Apricot	29.6	119.
		Cherry	64.4	176.
		Peach	66.4	88.6
51	Adventist School	Alfalfa	24.9	77.6
52	McClaskey	Cherry	44.4	118.
53	Thompson	Apricot	10.1	96.7
		Cherry	34.5	101.
54	Stadelman	Apricot	33.0	56.8
55	Stadelman	Alfalfa	29.1	77.8
56	Tenold	Cherry	27.9	55.0
57	Lewis-Brown Farm,	Alfalfa	5.1	6.5
	Beach Farm, and	Apricot	9.9	14.8
	Campus, Corvallis	Cherry	6.1	6.0
		Sour cherry	4.5	5.9
		Grape	4.8	5.5
		Peach	6.2	10.6
		Prune	5.2	5.3
		Gingko	5.3	8.2

Table 2. Fluorine content of foliage and forage samples as the average per crop, 1962

Crop	Number of samples		Fluorine content, dry weight basis					
			The Dalles				Corvallis*	
	July 16-20	Oct. 10-15	July 16-20		October 10-15		July 16-20	Oct. 10-15
			Range	Average	Range	Average		
			ppm	ppm	ppm	ppm	ppm	ppm
Alfalfa	11	10	6.5 - 83.6	31.2	53.0 - 166.	80.9	5.1	6.5
Apricot	14	14	7.0 - 44.0	25.9	43.4 - 178.	94.1	9.9	14.8
Cherry	44	43	6.9 - 111.	31.6	27.7 - 232.	95.0	6.1	6.0
Sour cherry	7	7	4.2 - 37.5	18.8	30.5 - 125.	66.9	4.5	5.9
Grape	2	2	11.8 - 22.3	17.1	42.9 - 89.9	66.4	4.8	5.5
Peach	20	20	5.5 - 362.	39.9	16.5 - 474.	92.5	6.2	10.6
Prune	4	4	16.4 - 46.1	29.2	77.2 - 200.	132.	5.2	5.3

Summary for The Dalles

	July 16 - 20	October 10-15
Total number of samples	102	100
Number of sampling locations	58	57
Range, all crops, ppm	4.2 - 362.	16.5 - 474.
Average, all crops, ppm	31.2	91.9

* There was only one sample per crop at Corvallis.

Table 3. Fluorine content of alfalfa forage samples, The Dalles area, 1962

Station No.	Farm	Fluorine content, dry weight basis	
		July 16-20	Oct. 10-15
		ppm	ppm
	Wetle (1 mi. N.W. of factory)	35.6	---
3	Stadelman	53.6	119.
6	Sinsabaugh	58.3	166.
17	Anderson	83.6	86.3
27	Ranslam, Edward	6.5	53.4
29	Kortage	11.2	---
38	Cooper, George	16.9	53.0
40	Martin, Jack	---	56.6
41	Renkin	11.5	63.6
45	Wagonblast	12.1	55.4
51	Adventist School	24.9	77.6
55	Stadelman	29.1	77.8
	Range	6.5 - 83.6	53.0 - 166.
	Average	31.2	80.9

Table 4. Fluorine content of sweet cherry leaf samples, The Dalles area, 1962

Station No.	Farm	Distance and direction* from aluminum factory		Fluorine content dry weight basis	
		miles	direction	July 16-20	Oct. 10-15
				ppm	ppm
1	Weeks	2¼	N	14.3	80.7
	Foster			27.8 1/	58.7 1/
5	Kroon	1	SW	111.	232.
8	Hertel	2½	W	30.4	116.
9	Fleck, K.	3	W	68.0	79.4
10	T.D. Exp. Sta.	2	S	84.0 2/	223. 2/
11	Fleck, J.	1 3/4	S	41.0 1/	---
				59.0	230.
13	Hendrix	2	S	19.4	180.
14	Meyer, W.			33.5	---
15	Ellett	2	SW	85.0	136.
16	Malcom	2	SW	46.1	224.
17	Anderson	1 3/4	SW	31.3	128.
18	Meyer, W.	2	S	37.8 2/	79.5 2/
19	Meyer-Erickson	2	S	--	85.3
20	Williams	2½	S	18.2 1/	96.8 1/
23	Meyer, W.			37.9 1/	168. 1/
24	Curtiss Bros.	3½	S	19.0 2/	82.2 2/
25	Davis	3½	S	18.2	43.4
26	Barrett	3 3/4	SW	21.6	43.5
27	Ranslam, Edward	4	SW	16.3	55.5
28	The Pines Dairy	4½	SW	13.0	41.3
30	Martin, John	6	SW	12.0	27.7
31	Meyer, W.	2 3/4	S	28.4	86.1
32	Ranslam, Earl	3	S	19.2	82.5
33	High Rolls Ranch	3	S	16.2	71.6
34	Bailey	3 3/4	S	21.4	43.4
35	Curtiss Bros.	4	S	14.9	48.1
37	Roberts	3¼	SE	87.9 2/	106. 2/
				21.2	73.2
38	Cooper, George	3½	S	8.7	64.7
39	Thienes	4 3/4	S	16.6	58.3
40	Martin, Jack	4½	SE	21.8	49.5
41	Renkin	4½	SE	6.9	59.9
42	Sander Bros.	5¼	S	8.6	52.6

1/ Bing cherry.
2/ Lambert cherry.
* Sampling stations located between N and NNW of factory are designated as N of factory; those located between NNW and NW of factory are designated as NW of factory; etc.

Table 4 (Continued)

Station No.	Farm	Distance and direction* from aluminum factory		Fluorine content dry weight basis	
		miles	direction	July 16-20	Oct. 10-15
				ppm	ppm
43	Elton	5½	S	10.9	55.9
44	Cooper, Glen	4	SE	42.5	88.1
46	Haner	5	SE	9.9	71.5
47	Jones	5	SE	16.8	77.8
48	Kaufman	4½	SE	11.2	70.2
49	Thompson	5¼	SE	12.8	63.9
50	Geiger	4	SE	64.4	176.
52	McClaskey	4 3/4	SE	44.4	118.
53	Thompson	5½	SE	34.5	101.
56	Tenold	5½	E	27.9	55.0
57	Lewis-Brown, Corvallis	120	SW	6.1	6.0

Table 5. Fluorine content of foliage and forage samples as the average for several crops grown at different distances and directions from the aluminum factory at The Dalles, July 16-20, 1962*

Distance from factory	Average fluorine content, dry weight basis				
	N to W	W to SW	SW to S	S to SE	SE to E
miles	ppm	ppm	ppm	ppm	ppm
	Seven crops**				
0-1	--	--	--	--	362.
1-2	--	--	42.3	53.6	--
2-3	14.3	32.3	18.0	29.5	--
3-4	--	50.2	16.8	25.0	53.5
4-5	--	--	13.6	18.3	32.8
5-6	--	--	12.0	9.1	24.2
	Apricots, peaches, prunes, sour cherries				
0.1	--	--	--	--	362.
1-2	--	--	36.5	--	--
2-3	--	20.2	18.0	22.3	--
3-4	--	32.4	11.5	17.8	48.0
4-5	--	--	15.9	22.3	33.0
5-6	--	--	--	4.2	10.1
	Sweet cherries				
0-1	--	--	--	--	--
1-2	--	--	63.5	--	--
2-3	14.3	30.4	17.9	33.1	--
3-4	--	68.0	22.2	34.2	64.4
4-5	--	--	14.6	18.0	44.4
5-6	--	--	12.0	10.8	31.2

* Includes only those stations sampled both on July 16-20 and October 10-15. Data for October 10-15 are presented in Figures 2, 3, and 4.

** The seven crops are listed in Table 2.

Table 6. Average fluorine content of forage and foliage samples of seven crops grown at different distances from the aluminum factory at The Dalles, 1962*

Distance from factory	Fluorine content, dry weight basis	
	July 16-20	October 10-15
miles	ppm	ppm
0-1	362.	474.
1-2	47.1	148.
2-3	23.9	93.3
3-4	26.5	74.5
4-5	19.4	62.7
5-6	15.1	61.4

* Includes only those stations sampled on both July 16-20 and October 10-15.

Table 7. Average fluorine content of foliage samples of sweet cherry trees grown at different distances from the aluminum factory at The Dalles, 1962*

Distance from factory	Fluorine content, dry weight basis	
	July 16-20	October 10-15
miles	ppm	ppm
0-1	----	----
1-2	63.5	176.
2-3	23.5	102.
3-4	33.5	84.2
4-5	19.9	69.0
5-6	17.8	59.4

* Includes only those stations sampled on both July 16-20 and Oct. 10-15.

Table 8. Average fluorine content of foliage samples of apricot, peach, prune, and sour cherry trees grown at different distances from the aluminum factory at The Dalles, 1962*

Distance from factory	Fluorine content, dry weight basis	
	July 16-20	October 10-15
miles	ppm	ppm
0-1	362.	474.
1-2	36.5	137.
2-3	19.3	74.8
3-4	20.7	67.2
4-5	21.2	55.6
5-6	7.2	67.4

* Includes only those stations sampled both on July 16-20 and Oct. 10-15.

Table 9. Fluorine content of spur and shoot leaves of Royal Ann sweet cherry trees, The Dalles area, July 16-20, 1962

Station No.	Farm	Fluorine content, dry weight basis, of leaves from shoots	spurs
		ppm	ppm
13	Hendrix	19.4	44.4
38	Cooper, Geo.	8.7	18.1
41	Renkin	6.9	11.1
46	Haner	9.9	15.3
48	Kaufman	11.2	18.0
49	Thompson	12.8	18.0
Average		11.5	20.8

Table 10. Range and average leaf fluorine content of seven crops, The Dalles area for samples collected since 1953

Date sampled	No. samples	No. locations	Fluorine content, dry weight basis	
			Range	Average
			ppm	ppm
August 13, 1953	53	19	1-17	6
July 1, 1957	67	37	3-25	11
October 2, 1957	73	40	0.1-24	10
June 20, 1958	76	40	3-40	7
October 7, 1958	70	39	16-197*	68*
June 17, 1959	76	42	6-106	26
August 27, 1959	78	44	18-207	73
July 8, 1960	87	47	14-248	77
September 20, 1960	95	50	38-431	140
July 12, 1961	103	53	12-217	65
September 7, 1961	102	57	16-204	68
July 16, 1962	102	56	4-362	31
October 10, 1962	100	53	16-474	92

* Aluminum factory started operating July 26, 1958.

Table 11. Fluorine content of foliage samples, The Dalles area, 1963

Station No.	Farm	Crop	Fluorine content, dry weight basis	
			July 16-18	September 19-20
			ppm	ppm
1	Weeks	Cherry, Royal Ann	11.2	18.6
4	Fleck, K.	Peach	15.4	28.5
5	Kroon	Cherry, Royal Ann	33.7	51.8
		Peach	20.4	---
8	Hertel	Cherry, Royal Ann	16.6	25.8
		Cherry, black	20.0	30.4
9	Fleck, K.	Cherry, black	15.3	26.2
		Peach	7.3	17.8
10	The Dalles Exp. Station	Cherry, Royal Ann	14.8	29.0
		Peach	8.9	18.5
11	Fleck, J.	Cherry, Royal Ann	20.1	71.9
		Peach	29.3	25.8
13	Hendrix	Cherry, Royal Ann		
		(6A & 6C, shoot leaves)	15.8	28.0
		(6A & 6C, spur leaves)	30.1*	39.8*
		(4C, spur leaves)	28.5*	34.3*
		(Caged tree, spur leaves)	33.5*	51.5*
15	Ellett	Cherry, Royal Ann	15.3	23.2
16	Malcom	Cherry, Royal Ann	19.0	35.5
17	Anderson	Cherry, Royal Ann	18.5	31.0
		Peach	11.1	27.0
18	Meyer	Cherry, black	11.5	15.9
19	Meyer-Erickson	Cherry, Royal Ann	16.2	20.7
		Peach	8.7	11.7
20	Williams	Cherry, black	12.5	13.0
21	Francois	Peach	6.7	9.2
24	Curtiss Bros.	Cherry, Royal Ann	7.8	12.2
25	Davis	Cherry, Royal Ann	13.3	17.2
26	McCollum	Cherry, Royal Ann	8.3	9.2
		Peach	6.1	20.2
27	Ranslam, Ed	Cherry, Royal Ann	4.7	10.8
		Peach	5.4	9.6
28	The Pines	Cherry, Royal Ann	6.7	11.6
30	Martin, John	Cherry, Royal Ann	5.9	13.9
31	Meyer	Cherry, Royal Ann	7.5	28.6
32	Ranslam, Earl	Cherry, Royal Ann	5.6	25.0
33	High Rolls	Cherry, Royal Ann	6.4	18.9
		Peach	6.3	14.4
34	Bailey	Cherry, Royal Ann	7.6	17.0
35	Curtiss Bros.	Cherry, Royal Ann	9.6	18.1
		Peach	7.0	8.8

* Not included in averages.

Table 11 (Continued)

Station No.	Farm	Crop	Fluorine content, dry weight basis	
			July 16-18	September 19-20
			ppm	ppm
37	Roberts	Cherry, Royal Ann	23.6	24.3
		Peach	9.3	---
38	Cooper, George	Cherry, Royal Ann	8.3	17.1
39	Thienes	Cherry, Bing	9.1	14.6
40	Martin, Jack	Cherry, Royal Ann	7.4	9.8
41	Renkin	Cherry, Royal Ann	4.3	10.7
		Peach	5.2	7.9
42	Sander Bros.	Cherry, Royal Ann	7.0	9.5
43	Elton	Cherry, Royal Ann	4.0	11.7
44	Cooper, Glen	Cherry, Royal Ann	10.7	17.6
46	Haner	Cherry, Royal Ann	7.2	13.9
47	Jones	Cherry, mixed	11.5	12.8
48	Kaufman	Cherry, Royal Ann	16.5	14.4
		Peach	12.5	10.8
49	Thompson	Cherry, Royal Ann	10.7	14.5
50	Geiger	Cherry, Royal Ann	29.6	41.4
		Peach	17.7	21.0
52	McClaskey	Cherry, Royal Ann	14.7	29.4
53	Thompson (Todd)	Cherry, Royal Ann	18.3	22.8
56	Tenold	Cherry, black	8.7	16.7

Table 12. Fluorine content of foliage samples as the average per crop, 1963

Crop	Number of samples		Fluorine content, dry weight basis			
			The Dalles			
	July 16-18	Sept. 19-20	July 16-18		Sept. 19-20	
			Range	Average	Range	Average
			ppm	ppm	ppm	ppm
Cherry	41	41	4.0-33.7	12.6	9.2-71.9	21.6
Royal Ann	34	34	4.0-33.7	12.6	9.2-71.9	22.2
Black	7	7	8.7-20.0	12.7	12.8-30.4	18.5
Peach	16	14	5.2-29.3	11.1	7.9-28.5	16.5

Summary for The Dalles

	July 16-18	Sept. 19-20
Total number of samples	57	55
Range, both crops, ppm	4.0-33.7	7.9-71.9
Average, both crops, ppm	12.2	20.3

Table 13. Fluorine content of alfalfa forage samples, The Dalles area, 1963

Station No.	Farm	Distance and direction from aluminum factory		Fluorine content, dry weight basis				
				April 12	April 25	May 10	May 23	June 20
		miles		ppm	ppm	ppm	ppm	ppm
3	Stadelman (east of house)	1½	S	27.0	27.5	17.0	29.0	28.7
3	Stadelman (west of house)	1½	S	63.7	61.2	43.6	31.9	25.7
	Herman (N.W. of No. 4)	1	SW	64.7	33.2	28.3	55.0	23.4
6	Sinsabaugh	2½	W	55.9	38.2	35.8	65.9	---
51	Johnson	4¾	SE	28.5	49.4	25.6	28.3	39.1
Average				48.0	41.9	30.1	42.0	29.2
Beach Farm, Corvallis				15.6	11.0	20.0	8.9	5.5

Table 14. Fluorine content of Royal Ann sweet cherry leaf samples, The Dalles area, 1963

Station No.	Farm	Distance and direction from aluminum factory		Fluorine content dry weight basis	
				July 16-18	Sept. 7-8
		miles	direction	ppm	ppm
1	Weeks	2¼	N	11	19
5	Kroon	1	SW	34	52
8	Hertel	2½	W	17	26
10	The Dalles Exp. Station	2	S	15	29
11	Fleck, J.	1 3/4	S	20	72
13	Hendrix	2	S	16	28
15	Ellett	2	SW	15	23
16	Malcom	2	SW	19	36
17	Anderson	1 3/4	SW	18	31
19	Meyer-Erickson	2	S	16	21
24	Curtiss Bros.	3½	S	8	12
25	Davis	3½	S	13	17
26	McCollum	3 3/4	SW	8	9
27	Ranslam, Ed	4	SW	5	11
28	The Pines	4½	SW	7	12
30	Martin, John	6	SW	6	14
31	Meyer	2 3/4	S	8	29
32	Ranslam, Earl	3¼	S	6	25
33	High Rolls Ranch	3	S	6	19
34	Bailey	3 3/4	S	8	17
35	Curtiss Bros.	4	S	10	18
37	Roberts	3¼	SE	24	24
38	Cooper, George	3½	S	8	17
40	Martin, Jack	4½	SE	7	10
41	Renkin	4½	SE	4	11
42	Sander Bros.	5¼	S	7	10
43	Elton	5½	S	4	12
44	Cooper, Glen	4	SE	11	18
46	Haner	5	SE	7	14
48	Kaufman	4½	SE	16	14
49	Thompson	5¼	SE	11	14
50	Geiger	4	SE	30	41
52	McClaskey	4 3/4	SE	15	29
53	Thompson	5½	SE	18	23

Table 15. Fluorine content of foliage samples as the average for cherry and peach crops grown at different distances and directions from the aluminum factory at The Dalles, 1963

Distance from factory	Average fluorine content, dry weight basis									
	N to W		W to SW		SW to S		S to SE		SE to E	
	July 16-18	Sept. 19-20	July 16-18	Sept. 19-20	July 16-18	Sept. 19-20	July 16-18	Sept. 19-20	July 16-18	Sept. 19-20
miles	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-1	---	---	---	---	---	---	---	---	---	---
1-2	---	---	---	---	18.5	33.6	---	---	---	---
2-3	11.2	18.6	18.3	28.1	8.0	13.9	11.0	19.2	---	---
3-4	---	---	11.3	22.0	8.5	14.7	11.7	22.1	23.6	31.2
4-5	---	---	---	---	5.6	10.7	9.4	12.5	14.7	29.4
5-6	---	---	---	---	5.9	13.9	7.2	11.9	13.5	19.8

Table 16. Average fluorine content of foliage samples of peach and cherry trees grown at different distances from the aluminum factory at The Dalles, 1963

Distance from factory	Fluorine content, dry weight basis	
	July 16-18	Sept. 19-20
miles	ppm	ppm
0-1	---	---
1-2	18.5	33.6
2-3	11.2	18.8
3-4	11.8	19.7
4-5	8.9	13.4
5-6	9.1	14.8

Table 17. Average fluorine content of foliage samples of sweet cherry trees grown at different distances from the aluminum factory at The Dalles, 1963

Distance from factory	Fluorine content, dry weight basis	
	July 16-18	Sept. 19-20
miles	ppm	ppm
0-1	---	---
1-2	19.6	38.6
2-3	12.7	19.0
3-4	12.9	20.8
4-5	9.3	14.5
5-6	9.1	14.8

Table 18a. Atmospheric fluorine content, The Dalles area, 1963

Date*	Location 1/		Date*	Location 1/		Date*	Location 1/			Date*	Location 1/	
	Elton	Gilbert		Elton	Gilbert		Elton	Gilbert	Hendrix		Gilbert	Hendrix
	µgF/M3**			µgF/M3**			µgF/M3**				µgF/M3**	
Mar. 28	1.0	12.9	Apr. 21	0.0	1.4	May 16	0.0	0.8		June 10	1.4	--
29	0.2	5.2	22	0.1	1.7	17	0.1	1.1	6.9	11	1.1	--
30	0.2	4.4	23	0.0	---	18	0.3	2.1	6.2	12	1.3	0.1
31	---	5.2	24	0.0	1.5	19	0.1	2.2	6.3	13	1.3	0.1
Apr. 1	---	5.2	25	0.0	1.6	20	0.6	2.5	6.2	14	1.1	0.6
2	0.3	5.6	26	0.0	1.3	21	0.2	1.7	1.2	15	1.0	0.4
3	0.2	5.5	27	0.0	1.0	22	0.0	1.0	0.1	16	1.9	0.3
4	0.2	8.5	28	0.0	1.2	23	0.0	0.8	0.1	17	1.1	0.0
5	0.2	7.2	29	0.1	1.5	24	0.0	0.6	0.0	18	1.0	0.0
6	0.2	5.4	30	0.0	0.7	25	0.0	0.5	0.0	19	1.0	0.0
7	0.1	5.0	May 1	0.0	0.8	26	0.0	0.6	0.7	20	0.8	0.0
8	0.1	4.5	2	0.0	0.6	27	0.0	0.7	0.0	21	0.8	0.0
9	0.1	3.9	3	0.0	0.7	28	0.5	0.8	0.4	22	0.8	0.0
10	0.1	3.8	4	0.1	0.9	29	0.1	0.7	0.0	23	0.6	0.0
11	0.1	3.1	5	0.1	1.1	30	0.1	0.7	0.1	24	0.5	0.0
12	0.1	3.5	6	0.1	1.1	31	0.0	0.2	0.0	25	0.4	0.0
13	0.3	4.4	7	0.1	1.0	June 1	0.1	0.6	0.0	26	0.4	0.2
14	0.2	3.1	8	0.0	1.0	2	0.2	0.5	0.1	27	0.3	0.3
15	0.1	1.5	9	0.0	0.9	3	0.2	0.4	0.1	28	1.0	0.3
16	0.1	1.7	10	0.0	0.9	4	0.2	0.5	---	29	0.4	0.3
17	0.1	2.2	11	0.0	0.5	5	0.2	0.3	---	30	0.3	0.3
18	0.1	1.4	12	0.0	0.8	6	0.2	0.4	---	July 1	0.5	0.4
19	---	1.7	13	0.0	0.9	7		1.1	---	2	0.6	0.3
20	0.1	1.4	14	0.0	1.4	8		1.1	---	3	0.7	0.9
			15	0.0	0.9	9		1.0	---	4	0.6	0.4
										5	0.4	0.3
										6	2.1	0.3
										7	0.8	0.5
										8	1.1	0.3

* Sampling started at 8 A.M. on date noted.

** Not corrected for air temperature and pressure.

1/ Elton, Gilbert, and Hendrix, Stations 43, 51, and 13, 5½ mi. SSE, 4½ SE, and 2¾ mi. SSW of factory, respectively.

Table 18b. Summary of atmospheric fluorine content, The Dalles area, 1963

Interval	µgF/M3**		
	Elton No. 43	Gilbert No. 51	Hendrix No. 12
March 28 - April 11	0.2	5.7	--
April 12 - 26	0.1	2.0	--
April 27 - May 11	0.0	0.9	--
May 12 - 26	0.1	1.2	2.7 (2)
May 27 - June 10	0.2(1)	0.7	0.1 (3)
June 11 - 25	--	1.0	0.1
June 26 - July 8	--	0.7	0.4
Cumulative F, 3/28 - 6/6	7.8	151.4	
F content, cherry leaves, July 16, 1963, ppm	4.0	29.6(4)	15.8

(1) May 27 - June 6.
(2) May 17 - 26.
(3) May 27 - June 3.
(4) At Geiger, No. 50, ¼ mile west of Gilbert.

** Not corrected for air temperature and pressure.

Table 19. Range and average fluorine content of leaf samples of peach trees collected since 1953 in The Dalles area

Date sampled	No. samples	Fluorine content, dry weight basis	
		Range	Average
		ppm	ppm
August 13, 1953	12	1-17	6
July 1, 1957	13	4-18	10
October 2, 1957	14	4-21	10
June 20, 1958	14	3-40	8
October 7, 1958	14	16-178*	76*
June 17, 1959	14	6-47	23
August 27, 1959	14	25-100	70
July 8, 1960	14	30-158	82
September 20, 1960	26	56-392	186
July 12, 1961	18	23-117	61
September 7, 1961	18	25-151	69
July 16, 1962	20	6-362	40
October 10, 1962	20	16-474	93
July 16, 1963	16	5-29	11
September 19, 1963	14	8-29	17

* Aluminum factory started operating July 26, 1958.

Table 20. Range and average fluorine content of leaf samples of sweet cherry trees collected since 1953 in The Dalles area

Date sampled	No. samples	Fluorine content, dry weight basis	
		Range	Average
		ppm	ppm
August 13, 1953	18	3-17	8
July 1, 1957	20	5-18	13
October 2, 1957	23	5-20	11
June 20, 1958	23	3-14	6
October 7, 1958	23	16-197*	65*
June 17, 1959	24	9-65	29
August 27, 1959	24	20-207	88
July 8, 1960	26	30-248	96
September 20, 1960	26	56-431	196
July 12, 1961	44	20-202	68
September 7, 1961	44	23-144	79
July 16, 1962	44	7-111	32
October 10, 1962	43	28-232	95
July 16, 1963	41	4-34	13
September 19, 1963	41	9-72	22

* Aluminum factory started operating July 26, 1958.