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A Preliminary Report on "Potash Production Pollutants and Shelterbelt Trees" Near Guernsey, Saskatchewan

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ABSTRACT

The scope of this examination was not sufficient to draw final conclusions concerning the total impact of the potash production emissions on shelterbelts, however these preliminary results indicate: 1) there is a dispersal of sodium and potassium chlorides from the potash operation, 2) certain shelterbelt species have the ability to accumulate considerable concentrations of these emitted elements in their foliage, 3) certain shelterbelt species are intolerant of these emitted elements, 4) in close proximity to the potash operation some macroscopic foliar damage symptoms were found that are typical of plant responses to high sodium and potassium chloride accumulations.

INTRODUCTION

In June of 1972 requests were received at the Northern Forest Research Centre from Mr. R. R. Sentis, Engineer, Air Pollution Control Branch, Saskatchewan Department of Environment and Dr. R. A. A. Morrall, Assistant Professor, Biology, University of Saskatchewan to provide information concerning the possible effects of potash production emissions on shelterbelts surrounding the Alwinsal operation near Guernsey, Saskatchewan. The request resulted from suspected damage to trees and shrubs in the vicinity of the plant.

Mr. Sentis revealed the steps in potash production and the composition of the emissions released as,

> "The potash refining process is a relatively simple process. The ore is mined, brought to the surface and dissolved. A flotation process is used to purify the KCl and the final process involves drying the pure product. The following reagents are used in the process: amine acetate, oil, pure amine, starch and percol. The total chemicals used would total less than one pound of ore processed.
>
> The capacity of the potash mine in question is rated at approximately 8,000 tons of ore per day producing slightly more than 3,000 tons per day of KCl. However, due to a prorationing system among the mines the plant is limited to 40 percent capacity. The greater portion of the waste is in liquid form. Discharge from the dryer stack consists mainly of sodium and potassium chlorides. Quantitatively the emissions are 2/3 KCl and 1/3 NaCl."

Emissions from this dryer stack can be seen in the upper cover photo. The location and approximate size of the liquid waste disposal lagoon is indicated on Map #1 and the lagoon dykes can be seen in Fig. #6.

PROCEDURES

A brief examination of some of the shelterbelts around the potash operation was conducted by Mr. K. Mortensen, a Survey Ranger with the Northern Forest Research Centre, on July 24 and 25 of 1972.

This procedure included the describing of affected shelterbelts and the gathering of fresh vegetative material for analysis and symptom diagnosis.

During this examination the Alwinsal potash mining operation was producing a clearly visible white plume from the stack drier (upper cover photo). This emission was noted as impinging on the area immediate to the potash operation for at least a portion of the day of July 25. The location of the potash operation in relation to the sample sites visited are indicated on Map #1.

RESULTS

Samples of dried foliage collected from two of the shelterbelts in the vicinity of the potash operation accompanied the original request. These foliage samples were subjected to atomic absorption unit analysis[1] in the laboratory to determine the levels of potassium, sodium, magnesium and chloride that were present on the dry weight basis.

Analyses were also run on normal foliage of the same species for comparative purposes. The results of these analyses follow in Table #1.

Table I Results From Foliar Analysis

Species	Sample location	Sample description	Analysis results (%) dry wt. basis Cl	K	Mg	Na
Willow	1.5 miles from potash mine	damaged foliage	.20	1.55	.33	.05
Willow	Edmonton area	normal foliage (control)	.09	1.18	.16	.02
Siberian Elm	.5 miles from potash mine	damaged foliage	.55	2.75	.46	.17
Siberian Elm	Edmonton area	normal foliage(control)	.14	1.89	.34	.02

Of special note is the very high concentration of chloride, potassium and sodium that has accumulated in the Siberian elm foliar sample that came from Guernsey area and relatively high concentrations of chlorides in both foliar materials from the Guernsey area, compared with that of the controls (from the Edmonton area).

During the field examination a shelterbelt was located immediately adjacent to the potash operation (see Sample Site #2 on Map #1, the mid cover photo, and Figure #1). The species sampled at this location were

[1] Y. Kalra of the Northern Forest Research Centre conducted these analyses.

Manitoba Maple, Northwest Poplar and Caragana. All were in very poor condition, suffering various degrees of defoliation and foliar discolorations (Figure #1 and the mid and lower cover photo's). The foliage that remained on the Manitoba Maple (Figure #3), the Northwest Poplar (Figure #2, and the lower cover photo) and the Caragana displayed marginal and intercostal necrosis and chlorosis typical of foliar response to extremely high sodium and potassium chlorides. The subsequent foliar analysis showed that the concentrations of these three elements were highest at this site (see Table II).

Table II Results of foliar analysis of current year's foliage from the shelterbelt samples obtained during field examination.

Species	Distance & direction from Potash Operation	Site #	Composition Percentage on a dry wt. basis		
			Cl%	K%	Na%
Manitoba Maple	Adjacent - South East	2	1.03	3.395	.090
	1/4 miles East	1	0.57	2.627	.087
	2-3/4 mile West-Southwest	5	0.17	2.040	.027
	3-1/4 miles Southwest	7	0.11	1.861	.055
	4-1/4 miles South	10	0.07	1.190	.025
	5 miles Southeast	11	0.09	1.313	.018
Northwest Poplar	Adjacent - Southeast	2	2.52	3.085	.235
	1/4 mile East	1	0.65	1.946	.134
	2-3/4 miles West-Southwest	5	0.08	1.041	.024
Caragana	Adjacent - Southeast	2	0.62	2.619	.252
	3-1/4 miles Southwest	7	0.12	1.245	.017
Willow	3/4 mile Southeast	9	0.39	2.370	.080
	3-1/2 miles Southwest	6	0.12	1.656	.036
Colorado Blue Spruce	1/4 mile East	1	0.05	0.673	0.21
(current year foliage only)	2-1/2 miles West	4	0.04	0.701	.025
	7 miles West	12	0.01	0.576	.001
Scotch Pine	2 miles West	3	0.05	0.372	.085
(current year foliage only)	3 miles Southwest	8	0.02	0.323	.039
Green Ash	4-1/2 miles East	13	0.04	0.907	.012
Elm	4-1/2 miles East	13	0.02	1.868	.022

Note the extremely high percentages in the deciduous species close to the potash operation and that the concentration gradients decreased with increasing distances from the potash operation.

Figure #1 Sample Site #2, adjacent to the Potash Operation. Note the poor condition of the Manitoba Maple.

Figure #2 Northwest Poplar foliage from Sample Site #2
Note the necrosis advancing inward from the leaf margins.

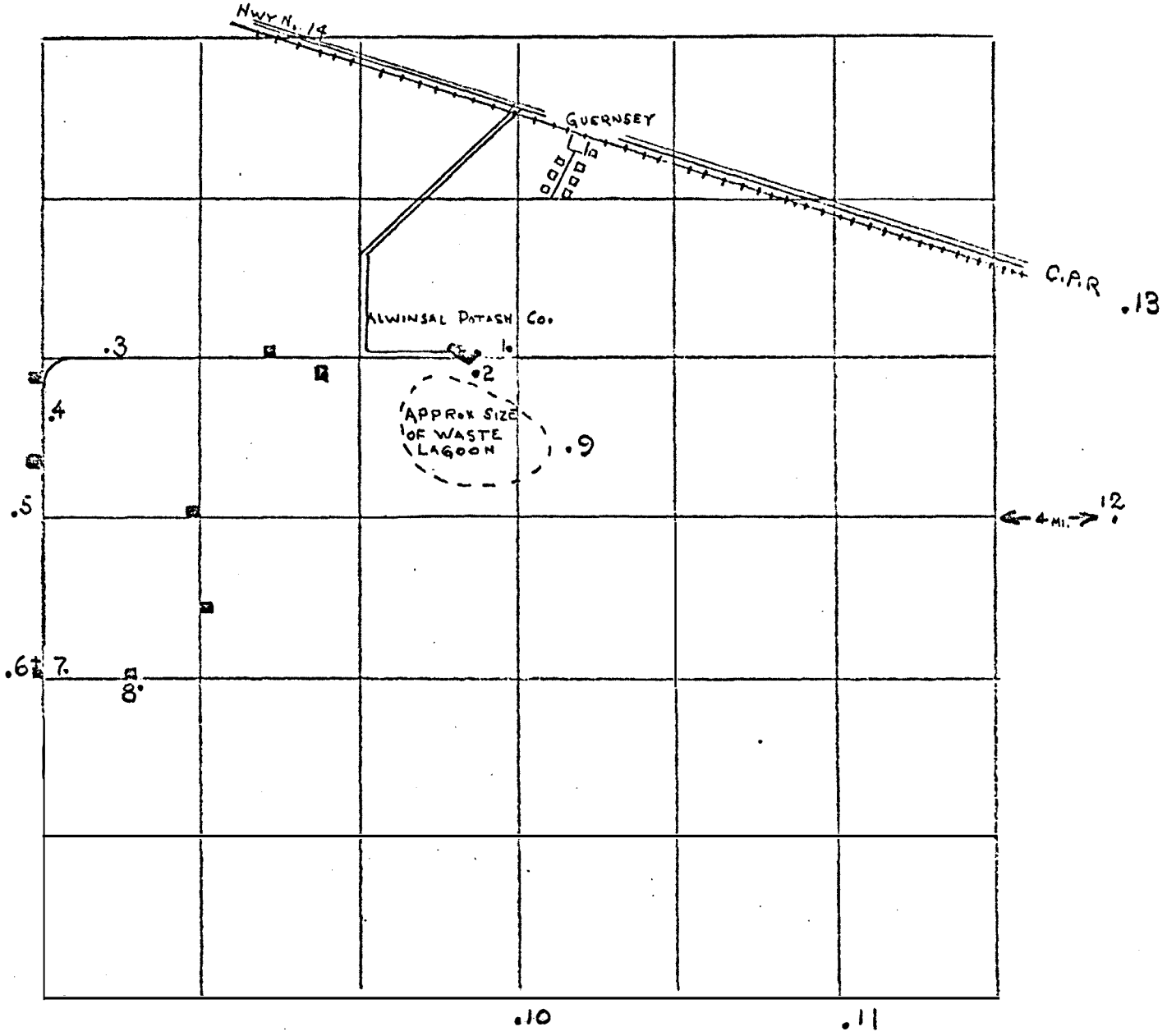
Figure #3 Manitoba Maple foliage from Sample Site #2
Note the marginal and intercostal necrosis and chlorosis developing on the leaves.

MAP #1

TOWNSHIP 33
RANGE 23
WEST SECOND MERIDAN

3 · SAMPLE POINT
■ · ADDITIONAL FARMSTEADS

SCALE 1 INCH = 1 MILE



A shelterbelt was located approximately one-half mile due east of the Alwinsal potash operation (see Map #1, Sample Site #1) surrounding a local cemetary (Figure #4). The three species sampled here were Northwest Poplar, Manitoba Maple and Colorado Spruce. The older Northwest Poplar displayed dead tops (Figure #4) as are common in the shelterbelts of southern Saskatchewan, usually the result of drought and other climate stress conditions.

The Manitoba Maple had some curled shoots, dead twigs and dead tops (older trees) which are usually associated with a herbicidal spray drift (2-4-D or the like). However, the foliage of both suffered a degree of marginal necrosis which progressed inwardly between the leaf veins (Figure #5) and is typical of plant response to high sodium and potassium chloride levels. Subsequent analysis showed the levels of these elements to be high in the foliage of these species (Table II).

The Colorado Blue Spruce at this location showed no symptoms on its foliage related to either chemical or drought conditions (Figure #4). The tolerance of spruce species to both drought and air pollutants is well known and this result was expected. Foliar analysis (Table II) indicated no accumulation of sodium and potassium chloride.

Figure #4 Sample Site #1 - Note the dead poplar tops, typically the result of climatic conditions, and the healthy condition of the Colorado Spruce.

Figure #5 Manitoba Maple foliage from Sample Site #1 Note the marginal necrosis beginning to develop at the leaf margins.

A willow shelterbelt was located approximately three-quarters of a mile southeast of the potash operation, near the end of the settling pond (Sample Site #9 on Map #1). The trees displayed sparce clumpy foliation (Figure #6), and somewhat distorted upturned new shoot growth (Figures #6 & #7). The foliage that remained, ranged in appearance from normal to shrivelled, darkly colored leaves with necrotic margins (Figure #7). Foliar analysis revealed the levels of sodium, potassium chloride to be very high in the foliage from this site also (see Table II).

Figure #6 Willow at Sample Site #9

Note the clumping of the foliage, the upturned, defoliated new shoot growth. The settling lagoon dam is in the background.

Figure #7 Willow foliage from Sample Site #9
Ranging from normal appearance (top left) to shrivelled, darkly colored leaves with necrotic margins.

The trees in the shelterbelts located to the west and southwest (Map #1, Sample Sites #3 through #8) some 2 to 3 miles from the potash operation displayed no macro foliar symptoms that can be directly related to the sodium and potassium chlorides. However, from the samples sent in, foliar chlorosis and foliar diseases appeared more frequently on the deciduous trees (Figure #8) from these sites (some 2 to 3 miles from the potash operation) than the trees from the Sites #10 - #12 (some 4¼ to 7 miles to the south and west of the potash operation - see Map #1). The accumulation gradients of sodium, potassium and chloride in the deciduous foliage decreased markedly with distances from the potash operation (Table II).

Scots Pine and Colorado Spruce, the only conifers represented in the shelterbelts in the area, showed no foliar damage symptoms and analysis did not indicate sodium, potassium and chloride accumulation.

Figure #8 Manitoba Maple foliage from Sample Site #5
Note the presence of chlorosis and diseases.

On the basis of this limited data an approximation of the various species' abilities to accumulate chloride, sodium and potassium in their foliage and respond via expression of symptoms is possible (Table III).

Table III Estimate of species' sensitivity to chloride, sodium, and potassium.

Species	Accumulation Abilities	Response (Sensitivity)
Manitoba Maple	high	high
N.W. Poplar	high	high
Caragana	moderate	high
Willow	moderate	medium
Elm	moderate	medium
Scots Pine	low	low
Colorado Blue Spruce	low	low

Also of interest are the concentrations of chloride, sodium and potassium that were monitored from the ambient air in the vicinity of the shelterbelt sites via dustfall samplers (Figure 9)by Saskatchewan Department of Environment during May and June of 1972 (Map #2 and Table IV). The accumulation gradients with distance from mineral source agrees with results of the foliar analysis.

Figure #9 A potash dustfall sampling device located in the vicinity of the Alwinsal potash operation.

MAP #2

Location of ALWINSAL SAMPLING LOCATIONS

Relevant to 1972 foliar sampling area.

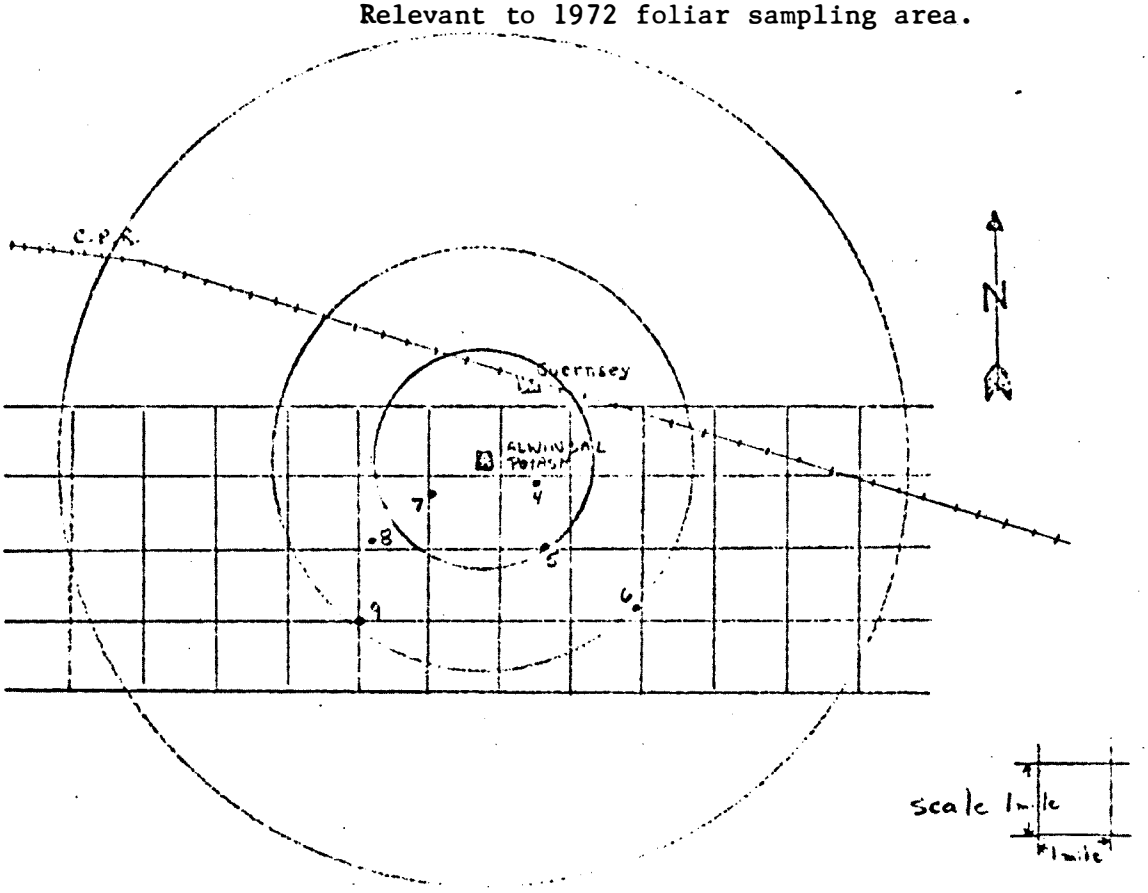


Table IV Concentrations of chloride, potassium and sodium collected at the Alwinsal sampling locations during May and June of 1972.

All concentrations are expressed in $Mgm/Cm^2/month$.

Sample Location	May/72			June/72		
	Cl	K	Na	Cl	K	Na
7	.220	.072	.088	.240	.006	.080
8	.013	.012	.006	.002	.003	.002
9	.006	.004	.002	.002	.003	.002
4	.020	.020	.010	.001	.019	.010
5	.014	.014	.006	.015	.014	.008
6	.007	.003	.003	.011	.013	.006

* Extracted from data supplied by R. R. Sentis, Saskatchewan Department of Environment.

DISCUSSION AND CONCLUSIONS

The deposition of sodium and potassium chlorides in the area around the Alwinsal potash operation is indicated by the results of the foliar analysis (Tables I & II) and the potash dust fall monitors (Table IV).

Foliar analysis and potash dust fall monitor results reveal that the concentration gradients of sodium, potassium and chloride decrease with distance away from the potash operation (Tables I, II & IV); which clearly define the potash operation as the source of these depositions. Possible sources are the stack dryer emissions of the type noted during the examination (see cover photo) and spray drift from the open settling lagoons. Lagoon seepage is not a probable contributor because foliar analysis reveals that high concentrations of sodium, potassium and chloride were accumulated some distances from the lagoon (Map #1 and Table II).

Unfortunately the location of the foliar sample sites has yielded rather spotty information concerning foliar accumulation and impacts on the shelterbelts, but it is apparent that certain shelterbelt species do accumulate potassium sodium and chloride in their foliage (Table III). The shelterbelts in the area suffered from the usual water and climatic stresses (Figure #5). However, the deciduous species of the shelterbelts examined in close proximity to the potash operation also showed foliar damage symptoms typical of those produced in response to high sodium and potassium chloride salt accumulations. These include necrosis and chlorosis of the foliage which began at the leaf margins and moved intercostally inward (Figures #1 and #2). Other distress symptoms such as foliar and twig distortion were also present (Figure #6). It was apparent that the various

species represented in the shelterbelts had different sensitivities to the sodium and potassium chloride emissions (Table III). More information will need to be obtained from the Guernsey area in order to properly identify the responses of the receptor shelterbelts species to the potash production releases, define the impacts to the shelterbelts, and delineate the area where shelterbelts are currently affected.