ASSESSMENT OF VEGETATION DAMAGE FROM $S0_2$ AND H_2SO_4 MIST EMISSIONS AT THE RED RIVER BRICK AND TILE CO. LTD. LOCKPORT, MANITOBA

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ASSESSMENT OF VEGETATION DAMAGE FROM $S0_2$ AND H_2SO_4 MIST EMISSIONS AT THE RED RIVER BRICK AND TILE CO. LTD. LOCKPORT, MANITOBA

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ABSTRACT

During the period June 5 to August 28, 1986, observations were carried out to determine whether $S0_2$ gas and H_2SO_4 mist emissions from the Red River Brick and Tile Co. Ltd. were causing foliar damage to vegetation in the immediate vicinity of the plant. White spruce, trembling aspen and a wheat crop adjacent to the brick plant were observed and compared to controls three times during the growing season. Descriptions of typical damage symptomology cited in the literature aided by coloured photographic illustrations of actual field vegetation damage were used to assess the presence and extent of vegetation injury. It was concluded that although $S0_2$ concentrations may have been high enough to cause chronic vegetation stress, in fact no damage to vegetation was observed. Local environmental factors, production schedules and product changes at the plant may have reduced the impact of emissions on the vegetation.

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BACKGROUND

Red River Brick and Tile, a division of I.XL Industries Ltd., has operated a brick manufacturing plant near Lockport, Manitoba since 1971.

The plant uses blends of Manitoba clays and shales from various parts of the province. Several processes used in brick manufacturing produce emissions which ultimately escape into the atmosphere. Sulphur dioxide ($S0_2$) is emitted when kiln firing temperatures are high enough. Also, because there is a relatively high water vapor content in the kiln exhaust, sulphuric acid mist (H_2SO_4) is formed.

In May, 1984, the Air Standards and Studies Section carried out a study to determine ambient ground level concentrations of $S0_2$ and H_2SO_4 in the immediate vicinity of Red River Brick and Tile Co. Ltd. (Szkolnicki 1985).

Results of downwind mobile monitoring indicated an average hourly $S0_2$ concentration of 0.188 ppm (based on 60 hours of downwind monitoring). Concentrations of $S0_2$ exceeded the Manitoba Air Quality (M.A.Q.) maximum one hour acceptable level of 0.34 ppm $S0_2$ nine times. The highest one hour level was 0.54 ppm. The average background concentration upwind was <0.01 ppm $S0_2$'

For H_2SO_4 mist, the average one hour concentration downwind of the plant was 226 ug/m^3 (0.06 ppm), based on forty-eight monitoring hours. The highest one hour concentration was 859 µg/m^3 (0.21 ppm). Concentrations of H_2SO_4 mist exceeded the proposed M.A.Q. maximum one hour limit of 100 µg/m^3 thirty eight times. The average background concentration was <30µg/m^3 (<0.01) ppm.

At present there are no compliance limits for $S0_2$ or H_2SO_4 mist emissions for Red River Brick and Tile Co. Ltd.

Because the Air Pollution Control Section was concerned that the emissions could cause vegetation damage, they requested that the Terrestrial Standards and Studies section conduct a vegetation study to determine if any visible damage was occurring. This report presents the results of that study which was carried out during the 1986 growing season.

STUDY PROCEDURES

Selection of Vegetation for Observation

Vegetation surrounding the plant is comprised primarily of agricultural fields planted to wheat and alfalfa separated by windbreaks of deciduous species, such as young trembling aspen. The only coniferous vegetation in the area is a small shelterbelt of white spruce, about fifty years of age, approximately 250 m northeast of the stack (Figure 1).

For the purpose of this study trembling aspen was selected as the deciduous species for observation because it is the most common. The white spruce shelter belt was selected because it is the only conifer vegetation in the area. Also, it is close enough to the plant to be affected and has been exposed to the emissions since the plant started operation in 1971. In addition, a field of wheat located approximately 150 m south of the stack, was chosen for observation.

Landscape plantings of spruce as well as a residual stand of aspen between the floodway and PTH #59 at Birds Hill Park were used as a control. The control wheat field was located between PTH #7 and the east side of Little Mountain Park (within the City of Winnipeg south and west of the intersection of PTH #7 and the perimeter highway PTH #101.)

Vegetation Damage Assessment

For the white spruce shelterbelt, located near the brick plant, 5 branch tips (current and second year growth) on each side (exposed and lee) of the shelterbelt were selected and tagged for observation. Five aspen branch tips on each side of the deciduous shelterbelt south of the plant were also tagged. In the wheat field, adjacent to the lee side of the deciduous shelterbelt, 5 locations were randomly selected and each was marked with a tent peg. At the control sites only 5 branch tips were tagged for each of the spruce and aspen. Each of the 5 observation sites in the control wheat field were also marked with a tent peg.

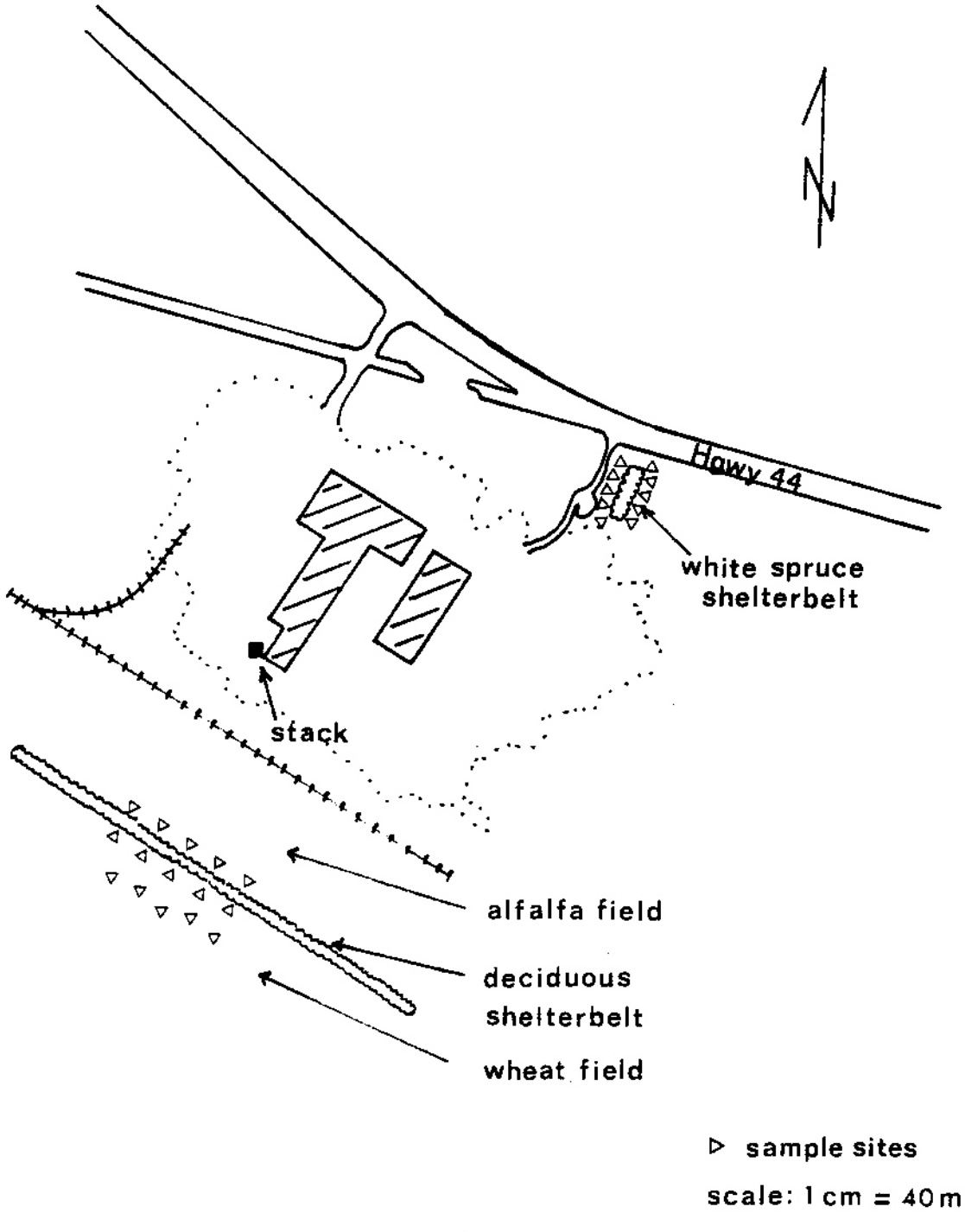

Figure 1. Sample site locations

Spruce needles, aspen leaves and wheat plants were checked for injury symptoms on three occasions; the foliage condition was documented with photographs. Observations began on June 5, to monitor any damage to new growth, since new growth tends to be more sensitive. The vegetation was examined again on August 6, to monitor any damage immediately after the period of maximum growth. The final survey was conducted on August 28, at the end of the growing season to assess the overall cumulative growing season damage, if any.

Damage assessments were made using a nine level coding system adapted from the manual, "Acid Rain National Early Warning System" (Canadian Forestry Service 1984). This manual is presently being used by the Terrestrial Standards and Studies Section and the Canadian Forestry Service to monitor for acid rain impacts at permanent biomonitoring sites. The coding was designed to record discoloration and other symptoms due to unknown abiotic causes. Symptoms caused by or attributable to insects and or diseases were also recorded. In addition, damage recognition and assessment was supplemented by descriptions and colour photo illustrations of actual $S0_2$ damage to vegetation in the field (Malhotra and Blauel 1980).

RESULTS

Early Growth Observations. June 5

At the spruce shelterbelt close to red River Brick and Tile all current year foliage appeared to be very healthy with no insect activity. Second year spruce foliage at two observation sites (one on the exposed and one on the lee side of the belt) had a low incidence of needle edge discoloration. In addition, two other sites, again one on each side, displayed a low incidence of edge discoloration as well as tip burn (ash-like tip). Insect activity appeared minimal, however insect webs and pupae casings were evidence of the presence of insects on older foliage.

At the deciduous shelterbelt south of the plant all the aspen foliage had healthy and normal coloring. However, extensive aphid and leaf miner activity was evident in the form of irregular shot holes, mining trails and discoloration typical of insect feeding.

Sample sites located in the wheat field south of the deciduous shelterbelt (lee side of deciduous shelterbelt) appeared very healthy. Nearby, some of the new germinants (two leaf stage 15 cm high) had a low incidence of tip browning, edge discoloration and brown longitudinal streaking along the entire leaf length. Insect activity appeared to be minimal.

Spruce control sites had normal color and were healthy with no insect activity evident. Control aspen foliage was normal except for extensive insect activity. The wheat in the control field was healthy, however, unlike the brick plant site, had extensive insect activity.

Mid Growth Season Observations. August 6

At the conifer shelterbelt, at Red River Brick and Tile, sites on both sides of the belt had healthy and normal coloration of current foliage except for one site on the le~ and one on the exposed side. Foliage on these two branches had minor marginal and tip discoloration. Second year foliage appeared healthy at all sites. Insect activity was rated low.

Sample sites along both sides of the deciduous shelterbelt displayed heavy insect activity. Foliage had numerous feeding patterns with accompanying discoloration. Foliar condition at the aspen control sites had a similar level of insect activity. The wheat sites at Red River Brick and Tile and the control were healthy and no insect activity was evident. The spruce control sites remained healthy and no insect activity was noted.

End of Growth Season Observations, August 26

Current year foliage at the spruce shelterbelt at Red River Brick and Tile appeared healthy. One branch on the exposed side, still had some minor tip discoloration. Also, one branch tip had been damaged by the wind and was dead. Second year foliage appeared healthy except for one branch which had a yellow green appearance. This was the same one that had edge discoloration when the earlier surveys were conducted.

Aspen sites at both Red River Brick and Tile and the control still had high levels of insect damage. These had caused the leaves to become somewhat chlorotic. The control spruce sites remained extremely healthy with no evidence of insect activity. Wheat sites at the Red River Brick and Tile and the control also remained healthy with no evidence of insect damage.

DISCUSSION

Low concentrations of $S0_2$ over an extended period of time or high concentrations over short exposure times can cause visible injury to vegetation (U. S. Environmental Protection Agency 1976, Malhotra and Sarkar 1979, Malhotra and Blauel 1980, Malhotra and Khan 1980).

Table 1 compares the $S0_2$ concentrations at which sensitive agricultural and forest plants may be damaged, with concentrations found in the 1984 Red River Brick and Tile Co. Ltd. study by Szkolnicki (1984). Injurious levels of $S0_2$ reported in the literature vary from 0.10 ppm - 1.00 ppm (1 hour average). The maximum one hour average $S0_2$ concentration recorded during the 1984 study was 0.54 ppm. The highest eight hour average $S0_2$ concentration in the 1984 Red River Brick and Tile study was 0.24 ppm while reports in the literature for concentrations with the potential to cause injury vary from 0.13 ppm to 0.95 ppm $S0_2$ (8 hour average). Because air monitoring was not carried out in 1986, it is not known if potentially injurious concentrations of $S0_2$ were present during the 1986 growing season. If the 1986 levels of $S0_2$ were the same as in 1984 they could have caused chronic stress/injury to sensitive vegetation in the immediate vicinity of the plant. However, injury to white spruce, aspen or wheat which might have been caused by $S0_2$ emissions was not observed in 1986. Either concentrations were lower or weather conditions at the time of exposure were not conducive to foliar injury. In 1984, H_2SO_4 mist concentrations downwind of the plant exceeded the proposed M.A.Q. guideline of 100 $\mu g/m^3$, 79% of the time, and the highest one hour average concentration was 850 $\mu g/m^3$, i.e. less than 1.0 ppm of H_2SO_4. However, even if concentrations of H_2SO_4 mist were similar in 1986, it probably would not have caused vegetation injury. In controlled experiments, 30 to 65 ppm of H_2SO_4 mist failed to cause injury to sensitive alfalfa and sugar beet (Linzon 1972, National Research Council 1977).

Table 1. Maximum tolerable $S0_2$ concentrations cited for sensitive vegetation.

Reference	Period	Maximum Tolerable $S0_2$ Conc. cited (ppm)	Maximum $S0_2$ Conc. Recorded-1984 study (ppm)
National Res. Council of Canada, 1977	1 (hr)	0.70	0.54
	8 (hr)	0.18	0.24
Ontario Ministry of Environment, 1978	1 (hr)	0.25	0.54
	8 (hr)	0.95	0.24
Malhotra and Blauel 1980	Various lengths of time	0.10 - 0.30	0.19*
Loman et al, 1982	1 (hr)	0.42	0.54
	8 (hr)	0.25	0.24
Linzon, 1972	1 (hr)	0.95	0.54
	8 (hr)	0.25	0.24
US. Environmental Protection Agency, 1976	1 (hr)	0.5 - 1.0	0.54

* Average hourly $S0_2$ level based on 60 downwind monitoring hours.

Because spruce foliage remains on the tree for several years, it can be used to assess past damage. Older foliage which was produced in the years 1982 through 1984 inclusive was examined. Needles which were 2 or 3 years old in 1984 would have been sensitive to $S0_2$ injury. There was no evidence of needle loss or injury during this period since the needle retention and condition was similar to the control spruce. Also, an examination of the general vigor of the shelterbelt showed no evidence of terminal dieback in the crowns, other physiological deformities or unusual insect and disease activity. This suggests that no acute or long term chronic stress has occurred in recent years.

The absence of damage symptoms in the presence of potentially chronic levels of $S0_2$ may in part be explained by the following factors:

1. The 30 year average prevailing wind direction for the May to August period at Winnipeg International Airport is south. The prevailing monthly wind directions recorded at St. Andrews Airport in 1986 were south southeast in May and south in June, July and August (Environment Canada 1982). Vegetation monitoring sites in this study are located south and northeast of the brick plant (Figure 1). Prevailing southerly winds during the monitoring period could well have contributed to minimizing any chronic or acute periods of $S0_2$ emissions impact.

2. Due to consumer demand for lighter coloured bricks, the plant has been using a clay with a lower sulphur content. In 1984 the plant utilized a higher proportion of clay from the Morden, Manitoba area, which contained high sulphur compounds. In 1986 the plant used more clay from Ste. Rose du Lac with less sulphur (*Dubesky, pers. com.). This production change may have resulted in a reduction in $S0_2$ levels.

3. The production schedule of the plant is determined by the volume and number of orders received. Therefore, the firing of the bricks in the high temperature kilns and the resultant release of $S0_2$ to the surrounding atmosphere is not a continuous process. The discontinuous nature of this manufacturing process could reduce the time that vegetation was exposed to the emissions.

   The sensitivity of vascular plants to $S0_2$ injury is determined by numerous factors including genetic characteristics, climatic conditions, nutrient status and physiological stage of plant development, to name a few. It may be that the presence or absence of these and many other factors precluded foliar damage even in the presence of potentially chronic levels of exposure.

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*(D. Dubesky - Environment Officer, Dept. of Environment and Workplace Safety and Health)

CONCLUSIONS

1. There was no evidence of past or present sulphur dioxide or sulphuric acid mist damage to vegetation in the immediate vicinity of the Red River Brick and Tile Co. Ltd.
2. Sulphuric acid mist levels are well below the levels, cited in the literature, which have the potential to cause vegetation injury.
3. It would appear that the potential for $S0_2$ related foliar injury has been reduced by a number of factors; a favourable prevailing wind direction during the growing season, the use of clay with lower sulphur content in 1986, the discontinuous nature of the manufacturing process and other unknown vegetative and environmental factors.

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