FILE REPORT NOR-Y-73

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COMMENTS ON THE VEGETATIVE SECTION OF THE CANADIAN PETROLEUM ASSOCIATION'S SUBMISSION TO THE ENVIRONMENT CONSERVATION AUTHORITY, ALBERTA DEPARTMENT OF THE ENVIRONMENT, EDMONTON, ALBERTA.

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INTRODUCTION

The Canadian Forestry Service was requested by the Environment Conservation Authority, Alberta Department of the Environment, to comment upon the contents of the vegetative section of a submission entitled "Environmental Effects of the Operation of Sulphur Extraction Gas Plants" and dated September 1972, and submitted to the Board by the Canadian Petroleum Association. The Canadian Forestry Service comment is contained herein.

COMMENTS

Readers of the Submission would have benefitted by some description of the modes of action by which sulphur dioxide injures plant tissues. To serve this purpose the following summarizes what is currently known.

Haselhof and Lindau (1903) reported that sulphur dioxide was bonded to aldehyde groups and that plant tissues were injured by the degradation of these compounds into sulphuric or sulphurous acid. Novak (1929) postulated that sulphur dioxide caused inactivation of iron in the chloroplasts which prevents the assimilation of organic compounds. Dorries (1932) stated that the interaction of acidic compounds resulting from sulphur dioxide split magnesium from the chlorophyll compound, changing it into a phenophytin and blocking the photosynthetic process. Thomas (1951) attributed the onset of acute injury symptoms to the excessive accumulation of either sulphite or sulphurous acid in plant tissues. Nikolavesky (1968) found that sulphur dioxide inactivated catalayse and increased both peroxidase and polyphenol-oxidase. Another report (Anonymous 1968) stated that hydrogen sulphide was formed from sulphur dioxide in the foliage, and this caused injury. Ziegler (1972) recently suggested that sulphur dioxide competes with carbon

dioxide for reaction sites and consequently interferes with photosynthesis. Wellburn (1972) has shown that sulphur dioxide causes swelling of the thylakoids within the chloroplasts and this damages them.

The harmful effects of air pollutants were separated by Guaderian (1960) into two distinct categories, 1) injury: the response of the plant 2) damage: the impairment of economic value. Knabe (1971) has established criteria by which harmful effects may be evaluated. In Tables 1 and 2 a modified form of this criteria is used to present the effects of sulphur dioxide on trees and forest communities that have been either reported in the literature or observed in the field by the author. These tables reflect a degradation in the condition or quality of the plants as they have deviated from their normal and do not express a comparison to a specific standard.

The phenomena which influence the effects of sulphur dioxide and other air pollutants on vegetation are summarized as follows:

1) The actual composition of the pollutant.

   A combination of gases can result in possible synergisms and predispositions or resistances.

2) The rate at which the pollutant reaches the receptor.

   This rate includes the concentration and quantity of the pollutants; and the interval and frequency at which the receptor is exposed.

3) The physical and physiological tolerance of the plant species to the pollutant as determined by genetic makeup.

4) The general vigor or health of the plant as a function of its ability to take stress.

5) The maturity and type of plant tissue the pollutant impinges on.

6) A wide variety of climatic conditions which strongly affect plant sensitivity both before and during exposure to the pollutant. These

factors include the qualitative and quantitative characters of light, temperature, wind, humidity and moisture. Loman et al (1972) provides a summary of conditions where tolerance levels are low.

7) Edaphic qualities such as soil moisture, acidity and nutritional availability.

In conclusion "conditions that favour good plant growth increase the capacity of the plant to assimilate sulphur dioxide, but reduce the plant's tolerance to this gas" (Loman et al 1972).

The Canadian Petroleum Association Submission makes reference to numerous studies which have been conducted on the variation in sensitivity of plants to sulphur dioxide gas. In each of these studies, only a few of the factors which affect sensitivity were chosen and tested as variables, with the other factors treated as constants. Examining the results of these studies out of context with the other variable factors results in an extremely attenuated picture regarding plant sensitivity rating, and some of the data presented in the submission strongly reflect this (e.g. Table 11 - 2 and Table 11 - 3).

The Submission contains reference to the sulphur dioxide sensitivity of the higher plants only, and disregards lower plants in the lichen and bryophyte groups which occur in abundance in all of Alberta's forest communities. These lower plant groups are much more sensitive to sulphur dioxide, with the lichens known to be damaged or eliminated from areas in England where constant annual concentrations of sulphur dioxide are around .02 ppm. (Mansfield and Bull 1972). Leblanc (1971) gives the following reasons for the lichen sensitivity to sulphur dioxide: 1) a high non selective capacity for accumulating substances from the atmosphere. 2) a low potential for

recovery after fumigation because of limited metabolic rates due to low chlorophyll content. 3) perennial evergreen habit. 4) lack of devices to close off gas transfer (the higher plants have specialized structures such as stomata which perform this task).

The sulphur dioxide concentration limits that are suggested in the Submission for Alberta are open to question. The evidence presented shows that damage does occur to Alberta plant species under the concentration limit recommended in the Submission. Dreisinger and McGovern's data from Sudbury, Ontario shown in Table 11 - 4 shows that damage did occur under .75 ppm. for 1 hr., during undefined environmental conditions to the following forest species which are native to Alberta: trembling aspen, jack pine, large toothed aspen, white birch, larch, willow and alder; and the following Alberta crop species: barley (missing from the table but included in Dreisinger and McGovern's 1970 presentation of the paper), oats, red clover, peas, rhubarb, timothy, lettuce, radish, squash, tomatoes, potatoes and raspberry. Wheat is not on the list of vegetation that Dreisinger and McGovern observed, but others have reported that it is a relatively sensitive species (e.g. Table 11 - 3 of the Submission lists it as such).

The environmental factors which control the susceptability of vegetation to sulphur dioxide were not reported in the evidence used in the Submission . Extrapolation of the "safe ground level concentrations and durations" from the data presented in the Submission to Alberta can be seriously questioned on this basis.

TABLE 1

INJURY CAUSED BY SULPHUR DIOXIDE AIR POLLUTION TO TREES AND FOREST COMMUNITIES

Criteria of effect	subject of investigation				
	part of a plant	individual plant	number of individuals	population (stand)	ecosystem
changes in cell components:	x	x	x	Na	Na
changes in metabolism	x	x	x	Na	Na
changes in cell structure	x	x	x	Na	Na
degree of foliar chlorosis or necrosis	x	x	x	Na	Na
premature foliar dropage	x	x	x	Na	Na
inhibited foliar growth	x	x	x	Na	Na
inhibited terminal growth	x	x	x	Na	Na
inhibited increment growth	x	x	x	Na	Na
predisposition to other stresses	x	x	x	Na	Na
plant death(s)	Na	x	x	Na	Na
percentage of plants injured to a certain degree	Na	Na	x	x	x
percentage of dead plants	Na	Na	x	x	x
decreased production of organic matter or decreased increment per area	Na	Na	Na	x	x
changes in number of species	Na	Na	Na	x	x
changes in abundance	Na	Na	Na	x	x
changes in coverage	Na	Na	Na	x	x
changes in general health conditions	Na	Na	x	x	x

x = detrimental changes have occurred

- = no changes have occurred

Na = not applicable to the category

TABLE 2

DAMAGE CAUSED BY SULPHUR DIOXIDE AIR POLLUTION TO TREES AND FOREST COMMUNITIES

Impairment in economic value	Subject of investigation				
Trees	part of a plant	individual plant	number of individuals	population (stand)	ecosystem
by reduced fiber yields					
a) wood fiber formed before pollutant release	Na	-	-	-	Na
b) wood fiber formed during pollutant release	Na	x	x	x	Na
by reduced quality of foliage (shelterbelts, ornamentals and Xmas trees)	x	x	x	x	Na
by decreased resistance to biotic and abiotic influences (e.g. bark beetles, frost)	x	x	x	x	x
Forest communities					
by increase of forest pests	Na	Na	Na	x	x
by reduced recreational value	Na	Na	Na	x	x
by reduced watershed value	Na	Na	Na	x	x
by reduced wildlife habitat	Na	Na	Na	x	x
by alterations in forest influences (e.g. filter capacity)	Na	Na	x	x	x
impairment in ideal value	x	x	x	x	x

x = detrimental changes have occurred

- = no changes have occurred

Na = not applicable to the category

LITERATURE CITED

Anonymous. 1968. Plants absorb sulfur dioxide release hydrogen sulfide. Sulfur Inst. J. 4: 17.

Dreisinger, B.R. and P.C. McGovern. 1970. Monitoring atmospheric sulfur dioxide and correlating its effects on crops and forests in the Sudbury area. Proc. Impact of Air Pollution on Vegetation Conference, Toronto: Pp. 23.

Dorries, W. 1932. Uber die Brauchbarkeit der spectroscopischen Phaophytinprobe in der Rauchschaden-Diagnostik. Z. Pflanzenkrankh. u. Gallenkunde 42: 257-273.

Guderian, Robert, H. Van Haut, H. Stratmann. 1960. Problems of the recognition and evaluation of the effects of gaseous air impurities on vegetation. Z. Pflanzenkr. Pflanzenpathol. Pflanzenschutz. 67 (5)257-264.

Haselhof, E. and G. Lindau. 1903. Die beschadigung der vegetation durch rauch. Gebruder Borntraeger. Leipzig. 412 p.

Knabe, Wilhelm. 1971. Air quality criteria and their importance for forests In: Proceedings of the XV Congress of IUFRO, Working Group "Fume damage" Sect. 24, pp 129-150.

Leblanc, Fabius 1971. Biological Methods for Mapping Atmospheric Pollution. In: Proceedings of the XV Congress of IUFRO, Working Group "Fume damage" Sect. 24 pp 104-126.

Loman, A.A., R.A. Blauel and D. Hocking. 1972. Sulphur dioxide and Forest Vegetation. Info. Rept. NOR-X-49. Nor. For. Res. Centre.

Mansfield, T.A. and J.N. Bull. 1972. The effects of SO_2 Pollution on Plant Life. In: The Environment This Month, Aug. Issue, Lancaster, England.

Nikolaevsky, V.S. 1968. Activity of certain enzymes and the gas resistance of woody plants. Trud. Inst. Ekol. Rast. Zivot. Ural sky Fil. ANSSSR 62: 208-211.

NOVAK, K. 1929. Damage to vegetation from gases in smoke. Z. Angew. Chem. 42: 123-126.

Thomas, M.D. 1951. Gas damage to plants. Ann. Rev. Plant Physiol. 2: 293-322.

Wellburn, A.R., O. Majernik and F.A.M. Wellburn (1972): Effects of SO_2 and NO_2 polluted air upon the ultrastructure of chloroplasts. Environmental Pollution 3: 37-49.

Ziegler, I. (1972): The effect of SO_3^{--} on the activity of ribulose-1, 5-diphosphate carboxylase in isolated spinach chloroplasts. Planta (Berlin) 103: 155-163.

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