

**Air quality observed
in the Sorel region in 1995**

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Introduction

The cities of Sorel and Tracy, located on the St. Lawrence River, are home to a number of metal manufacturers such as *QIT- Fer et Titane Inc.*, *Tioxide Canada Inc.* and *Atlas Stainless Steels*. These industries are major sources of atmospheric emissions of particulate matter and volatile organic compounds (VOCs). According to the Residual Discharge Inventory System (RDIS), particulate emissions from *QIT- Fer et Titane Inc.* totalled over 12,223 tonnes in 1990, more than for all other firms in this sector in Quebec. This company in particular has already been the focus of special attention by governments, and the Quebec Department of the Environment (MENV) has measured various pollutants from several sources at the plant. Consequently, Environment Canada and MENV worked together to initiate an ambient air sampling program in 1995 to determine if this industrial zone was affecting air quality in the region.

The locations of sampling stations were chosen by taking into account meteorological conditions in the region during the study period (August and September 1995). Three sites were selected: Tracy, St. Ignace de Loyola and Sorel (Figure 1). The following parameters were measured in the project: fine particulate matter with a diameter less than 10 μm (PM_{10} and $\text{PM}_{2.5}$), metals, polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs). Data on total suspended particulates (TSP) and SO_2 measured on a regular basis by MENV at the station located at the Sorel post office were also included, as were data on TSPs measured at the St. Joseph de Sorel station.

Table 1 Summary of parameters measured during project

Parameter and site	TSP	PM_{10} and $\text{PM}_{2.5}$ Dichotomous sampler	PAH	VOC	SO_2	NO_x
Sorel	X	X	X	X	X	X
St. Ignace de Loyola		X	X			
Tracy		X	X			
St. Joseph de Sorel	X				X	

Location of sampling sites in Sorel area

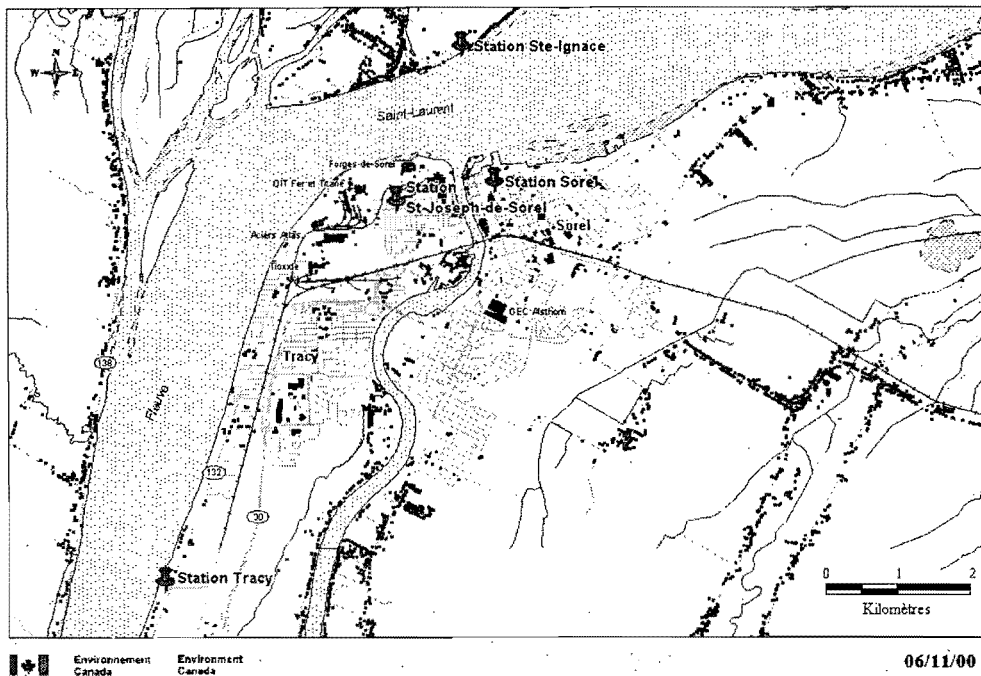


Figure 1 Location of sampling sites

Results

The results obtained by MENV show that TSP were higher in Sorel (median: $44.5 \mu\text{g}/\text{m}^3$) than in St. Joseph de Sorel (median: $32 \mu\text{g}/\text{m}^3$). Data obtained from the PAH samplers showed that particulate levels were higher at St. Ignace de Loyola than at Sorel and Tracy (results not shown); these samplers do not provide reliable TSP measurements, however. Levels of fine particulate matter (PM_{10}) were highest at Sorel, intermediate at St. Ignace de Loyola and lowest at Tracy (Table 2). Measures of the fine ($\text{PM}_{2.5}$) and coarse ($\text{PM}_{2.5-10}$) fractions of PM_{10} made with the dichotomous sampler showed that, in Sorel, the coarse and fine fractions were equally high with values of 53% and 47% respectively (Table 3). At St. Ignace de Loyola and Tracy, however, the coarse fraction was greater (60%) than the fine fraction (40%). These results can be explained by the fact that the St. Ignace de Loyola site is located downwind of the industrial area and by the presence of excavation work near Tracy.

Table 2 Summary of TSP and PM₁₀ concentrations measured in the Sorel region during the project

Parameter	TSP		PM ₁₀		
	Sorel	St. Joseph de Sorel	Sorel	St. Ignace de Loyola	Tracy
Sampler	High volume	High volume	Dichotomous	Dichotomous	Dichotomous
n (number of samples)	10	11	9	8	10
Mean	41.9	39.4	15.8	11.3	7.6
Median	44.5	32	15.3	10.1	7.2
Minimum	24	24	7.2	3.1	3.5
Maximum	58	67	29.5	28.5	16.3

Table 3 Distribution of the coarse fraction (PM_{2.5-10}) and fine fraction (PM_{2.5}) of PM₁₀ measured during project (µg/m³)

Station	Sorel		St. Ignace de Loyola		Tracy	
	Coarse (2.5 - 10 µm)	Fine (< 2.5 µm)	Coarse (2.5 - 10 µm)	Fine (< 2.5 µm)	Coarse (2.5 - 10 µm)	Fine (< 2.5 µm)
n (number of samples)	9	9	8	8	10	10
Mean	8.44	7.36	7.20	4.11	4.58	3.03
Median	8.27	6.51	6.15	3.3	4.14	2.16
Minimum	3.76	3.39	2.12	0.98	1.35	1.55
Maximum	17.9	21.5	18.6	9.92	11.1	5.89

At the St. Ignace de Loyola station, unlike the Sorel and Tracy stations, PM₁₀ levels (including both the coarse and fine fractions) increased significantly with the number of hours the station was downwind of the industrial area (Figure 2). At Sorel, a significant relationship was found between the wind direction and the coarse fraction but not for the fine fraction.

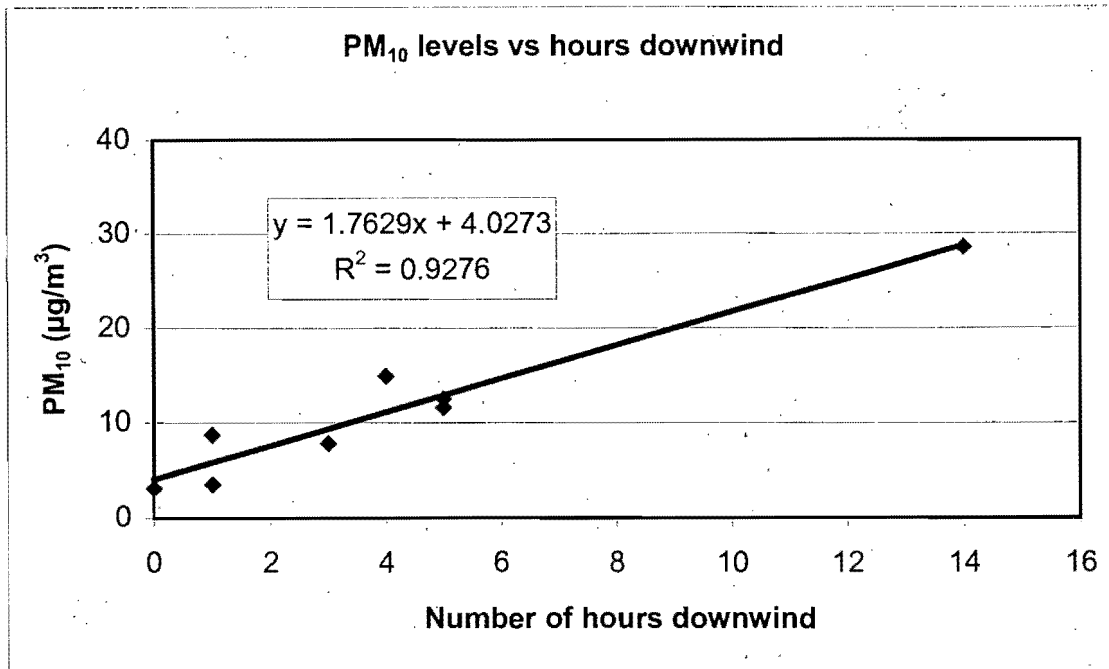


Figure 2: Influence of wind direction on PM₁₀ levels measured at St. Ignace de Loyola

Particulate matter levels were generally lower in Sorel and St. Ignace de Loyola than in Montreal, but similar to or greater than levels measured in less polluted environments elsewhere in the province. Values for Tracy were comparable to those measured in rural areas. TSP levels obtained with the high-volume sampler were within ambient air quality criteria and, throughout the project, no values exceeded the criteria used by the *Communauté urbaine de Montréal* (Montreal Urban Community) for PM₁₀.

Metal levels found in PM₁₀ were generally higher in Sorel and lower in Tracy (Table 4). Overall, the 15 elements found in the greatest concentrations in the particulate matter sampled at the three stations represented over 90% of all metals measured. The total metal content represented close to one third of the mass of PM₁₀ sampled at each site. Some metals such as iron, calcium and aluminium were found mainly in the coarse fraction, while others such as sodium and sulphur were found mainly in the fine fraction; a few metals such as titanium were found more or less equally in both fractions. Although metals found in the coarse fraction can usually be attributed to local emission sources, this does not mean that elements found predominantly in the fine fraction come exclusively from distant sources. Sulphur in the fine fraction, for example, may come from either distant or local emission sources. In general,

sulphur found in particulate matter results mainly from the atmospheric transformation of sulphur dioxide (SO₂).

Table 4 Median concentrations of the 15 most common elements and the total metal content (Σ) measured at the three stations

Sorel		St. Ignace de Loyola		Tracy	
Metal	Concentration ($\mu\text{g}/\text{m}^3$)	Metal	Concentration ($\mu\text{g}/\text{m}^3$)	Metal	Concentration ($\mu\text{g}/\text{m}^3$)
Ca	0.5430	Fe	0.5005	S	0.3155
Fe	0.5080	Ca	0.4781	Pr	0.2745
S	0.3800	S	0.4077	Si	0.2431
Si	0.3791	Si	0.3760	Fe	0.2276
Na	0.2018	Al	0.1353	Ca	0.2102
Pr	0.2010	Na	0.1321	Al	0.1134
K	0.1561	K	0.1074	Na	0.1113
Al	0.1479	Pr	0.0990	K	0.0588
Ti	0.0748	Ti	0.0794	Ti	0.0358
Mg	0.0734	Mg	0.0495	Mg	0.0315
Zn	0.0487	Zn	0.0342	P	0.0244
P	0.0414	Mn	0.0193	Zn	0.0178
Mn	0.0342	Cl	0.0143	Cl	0.0153
Cl	0.0264	Cu	0.0138	Cu	0.0143
Cu	0.0254	P	0.0124	W	0.0101
Σ 47 metals	3.7759	Σ 47 metals	2.8055	Σ 47 metals	2.2818

Iron and titanium, among the most abundant metals measured in the ambient air during the project, were also found in the gases emitted from the emergency flares at *QIT- Fer et Titane Inc.* during a characterization study carried out in 1992 (Bougie 1995). Sulphur has traditionally been, and still is, one of the gases emitted in great quantities into the atmosphere by this industry. An analysis of metal levels, taking account of the effects of wind direction, shows that the industrial area had a significant influence on ambient air levels of iron, sulphur and titanium in St. Ignace de Loyola (Figure 3). Calcium and sodium levels also increased when the sampling site was directly downwind of the industrial area (not illustrated). In Sorel, however, levels of these five metals could not be linked statistically to wind directions from the industrial area. Lastly, in Tracy, metal levels were found to decrease when the wind was coming from the direction of the industrial area, located roughly six kilometres away.

The metals measured in St. Ignace de Loyola reflected the composition of particulate matter produced in electric arc furnaces: iron, zinc, silica, calcium oxide, sodium oxide, sulphur, and

aluminium oxide (Hatch Associates 1995a, 1995b). Titanium could also come from *Tioxide Canada Inc.* since this firm processes titanite iron ore and produces titanium oxide (Rallon 1991).

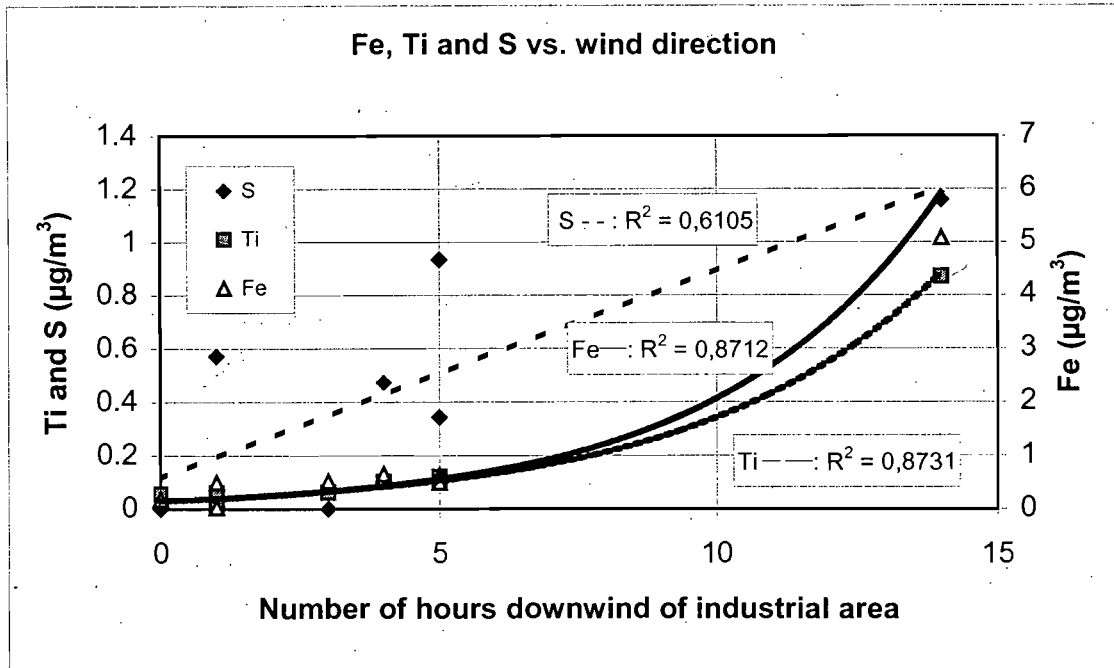


Figure 3 Influence of wind direction on levels of Fe, Ti and S measured at St. Ignace de Loyola

Although Quebec has few standards on metal concentrations, lead levels were within the legal limit. Atmospheric lead concentrations have no longer been a problem in the province since lead gasoline was banned.

Real-time measurements of SO_2 and NO_x were taken at the Sorel station under Quebec's air quality monitoring program, the *Programme de surveillance de la qualité de l'atmosphère* (PQSA). Only low concentrations of these contaminants were found during the 1996 sampling program, falling within applicable federal air quality objectives and provincial standards. In the case of SO_2 , however, mean hourly and 24-hour concentrations measured in Sorel over an entire year exceeded these standards and objectives (MENV 1995). SO_2 and NO_x may be emitted by local industries, while NO_x emissions may also result from motor vehicle transport.

PAH concentrations were highest in Sorel, intermediate at St. Ignace de Loyola and lowest at (Table 5). The main PAHs measured were phenanthrene, fluorene, 2-methylfluorene, fluoranthene and pyrene. Only small concentrations of B(a)P, one of the most studied products

in this family, were found. At St. Ignace de Loyola, PAH levels increased with the number of hours the station was downwind of the industrial area. Although PAHs were found in gas emissions from two sources at *QIT-Fer et Titane Inc.*, an analysis of relationships between the various PAHs measured in the ambient air showed that vehicle emissions were the main source of PAHs in the Sorel regions. In general, the PAH values obtained were representative of values found in other environments in Quebec relatively unaffected by point sources. B(a)P concentrations obtained were also below Quebec's annual interim standards (0.9 ng/m³); the standards did not really apply in this case, however, due to the limited duration of the project.

Table 5 Summary of PAH and B(a)P concentrations (ng/m³) measured in the Sorel region during the project

	Sorel	St. Ignace de Loyola	Tracy	Sorel	St. Ignace de Loyola	Tracy
Product	PAH			Benzo(a)pyrene [B(a)P]		
n	10	9	10	10	9	9
Mean	30.7	17.5	11.6	0.16	0.34	0.17
Median	33.2	16.4	12.7	0.08	0.40	0.05
Minimum	17.9	7.1	4.7	0.02	0.09	0.01
Maximum	43.3	29.0	18.4	0.65	0.62	0.19

VOCs were only sampled in Sorel during the project. The ten VOCs with the highest concentrations made up roughly 80% of all VOCs found and consisted of toluene, xylenes, benzene, 1,1,1-trichloroethane and 1,4-dichlorobenzene (Figure 4). Trichloroethane and trichloroethylene are often linked to the iron and steel industry, while 1,1,1-trichloroethane, 1,2,4-trimethylbenzène, benzene, toluene and xylenes may come from industrial processes using coke ovens, according to information from U.S. steel plants (Hatch & Associates Ltd. 1995a and b). An analysis of the results based on wind direction does not show any significant relationship between the industrial area and VOC levels during the project. Automobiles are probably the source of many of the VOCs since vehicle emissions may also contain toluene, benzene and xylenes. The main contributors to the formation of photochemical oxidants are xylenes, 1,2,4-trimethylbenzene and toluene. VOC concentrations measured in Sorel were lower than those observed in Montreal, but were slightly higher than those measured in Brossard.

Main VOCs measured in Sorel

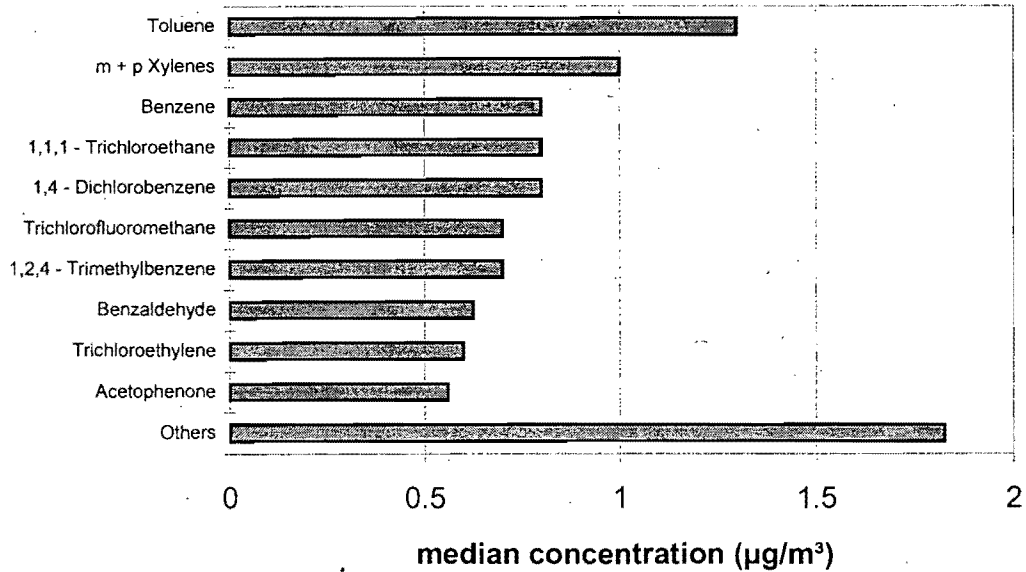


Figure 4 Main VOCs measured in the ambient air in Sorel during the project

Conclusion

In conclusion, emissions of pollutants from industries in Sorel were found mainly to have an effect on levels of total suspended particulates and metals in the surrounding region. Of all the sampling stations, the station at St. Ignace de Loyola was the one most affected by emissions from the industrial area during the project. Even though some PAHs and VOCs could have come from the industrial area, other sources such as motor vehicles seemed to have had more impact on levels obtained at the sampling stations. All standards and criteria taken into account were met.

If the sampling program had been carried out at a different time of year, however, different results might have been obtained due to changes in the prevailing winds. The results do not suggest that emissions from the industrial area had any impact on air quality in Sorel, since winds rarely came from the direction of the industrial area during the project (less than 5% of the time).

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