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Sulphur Dioxide and Health

Summary of recent findings from Health Canada

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Overview

Health Canada has recently concluded a literature review of the current state of research into the health impacts of airborne sulphur dioxide (SO_2).[1] The study identifies what has been learned by recent health investigations and research into exposure to ambient airborne SO_2.

This research is the basis for setting a Canadian Ambient Air Quality Standard (CAAQS) for SO_2 to improve air quality and reduce health risks.

The main findings are:

- Acute (short-term) exposure to sulphur dioxide is linked to respiratory morbidity (illness)
- Sensitive populations such as asthmatics, children, unborn children, and the elderly are more susceptible to adverse effects when exposed to SO_2 at current ambient levels
- There may be a causal relationship between long-term, low-level exposure to sulphur dioxide and prenatal development issues (congenital heart defects and preterm delivery). This warrants further research.

Progress to reduce sulphur dioxide has been made across Canada in the last 20 years. However, Alberta is the country's largest emitter of sulphur dioxide. The oil and gas sector has reduced its contribution over time but remains the largest source of SO_2 in the province, while the coal-fired power sector is a close second — and its total SO_2 emissions have remained relatively unchanged over the last 20 years. Coal-fired emissions represent the largest opportunity to make improvements in human health by reducing SO_2 in Alberta. This reaffirms the necessity of the Alberta government's plan to phase out coal by 2030.

Health Canada research and implications for Albertans

Acute exposure

The primary finding from the research highlights strong evidence of causality between acute (short-term) exposure to SO_2 and respiratory morbidity. Respiratory morbidity generally refers to the reduced health or function of the respiratory system, and includes health conditions such as asthma, bronchitis and emphysema.

Monitoring data, corroborated by exposure modelling, shows that for most Canadians, exposure to SO_2 occurs during intermittent spikes in ambient concentrations.

There was strong evidence for causality between short-term SO_2 exposures and respiratory morbidity, based on controlled human exposure studies. The assessment identified a 10-minute human health reference concentration of 67 parts per billion (ppb). Exposure to concentrations greater than this for 10 minutes would likely result in health impacts, especially for sensitive subpopulations.

The current 1-hour Alberta Ambient Air Quality Objective for SO_2 is 172 ppb, and does not reflect this new research by Health Canada. At this higher concentration, and over the longer 1-hour period, SO_2

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[1] Health Canada, *Human Health Risk Assessment for Sulphur Dioxide: Analysis of Ambient Exposure to and Health Effects of Sulphur Dioxide in the Canadian Population* (2016). http://publications.gc.ca/collections/collection_2016/sc-hc/H144-29-2016-eng.pdf

concentrations are likely to result in health impacts even while they do not exceed the provincial standards.

Prenatal and early childhood exposure

Just as our understanding of the risk for the overall population of short-term high-level exposure to SO_2 has become clear, a new concern is emerging: low-level SO_2 exposure to pregnant women and the resulting health impacts in prenatal and postnatal development. The assessment identifies the need for further research to understand the prenatal health risk of low-level exposure to airborne SO_2; however, current research does identify a high certainty of health effects in prenatal development and a high certainty for public exposure to the levels of SO_2 that can cause these effects.

Further study is warranted to identify the specific pathway by which SO_2 affects prenatal development, the specific concentration where health effects arise, and the influence of other co-pollutants in those effects. While there is some evidence of connections between prenatal SO_2 exposure and pre-term birth, congenital heart defects, cleft lip, and asthma, further research is necessary to confirm if a cause and effect relationship exists.

This gap in knowledge is a concern since the health effects may present themselves at relatively low concentrations, and at ambient concentrations routinely experienced throughout Canada.

Sensitive populations

Overall, this new research supports the finding that the following sensitive populations are more susceptibility to adverse effects from SO_2 exposure under current Canadian ambient conditions:

- Asthmatics (8.9 per cent of Canada's population)
- Unborn children
- Children
- Elderly people (14.8 per cent of Canada's population)
- People with odour impairments (this typically comes from reoccurring exposure to high concentrations; people so affected are less able to notice and remove themselves from dangerous levels of pollution)

This adds to the evidence of increased risk to these populations from poor air quality; these groups are also known to be sensitive to smog and fine particulate matter which are also components of air pollution.

Sources of sulphur dioxide

The emissions of SO_2 from natural sources, such as volcanoes and forest fires, are estimated to be small compared to industrial sources. Environment Canada estimated that natural sources of SO_2 accounted for approximately 100 tonnes in 2011, while man-made sources added 1 million tonnes in the same year. For SO_2, natural sources are rarely relevant.

Early recognition of the contribution of SO_2 to acid rain led to policies that have achieved reductions of SO_2 pollution in recent decades. These include new requirements for low-sulphur transportation fuels implemented in the 1990s, more stringent standards for sulphur recovery at oil and gas facilities, and, most recently, Ontario's phase out of coal-fired electricity generation.

Alberta is now the largest contributor to Canada-wide sulphur oxide pollution, emitting approximately 12 per cent more than Ontario while having less than one-third of the provincial population.

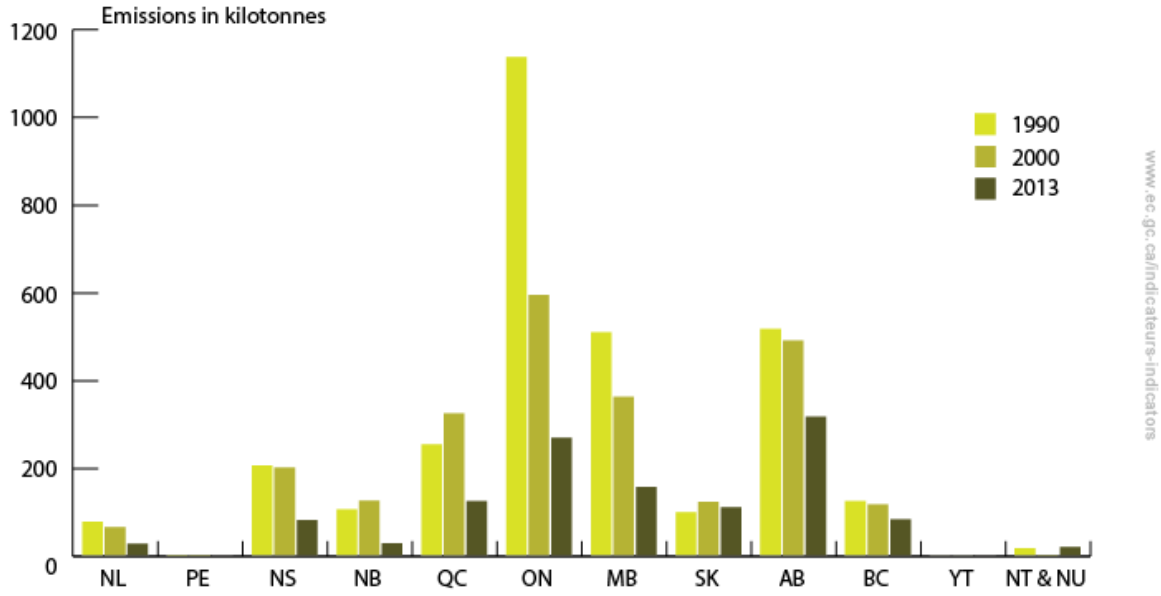

Figure 1: Canadian sulphur oxide emissions by province and territory

Source: Environment Canada[2]

The two largest sources of man-made SO_2 in Alberta are the upstream oil and gas industry and coal-fired electricity generation. Together these two sources accounted for 92 per cent of Alberta's SO_2 pollution in 2014. Historically, emissions from the upstream oil and gas industry have been the dominant source in Alberta, but this sector has seen a substantial decrease in SO_2 from the high levels measured in the mid-90s. In contrast, there has been no significant reduction of SO_2 from coal-fired electricity generation in Alberta.

While improved sulphur standards from oil and gas facilities have led to lower overall SO_2 pollution, the growth of oil and gas operations in some regions has actually led to localized higher exposures. Oil and gas operations and their associated SO_2 emissions range from relatively small (small, distributed well sites) to very large (oilsands operations or sour gas processing), and many operations can be, and typically are, located close together resulting in higher localized concentrations of SO_2 in certain areas.

In contrast, the emissions from coal plants are concentrated in only six facilities in Alberta (see Figure 3),with the vast majority at only three general plant locations. In particular, coal plants dominate SO_2 pollution in the Capital Region where they contribute to ongoing wintertime smog events. In investigating these episodes, Alberta Environment determined that 69 per cent of total SO_2 pollution was produced by coal-fired electricity facilities in the Capital Region.[3]

The prevalence of these sources in certain regions of Alberta is also demonstrated by Environment Canada's video modelling of SO_2 plumes from large emitters across British Columbia, Alberta and Saskatchewan. The three-dimensional plumes reflect SO_2 concentrations of at least three parts per billion. The way in which the plumes travel was modelled using real weather conditions from a four week period in the fall of 2013. The video visually represents where SO_2 is generated, how it moves through the atmosphere and where it eventually lands.[4]

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[2] Environment and Climate Change Canada, "Sulphur Oxide Emissions." https://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=402A9845-1

[3] Alberta Environment, *Capital Region Fine Particulate Matter Science Report* (2014), 33.

[4] Pembina Institute, "New images of air pollution in Alberta", October 8, 2015. http://www.pembina.org/blog/new-images-of-air-pollution-in-alberta#videxp

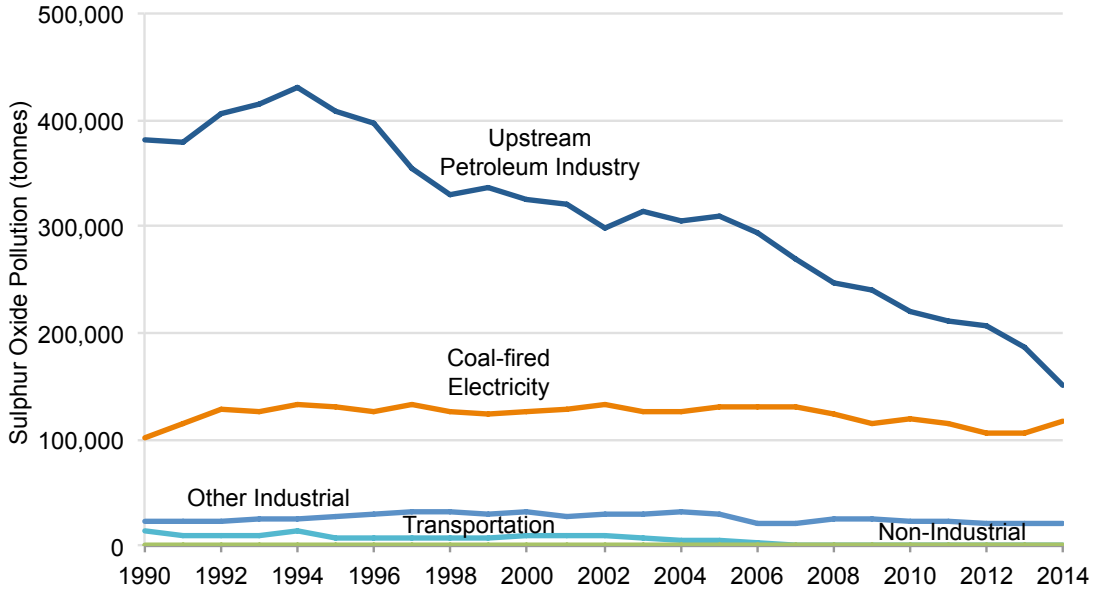

Figure 2: Alberta historic man-made sulphur oxide emissions

Data source: Environment Canada[5]

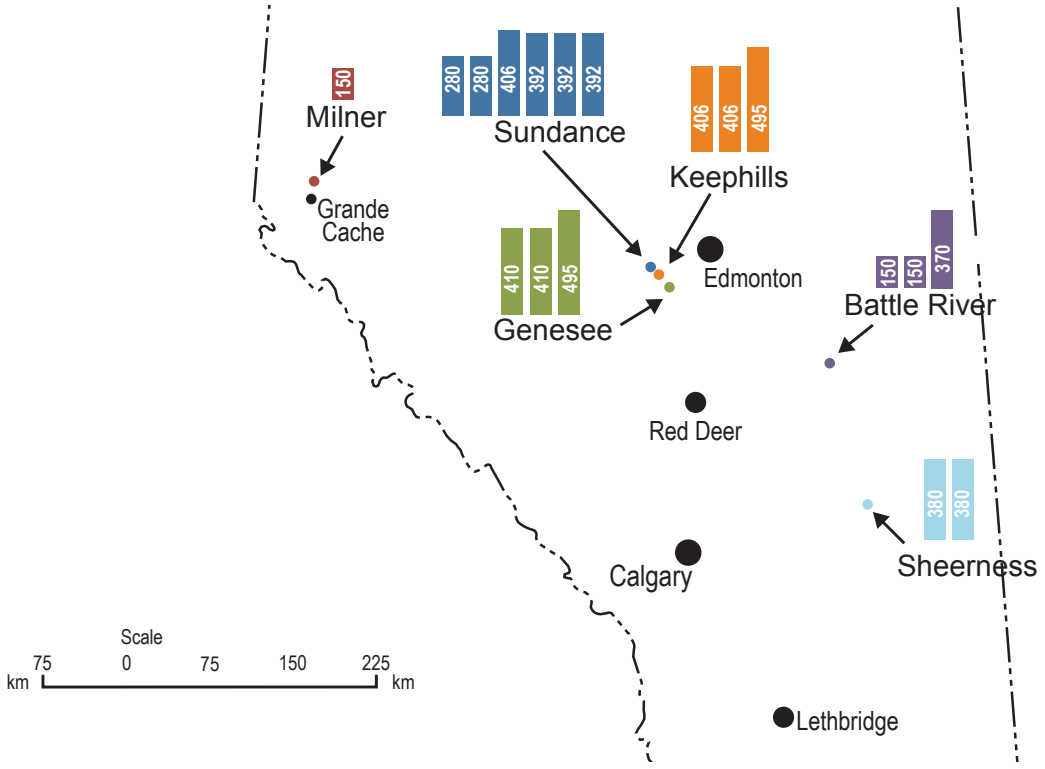

Figure 3: Coal-fired electricity generation units in Alberta (coloured bars denote unit size in MW)

[5] Environment Canada, Air Pollutant Emission Inventory. http://www.ec.gc.ca/inrp-npri/donnees-data/ap/index.cfm?lang=En

This evaluation of the sources of SO_2 in Alberta highlights the main opportunities for reducing overall public exposure to this pollutant. By far the biggest opportunity to make major reductions is for Alberta to remain committed to the phase out of all coal-fired electricity by 2030. Phasing out this one source alone would reduce provincial SO_2 pollution by 40 per cent and move Alberta out of the top-polluter rank. Ensuring that the oil and gas industry remains committed to reducing its overall SO_2 pollution — particularly in areas with a high concentration of oil and gas activity — would reduce exposure to this pollutant even further.

Summary of Health Canada findings

The table below summarizes the findings of the SO_2 health risk assessment, as reported by Health Canada.

Table 1: Summary of the human health effects assessment conclusions

Endpoint	Exposure Duration	Effects	Health Canada Conclusions
Respiratory morbidity	short-term	Respiratory symptoms, lung function, airway inflammation, airway hyperresponsiveness, emergency visits/hospitalizations	Causal relationship (adults) Causal relationship (children)
	long-term	Respiratory symptoms and lung function	Inadequate to infer a causal relationship
Cardiovascular morbidity	short-term	Emergency visits/hospitalizations	Inadequate to infer a causal relationship
	long-term	Blood markers, arterial stiffness	No conclusion
Mortality	short-term	Non-accidental and cardiopulmonary	Suggestive of a causal relationship
	long-term	Non-accidental and cardiopulmonary	Inadequate to infer a causal relationship
Carcinogenicity	•	DNA damage, carcinogenesis, co-carcinogenesis or tumour promotion, incidence of lung cancer	Inadequate to infer a causal relationship
Developmental	•	Congenital heart defects	Weakly suggestive of a causal relationship
Reproductive/ Developmental	•	Preterm delivery	Weakly suggestive of a causal relationship
		Intrauterine growth restriction, Cleft lip and cleft palate, neonatal hospitalization and infant mortality	Inadequate to infer a causal relationship
Prenatal and neonatal outcomes	•	Low birth weight	Inadequate to infer a causal relationship