Effectiveness of the national pollutant release inventory as a policy tool to curb atmospheric industrial emissions in Canada

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Highlights

- National Pollutant Release Inventory data accuracy is understudied
- Facilities across steel making, power generation, and oil extraction sectors report increasing emissions
- Self-reported data from industry requires verification to ensure government programs are successful in achieving their goals

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Abstract

To curb greenhouse gas emissions and reduce concentrations of toxic substances in Canada's atmosphere, many pieces of environment legislation are targeted at reducing industrial emissions. Traditional regulation prescribes penalties through fines to discourage industries from polluting, but in the past two decades, alternative forms of environmental regulation like the National Pollutant Release Inventory (NPRI) have been introduced. NPRI is an information management tool which requires industries to self-report emissions data based on a set of guidelines determined by Environment and Climate Change Canada, a federal agency. The tool works to inform the public regarding industry emissions and provides a large database that can be analyzed by researchers and regulators to inform emissions trends in Canada. These tools have seen some success in other jurisdictions (e.g., United States and Australia). However, some research assessing the U.S Toxic Release Inventory suggests there are fundamental weaknesses in the self-reported nature of the data, and incidences of under-reporting. This preliminary study aimed to explore NPRI in Canada and test its effectiveness against the National Air Pollutant Surveillance Network (NAPS), an air quality monitoring program administered by the federal government. While instances of under-reporting were undetected, their study identified areas of weakness in the NPRI tool and instances of increasing emissions across various industrial sectors in Canada.

Keywords: Air pollution; National Pollution Release Inventory; National Air Pollutant Surveillance Network; Industrial emissions; Self reporting; Environmental regulation.

1. Introduction

A regulatory tool that has recently gained traction as an alternative to traditional forms of environmental regulation are information management tools that provide publicly available self-reported data from industry (Bui and Meyer, 2003). These tools have been implemented successfully internationally. The United States (U.S.) Toxic Release Inventory (TRI) is arguably the most developed environmental pollutant reporting system and longest running tool, beginning in 1986 (US EPA, 2016). Australia also recently developed such a tool, the National Pollutant Inventory (NPI) in 1998, basing much of the guidelines on the TRI (Australian Government, 2015). Enacted under federal legislation, the National Pollutant Release Inventory (NPRI) is Canada's version of the information management tool (Tang & Mudd, 2014). The NPRI provides publically-accessible data regarding pollutant emissions and transfers from a variety of industries across the country. The NPRI was first established in 1993 and received legislative authority under the *Canadian Environmental Protection Act* in 1999. The tool is managed solely by the federal agency, Environment and Climate Change Canada (ECCC) (ECCC, 2016a).

Commercial facilities and industries that surpass reporting thresholds outlined under CEPA are required, by law, to report emissions data to the inventory. Failing to report emissions is punishable under CEPA 1999 guidelines (ECCC, 2016a). It is the facility's responsibility to gather their own data for reporting, which has been a point of discussion in the true accuracy of the tool. Reporting is aimed at gathering data on significant point-sources and contaminants of high quantities present in the environment. Currently, there are 343 listed substances tracked by NPRI and in 2014, 7720 facilities reported to the database (ECCC, 2016a). Since its inception,

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substances have been added or removed based on their current use or environmental effects. ECCC may refer to other countries that have similar tools in place to guide the substance list. Similarly, advancements in science and technology may prompt the addition of new substances that had not been previously considered. Although reporting is required by law, reducing emissions is voluntary, making the tool an alternative to conventional policy and regulation (ECCC, 2016a).

The data is organized and compiled into an online database, accessible to the public (https://www.ec.gc.ca/inrp-npri/). The NPRI intends to serve many functions. The inventory has five major goals to: (1) assist in identifying pollution prevention priorities; (2) support the assessment and risk management of chemicals and air quality monitoring; (3) help develop regulations to reduce releases of air pollutants; (4) promote actions to reduce emissions; and (5) inform the public (ECCC, 2016a). In recent years, the NPRI has also worked to inform multilateral environmental agreements, such as the Clean Air Strategy (Officer of the Auditor General, 2009). The tool provides communities information that may inform their purchasing habits, and attitudes towards particular industries. Interestingly, the government does not make explicit reference to the NPRI's ability to give power to the public in a 'right to know' framework. It is the intention, however, that the NPRI tool acts as an incentive for industries to improve their environmental standards.

Overall, the NPRI programs had been viewed as successful in the early literature assessing the first few years of the NPRI being in effect (Harrison and Antweiler, 2003a). It was estimated that the first three years of the NPRI brought a reduction of 38% in reported emissions.

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Similar results were seen in the U.S., prompting many observers to suggest self-reporting policies may be equally as effective as traditional regulatory measures (Harrison and Antweiler, 2003a, Dingwerth and Eichinger, 2010).

However, there has been some evidence suggesting weaknesses in the programs. Issues including lack of compliance, data inaccuracies, and the omission of substances from reporting have been suggested for the US TRI (Gottlieb et al., 1995). One such study identified under-reporting in the US TRI after comparing the self-reported data to air quality surveillance monitoring stations around emitting facilities (DeMarchi and Hamilton, 2006). In a review of current literature regarding Canada's NPRI, very few studies were identified (eg. Hoffman et al., 2015). In particular, there were no identified empirical studies that examined NPRI data in comparison to measured ambient emissions.

In efforts to understand the potential weaknesses that may exist in the NPRI, self-reported data was compared to monitoring data from the National Air Pollutant Surveillance Network (NAPS) (https://www.ec.gc.ca/rnspa-naps). NAPS data is collected, monitored, and analyzed by ECCC and has air quality monitoring stations across Canada. By using the NAPS as a reliable indication of pollutant concentrations in the atmosphere around Canadian facilities, comparisons were drawn between trends in both datasets. This study aims to (1) outline the current NPRI and NAPS programs; (2) understanding the current theoretical framework governing pollution abatement incentives; (3) compare NPRI and NAPS data to inform the accuracy of reporting; (4) analyze NPRI data and trends, and; (5) provide recommendations on improving the NPRI program.

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1.1 National Pollutant Release Inventory

The NPRI was initially received as a success from many scholars and policy-makers considering the initial few years of the program (Harrison and Antweiler, 2003b). Their positive outlook suggested the intention of the inventory, to publicize otherwise embarrassing data, had prompted consumer or environmental group pressure to influence industries. However, other factors may be driving decreasing emissions such as regulations or economic factors. Harrison and Antweiler (2003) attempted to understand what was driving polluters to lower emissions by examining NPRI data. They assessed the percent change of NPRI data over a seven-year period between 1993-1999. However, the authors pointed out that during the time that data was collected, many reporting changes had been occurring due to the relative infancy of the NPRI.

An interesting observation in the data is that a few particular facilities had exceptionally large emission reductions which influenced the overall provincial and national reduction percentages (Harrison & Antweiler, 2003). The drastic reduction in a paint pigment facility was seen as an anomaly and prompted by federal and provincial regulatory enforcement actions (Harrison & Antweiler, 2003). Similarly, pulp and paper mills, which also contributed greatly to the overall emission reductions, were under the control of extensive provincial regulatory reforms in the 1990s and stricter federal enforcement measures (Harrison, 1995, 1996). Following an analysis on the introduction of guidelines for pollutant releases, it was found the pulp and paper mills reduced emissions likely because of traditional forms of regulation, such as provincial industrial approval regulations (Hoffman et al., 2015). While the studies were not able to definitively conclude the sole reason for decreased emissions, presumably reductions may be

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attributable to a combination of factors, including traditional regulatory instruments (Harrison, 1996).

Harrison and Antweiler (2003) did, however, identify some fundamental weaknesses in the NPRI tool. Of most evident, is the self-reporting nature of the tool. The industries ability to report and recover their own data presents a clear bias, and combined with minimal oversight from regulating bodies, industries are often left to estimate. These estimations are under no particular scrutiny for reliability, which can have the potential for hugely miscalculated values. Further, estimation methods may be altered over time, which can skew the data. For example, research on the U.S. TRI found that 50% of industries studied reported production-related waste reductions, were actually re-categorizing waste streams, rather than actual reduction in pollution levels (Natan and Miller, 1998). Last, the NPRI is focussed on high-quantity emissions from toxic contaminants. Some toxic contaminants can pose human or ecological health problems at very low concentrations, which may be over looked (Harrison and Antweiler, 2003). The NPRI undergoes extensive changes each year. These changes may be the addition of substances, alterations in reporting methods, or recommendations for estimation methods, which poses problems when assessing the data over time (Fig. 1).

<FIGURE 1 HERE>

1.2 National Air Pollutant Surveillance Network

The NAPS network is another emissions monitoring tool managed by ECCC to gather long-term ambient air quality data, for public release, from 286 stations across Canada. The program is a collaboration between multiple provinces, territories, and municipalities (Fig. 2; ECCC, 2013; Hoffman et al., submitted). Stations collect samples in air canisters are then analyzed by ECCC for over 167 volatile organic compounds, including sulfur dioxide, carbon monoxide, and

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particulate matter. The program has been in effect since 1970, providing consistent data for >20 years (ECCC, 2013).

<Fig 2 here>

<Table 1 here>

The NAPS network is arguably a more accurate environmental monitoring tool than NPRI (Table 1). For example, NAPS data is collected and analyzed by ECCC. Whereas, NPRI data is voluntarily reported introducing potential inaccuracies or under-reporting (Hoffman et al., 2015). Further, NAPS is a consistent monitoring tool, in which hourly, daily, and monthly data are produced (ECCC, 2013). Data has been collected and analyzed using similar methods since inception. By comparison, NPRI is self-reported, and self-estimated data. Substance releases have been based on thresholds determined by ECCC (ECCC, 2016a), but thresholds have frequently changed year-to-year, making inter-annual emissions comparisons difficult. Moreover, NPRI self-reporting provides flexibility in the collection of emissions data. Emissions to land, water, and air are reported on-site. Recently, facilities were also required to report emissions off-site. ECCC (2016a) recommends best practices for estimating emissions data; however, industries often alter methods used to calculate emissions. Facilities are also required to maintain their own records using their own methods, which introduce opportunities for inaccuracies in reported releases.

2. Incentives for Pollution Abatement

The NPRI works as a tool to inform the public, regulatory bodies, and industry about their emissions data. Several incentives exist that drive pollution abatement by industries. A combination of internal and external pressures work to effect change in a facilities pollution control. Internal pressures include the number of employees working at a facility, which influences the scale of production, management, and production volume. According to Harrison and Antweiler (2003), external factors are categorized into five groups: consumers, workers, shareholders, community groups, and regulators.

In another study, Antweiler and Harrison (2003) assessed how industries respond to pressures from verified or anticipated green consumerism. They used economic modelling to predict the effect of green consumerism on companies. Results indicated potential impact of green consumerism on companies with greater exposure to consumer markets. For example, companies that were more likely to be influenced by green consumerism, made great progress in decreasing emissions. However, the impact of green consumerism identified in the model was still very small.

Another incentive to reduce emissions in response to programs like NPRI is benefits from public recognition. A company that adheres to these programs, reduces emissions, and publicizes their success in participating in voluntary programs may not only improve public perception of the company, but other benefits. These benefits allow firms to increase market shares, or increase prices for their products because of participation in NPRI-like programs (Khanna, 2001). Community groups and environmental watchdog organizations can pressure companies to participate in pollution abatement activities. Harrison and Antweiler (2003), suggest at the national and local levels interest groups typically focus on facilities with the highest emissions. Larger facilities that receive more interest from interest groups are more likely to curb emissions.

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Incentives to reduce emissions are not solely from community pressures, but also investor and market-based pressures. These pressures may be for a variety of reasons whether investors have true concerns about the environment, receive community pressure, self-interest in negative effects from a community, or government pressures (Harrison and Antweiler, 2003). Similarly, facilities that do exhibit poor environmental performance, investors may view this as a risk to exposing the company to liability, penalties, and the costs of compliance in the future. These influences may have the potential to alter the company's stock prices (Khanna et al., 1998). Traditional regulation and coercive pieces of legislation are arguably one of the greatest incentives for pollution abatement. Understandably, facilities will reduce emissions if required to do so by law. Therefore, traditional regulation that may be the cause for decreases in emissions observed in NPRI and TRI programs. Several studies suggested that increasingly strict regulations were the most important determining factor for facilities to reduce emissions (Khanna, 1999). In particular, Harrison and Antweiler (2003) found that traditional regulations like the *Fisheries Act* and *Canadian Environmental Protection Act* were the greatest causes for emission reductions reported in NPRI during the 1990s.

3. Methods

To understand accuracy of NPRI reporting, a comparison of emission trends between NPRI and NAPS data was conducted. Emission trends were compared at three facilities across Canada including paper and pulp, energy generation, and steel making. Multiple industry types were selected to compare trends across different sectors. When choosing facilities, the amount of available data was considered. Initial review of NPRI data yielded many gaps in reported

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emissions that would not provide sufficient data for analysis. Facilities with multiple data gaps were omitted. Further, consideration was given to the types of reported substances. To compare NPRI and NAPS data, substances that were reported consistently between 2002 and 2015 were required. Three reported substances overlapped between NAPS and NPRI, and were used for this study (sulphur dioxide, carbon monoxide, and nitrogen dioxide). Locations of facilities and location of NAPS stations were also considered. According to DeMarchi and Hamilton (2006), when comparing the TRI inventory to an air surveillance monitoring, a radius of 50 km was used between facilities and monitoring stations. For this study, facilities and monitoring stations were between 3.5 and 10km away. Wind direction was not considered in this study.

Facilites included a steel plant in Hamilton, Ontario (ArcelorMittal Dofasco, 43°15'34.9"N 79°48'40.0"W), energy generation plant in Sault Ste. Marie in northern Ontario (Essar Power, 46°31'18.1"N 84°21'49.3"W), and an oil and gas facility in Fort McKay, Alberta (Suncor Power, 57°02'33.0"N 111°54'18.0"W). The NAPS and NPRI websites were used to collect all data. Yearly mean (ppb) emissions for each substance were recorded from 2002 to 2015. Data was imported into Microsoft Excel to create scatter plots and calculate correlations.

4. Results

4.1 NPRI Data

In the steel making facility, slight upward trends were observed for all substance releases, but all were weakly correlated (Fig. 3). Nitrogen dioxide emissions were highly variable, particularly, between 2014 and 2015 where a sharp decline was observed.

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Consistent decreases in emissions were observed across all substances at the energy generation plant (R^2 = 0.353-0.763) (Fig. 4). Sulphur dioxide showed only a weak decreasing correlation where emissions were lower in 2009 but increased by 2012. Carbon monoxide and nitrogen dioxide decreased sharply releases decreased sharply. The lowest recorded emissions were observed between 2009 and 2010 for all 3 substances. Peak nitrogen and carbon monoxide emissions were observed in 2008.

Oil and gas operations in Fort McKay at the Suncor plant showed consistent increases in emissions between 2002-2015 (Fig. 5). Sulphur dioxide emissions increased seven-fold from 2002 to 2015 (R^2 = 0.65). In 2012, releases reached 180 kg/year. Nitrogen dioxide releases have seen two considerable peaks in emissions during 2009 and 2012. Only weak upward correlations were observed in nitrogen dioxide and carbon monoxide releases.

4.2 NAPS Data

NAPS data is collected and analyzed continuously. Mean annual measurements of substances at stations showed wide variation. NAPS data was measured and reported in parts per billion (ppb).

Mean sulphur dioxide concentrations near the Elgin and Kelly monitoring station (steel industry) showed little temporal variation. Initial measurements in 2002 showed an average sulfur dioxide concentration of 5 ppb. After 13 years, average concentrations in 2015 were 5.1 ppb. Mean nitrogen dioxide concentrations decreased slightly after 13 years (21 to 12 ppb). Carbon monoxide concentrations were stable with the inter-annual variation.

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Mean nitrogen dioxide concentrations measured near the power generating monitoring station remained constant at 5 ppb from 2006-2015. Prior to 2006, data were unavailable and were not included in this study. Mean sulphur dioxide concentrations varied between 0.6 - 2 ppb throughout the study. Mean carbon monoxide concentrations were unavailable. Missing data and monitoring stations lacking analyses for particular substances were common making data interpretation challenging.

Mean sulphur dioxide concentrations remained stable near the oil and gas NAPS monitoring station (~1 ppb). Data were missing for 2007. Mean nitrogen dioxide concentrations increased slightly from 4 to 7 ppb at the Fort McKay monitoring station. Mean carbon monoxide data were unavailable. Although, the next nearest monitoring station (30 km east of the original monitoring station) reported data.

4.3 NPRI vs. NAPS

Mean NPRI and NAPS concentration data were compared to assess for correlations and determine accuracy of NPRI data. Carbon monoxide concentrations in NAPS data from the power generation and oil and gas sectors were unavailable and were excluded from analyses. In all three substances assessed at the steel making facility, no strong correlations were identified between the NAPS and NPRI data (Fig. 6). At the oil and gas facility, sulphur dioxide emissions had a prominent negative correlation between NAPS and NPRI data (Fig. 7). While NAPS indicated decreasing substance concentrations, NPRI releases showed increasing sulfur dioxide releases from 2002-2015. However, because of stable substance concentrations between NAPS data, it is difficult to observe trends between NAPS and NPRI data. Results from the oil and gas facility indicated very weak correlations between NPRI and NAPS releases. In most cases,

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NAPS data only had variations between 1-3 ppb changes in substance concentrations. The power generation plant also did not have any strong correlations between NPRI and NAPS data (Fig. 8). Sulphur dioxide showed weak positive correlation because both NPRI and NAPS decreased slightly. Nitrogen dioxide had a fairly weak positive correlation between the NPRI and NAPS data (Fig. 8).

5. Results and Discussion

Decreasing emissions were not observed in the oil and gas, and steel industry cases. While only weak increasing substance releases were reported, it raises concerns, despite positive national outlooks from NPRI on emissions. Even slightly increasing emissions suggest that NPRI is failing to inspire the change it aims to promote, nor are other environmental regulations that closely monitor criteria classified air contaminants such as carbon monoxide and sulphur monoxide. The power generation plant was the only example that yielded obvious decreases in emissions over 13 years. Interestingly, in 2009, the Essar power plant opened a co-generation facility to reduce dependence on the provincial power grid by 50% and to reduce nitrous oxide emissions by 15% (400 tonnes/year) (Northern Ontario Business, 2009). However, NPRI results did not indicate substantial decreases in any substances assessed. Many nitrogen dioxide decreased the following year by approximately 220 kg, but emissions have steadily increased since.

Between 2012 to 2014, the steel making facility faced 13 different environmental charges by the provincial Ministry of Environment. Charges were related to their coke-making facility and allowing air emissions that blocked light by more than 20% for six consecutive minutes. Permitting light to be blocked by air emissions for this amount of time is a violation of the

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Environmental Protection Act. The company pled guilty to six of the charges and was fined $350,000 CAD (CBC, 2014a). The lack of decreasing emissions was observed throughout this study despite having traditional regulatory tools (e.g. *Environment Protection Act*). At the steel making facility, only the strictest of regulations may be able to induce change. For example, slight decreases in nitrogen dioxide and sulphur dioxide were observed following the *Environmental Protection Act* violations.

It seems unlikely that NPRI has been responsible for positive changes in the steel making facility emission practices as increased emissions were observed for most years. In 2014, Dofasco announced it would be removing one of their coke ovens and upgrading two others (CBC, 2014b). Although attributing reductions in emissions due to these upgrades remains to be seen. The oil and gas facility also had increases in emissions, but cyclical nature of the industry may be responsible (Gulas et al., 2017). Suncor itself has also been charged with multiple environmentally related infractions over the past decade (e.g., CBC, 2009). The majority of these violations require payment of a fine and activity can proceed as usual. Seeing as there were increases in emissions over the years it is highly unlikely that NPRI has been successful in informing citizens and igniting industry to take action in reducing their emissions.

NAPS substance concentrations remained fairly stable over 13 years. Similarly, previous literature found underreporting was occurring in other jurisdictions (e.g. U.S. TRI) (Koehler and Spengler, 2007). It was assumed that NPRI emissions would be decreasing due to the NPRI website indicating successes in decreasing emissions across all sectors (ECCC, 2016a). However, NPRI and NAPS data were compared and there was no strong correlation found. Most NAPS data across all sectors indicated minor decreases in substance concentrations. However, NPRI data mostly indicated increasing in emissions. While underreporting may responsible, this

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was not verified.. However, increasing emissions in the oil and gas, and steel industry suggest there is no incentive to underreport or implement pollution abatement techniques.

Underreporting emissions may occur for several reasons. Reputation of the facility may be a reason to underreport emission levels, using a tool such as NPRI which aims to inform the public. Reporting lower emission levels to the NPRI database may also be advantageous for a facility if regulatory officers review the data. For example, it would likely reduce the likelihood of any ‘red flags’ in their emissions. While there may be incentives to underreport, facilities like Dofasco do not seem to receive attention due to NPRI-derived data. Despite NPRI data indicating increases in emissions, Dofasco received penalties because of traditional forms of regulation (e.g. *Environmental Protection Act* violations). Presumably NPRI data informed regulators, but changes in emissions may only result from hefty fines and penalties. Because the NPRI tool receives little attention from the media, community, and NGOs, incentives for companies to improve pollution abatement techniques to reduce emissions levels on the publicly accessibly NPRI site remains low.

6. Recommendations

Although this study provided limited evidence of inaccurate NPRI reporting or a lack of correlation in NAPs and NPRI data, it helps highlight the lack of scholarly research conducted to assess the effectiveness of NPRI. Several studies by Harrison and Antweiler (2003) were used to inform this study, but those were the few studies identified which specially addressing the Canadian environmental monitoring tool (Mudd, 2014). Earlier studies conducted on NPRI were mostly published in the 1990s when the tool was first introduced, but there has been a lack of

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studies using NPRI data since. Conversely, the U.S.' TRI has an extensive body of literature using the tool to assess effectiveness of TRI data to inform other areas of research, such as health (Currie et al., 2015). The TRI has been established five years longer than NPRI and is more robust (e.g., website accessiblity, substance list, and funding). More research related to the NPRI tool is required, as it has the potential to provide information that can readily accessed by the public, researchers, and regulators. For example, more research critically analyzes the tool may assist in improving the NPRIs functions.

Allowing the public to understand and to subsequently promote change in industry practices and their toxic releases is one of the main goals of information-based tools such as NPRI. However, if data is difficult for the public to access, then the ability of the tool to inform communities may not succeed. A particular issue that creates a level of unawareness is the relationship between reported discharges and impacts to environmental or human health. Trends displayed in the data only provide the weight (mass) of discharged substances; however, these amounts must be compared to guidelines (i.e., CCME) to understand levels of toxicity. Reporting mass discharge does not indicate levels of toxicity or risks imposed. If public understanding is to be increased, then individuals using NPRI data need to understand how toxic emission levels are to their community. Furthermore, improvements in website accessibility would assist public navigation of the site to find information related to facilities in their area. Substance information should be presented more clearly so that the public can understand what the substance is, where it is derived, and what the potential environmental and health impacts are.

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While the self-reporting nature of NPRI creates an inherent weakness in the accuracy of data, particular issues arise when assessing temporal data over time. Facilities that report data may change estimation methods over time. Data is reported to an online system organized by ECCC. Guiding documents on how estimations should be made are provided to organizations, but adpoting these methods are not required by law. In previous studies (e.g., DeMarchi and Hamilton, 2006), it was observed changes in emissions were most likely due to *paper reductions*, where facilities altered the way they categorized emissions or substance releases. Considering facilities that meet the standard, by law, must report to NPRI, more stringent estimation measures would increase data accuracy. Over time, guidance documents prepared by ECCC may also alter the recommended estimation protocals used to measure substances. When using NPRI data, changes to reporting methodology should be taken into account when assessing temporal trends.

Similarly, thresholds used to determine whether a substance should be reported. These thresholds may also change over time, creating data gaps. Sectors required to report is also a changing variable in NPRI reporting, which further reduces the accuracy of data. Despite NPRI reporting being required under law, facilities are not required to conduct additional monitoring beyond what information is available and what is already required under the provisions of other legislation or bylaws. Because of this, there is not enough incentive for facilities to improve their quality of data reporting. Another weakness in NPRI is facilities are not required to report to NPRI if they have less than ten employees, despite producing NPRI-listed substances, small facilities may still cause large impacts on the environment depending on released substances but will not be reported on NPRI, reducing the number of reporting facilities. Improving the accuracy of data is not limited to reporting measures, but also quality assurance. Most quality

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checks to ensure data is properly reported is desk based through the reporting computer system. Increasing on-site visits to ensure substance reporting is accurate may improve the overall accuracy and place pressure on facilities to always maintain accuracy record keeping of their emissions. Improving our accuracy of NPRI data may not only improve analyses but may entice more attention from researchers and greater use by the public.

7. Conclusion

The NPRI tool was once met with praise as a new form of regulation aimed at decreasing emissions in Canada. Initially decreases were seen across the country; however, studies from other jurisdictions have indicated flaws in self-reported information tools citing underreporting of emissions and inaccuracy in substance release estimation. This study sought to assess the accuracy of NPRI data by comparing substance release data to NAPS measurements. Emissions have increased over time in steel and oil and gas facilities assessed. Further, NAPS data indicated only very slight decreases. No strong correlations were identified when NPRI and NAPS data were compared. The lack of correlations makes it difficult to identify whether these datasets are consistent or inconsistent with each other. No conclusive evidence was found of underreporting. Despite the NPRI website reporting decreases in emissions across the county, the facilities assessed in this study reported that emissions have increased. Improvements should be made to the NPRI tool to strengthen its effectiveness in meeting its goals. Improving public understanding of the tool is key to increasing the power NPRI may have in influencing facilities to decrease their emissions. By making improvements to the NPRI tool, the public may have

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increased awareness of emissions in their communities, inspiring them to promote change in industrial pollution.

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Table 1.: Comparing NPRI and NAPS.

	NPRI	**NAPS**
Reporting Method	Self-reported	Year round monitoring stations
Frequency of Reporting	Annually	Hourly
Analysis	Yearly ECCC report	Yearly ECCC report
Substances Listed Amount	343	167
Years of Reporting	24 (started in 1993)	36 (Started in 1970)

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Figure Legends

Fig. 1. Changes made to the NPRI substance list over time (adapted from ECCC, 2016a).

Fig. 2. Locations of NAPS monitoring stations across Canada (adapted from ECCC, 2013).

Fig. 3. Steel industry NPRI data (kg) from 2002-2015.

Fig. 4. Power generation NPRI data (kg) from 2002-2015.

Fig. 5. Oil and gas NPRI data (kg) from 2002-2015.

Fig. 6. Comparison of NPRI and NAPS data for each substance for a steel making facility from 2002-2015.

Fig. 7. Comparison of NPRI and NAPS data for sulphur dioxide and nitrogen dioxide for an oil and gas facility from 2002-2015.

Fig. 8. Comparison of NPRI and NAPS data for sulphur dioxide and nitrogen dioxide for a power generation facility from 2002-2015.

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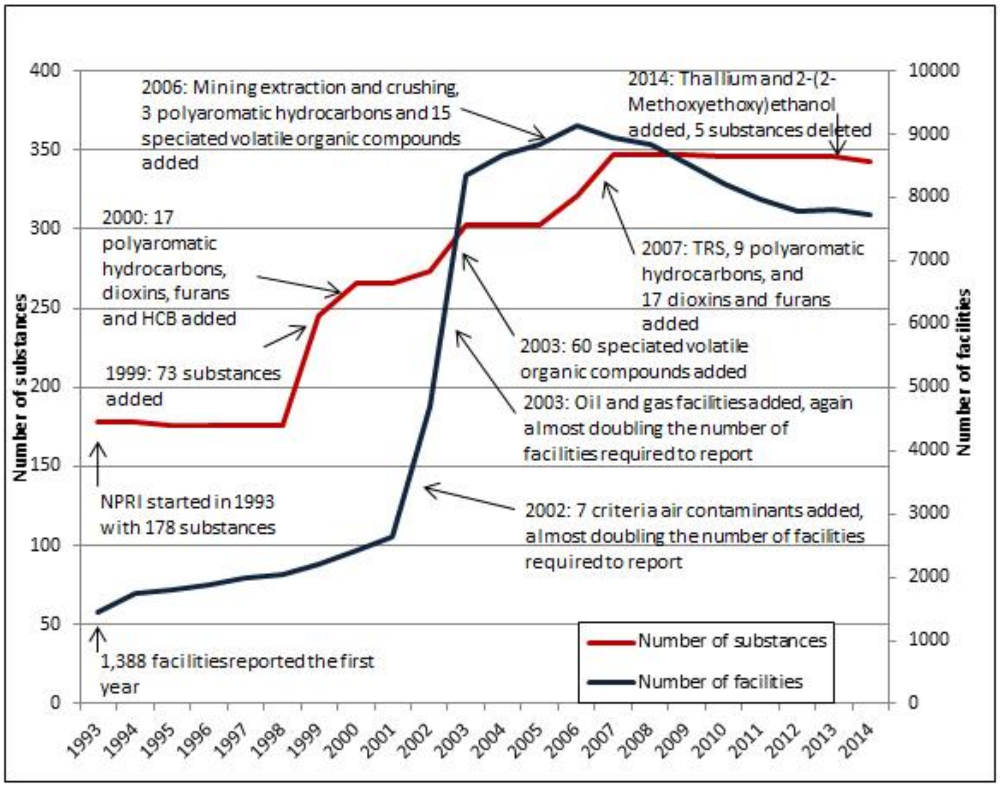
Fig. 1



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556 **Fig. 2**

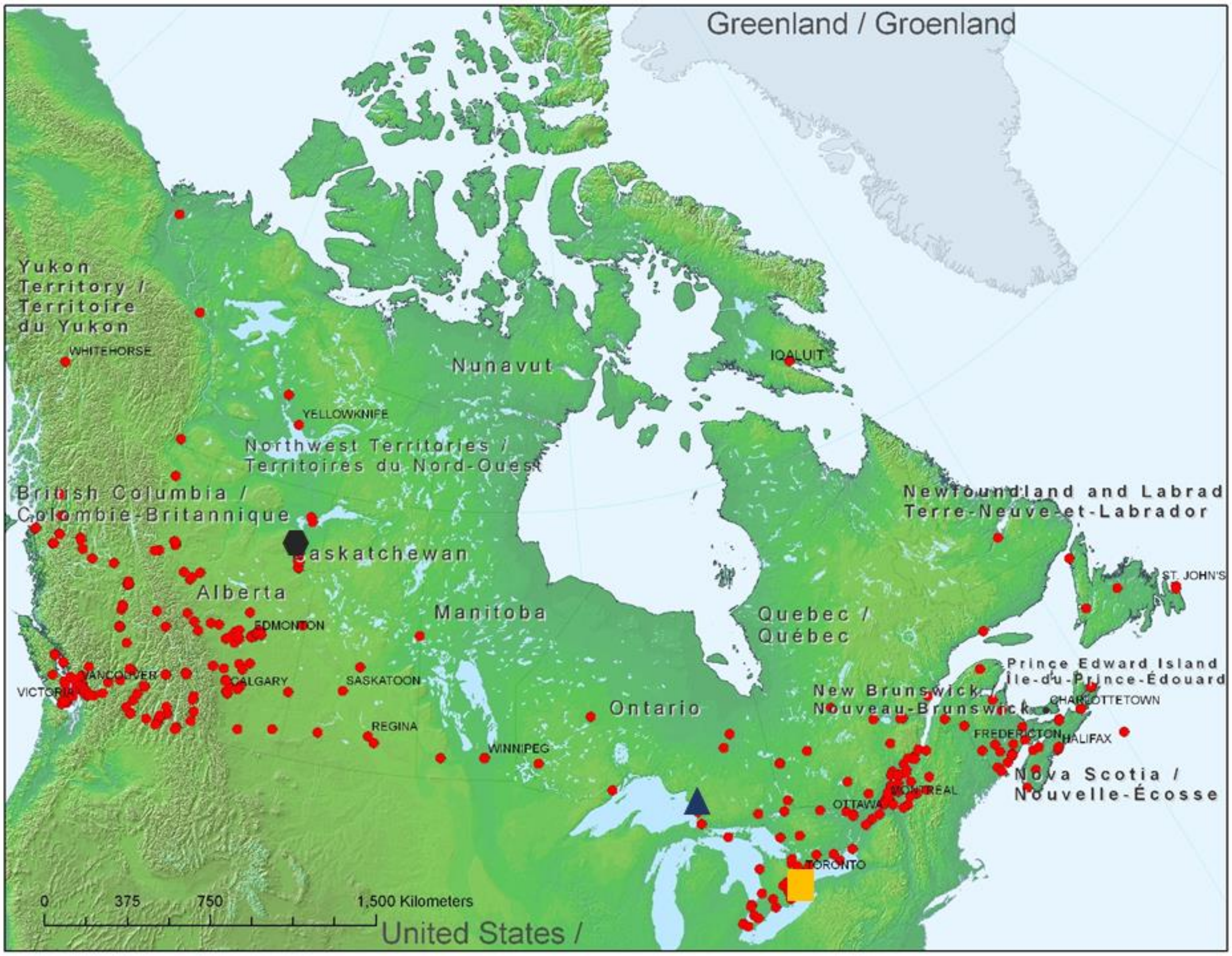

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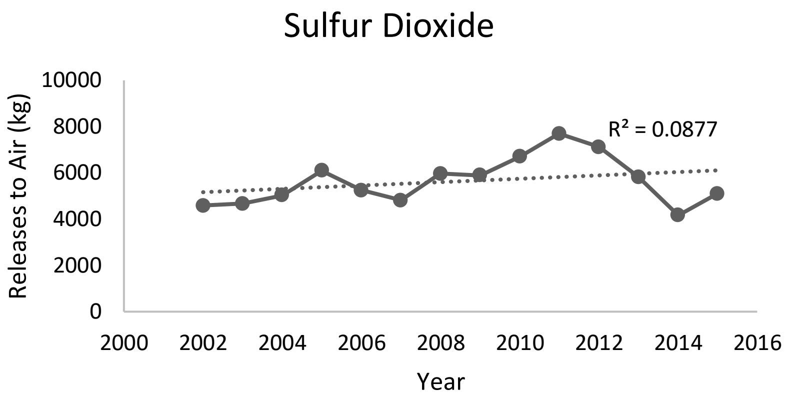
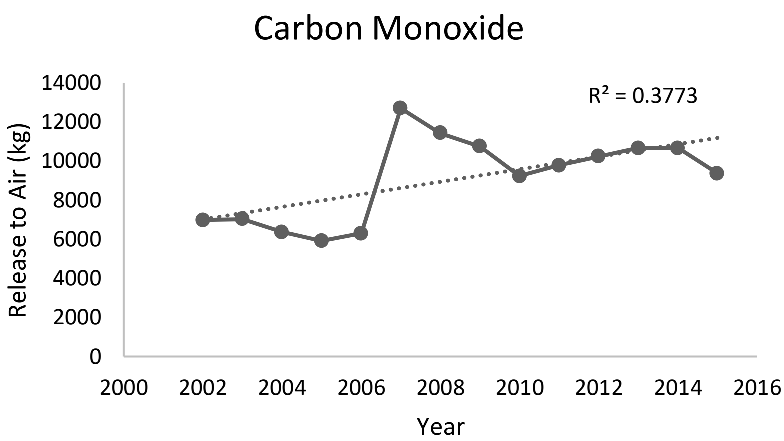
Fig. 3





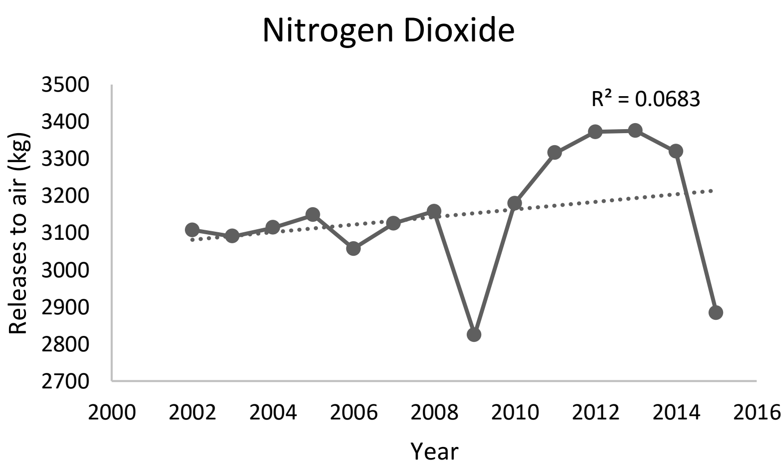


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Fig. 4.

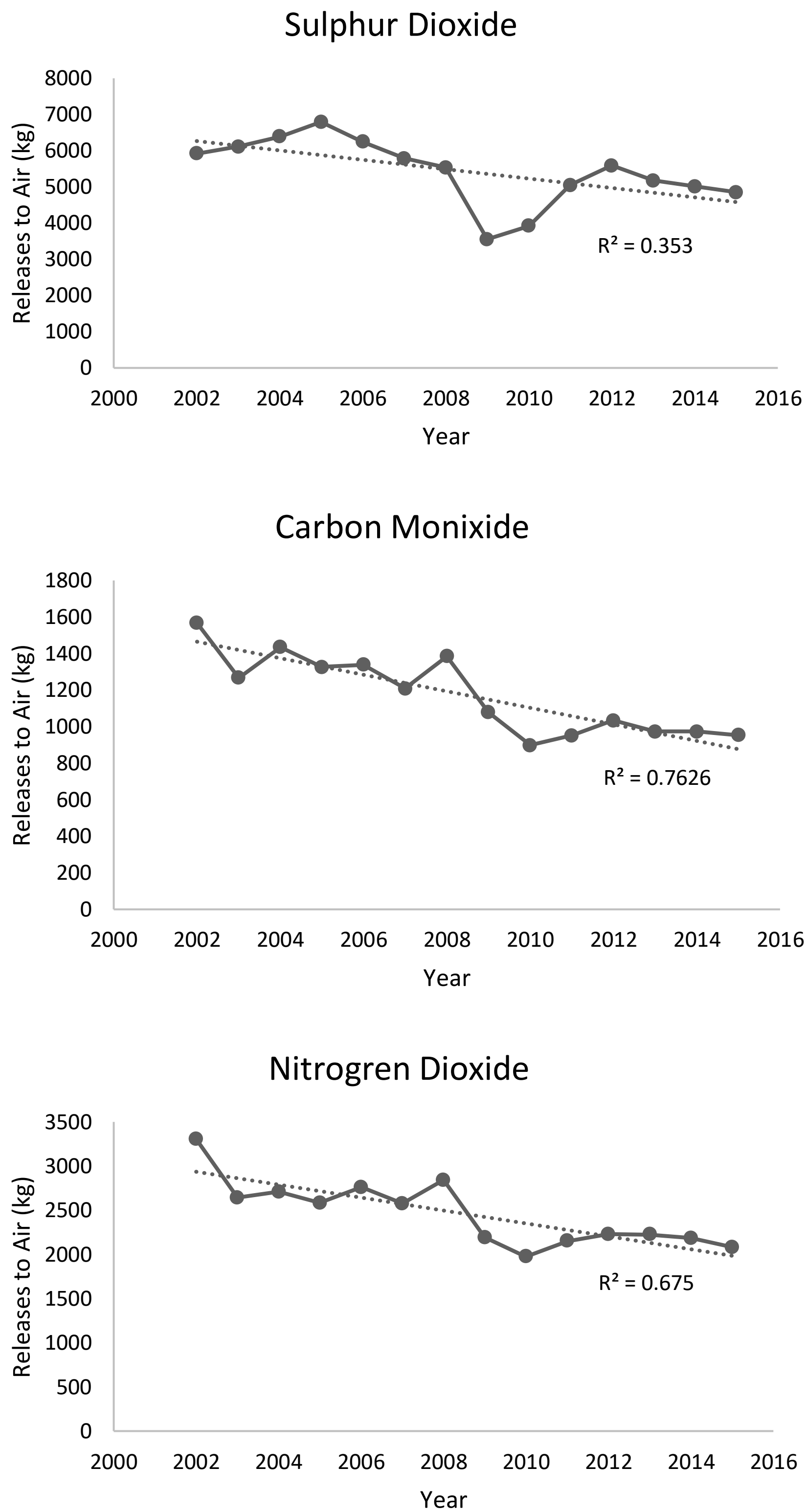

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Fig. 5.

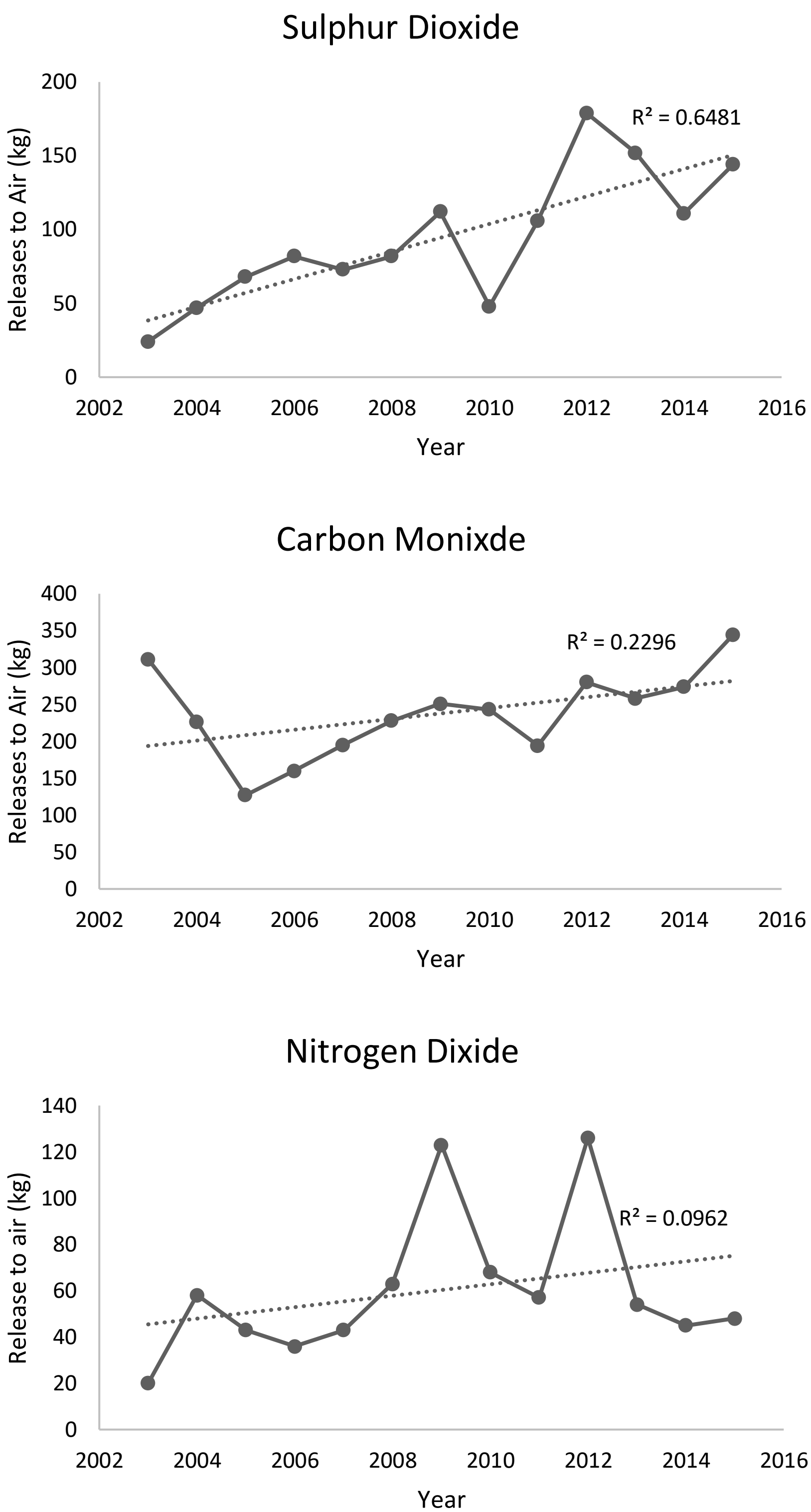
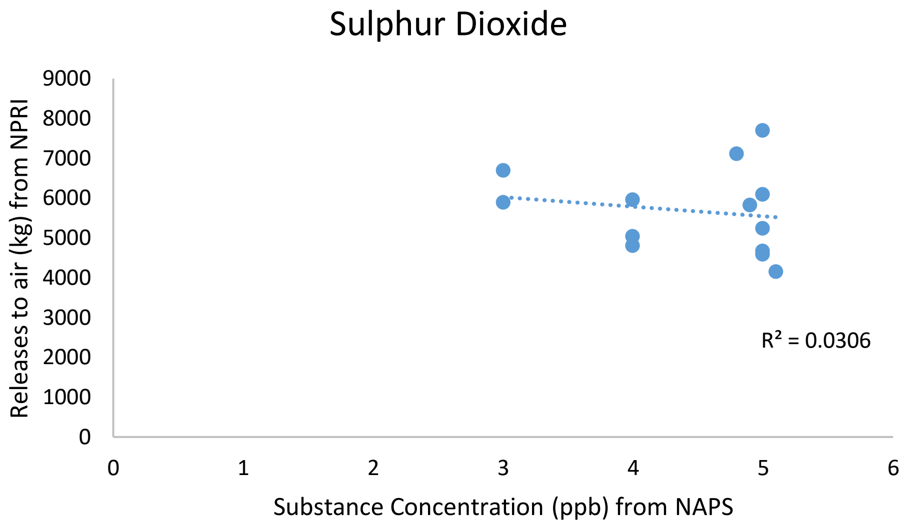
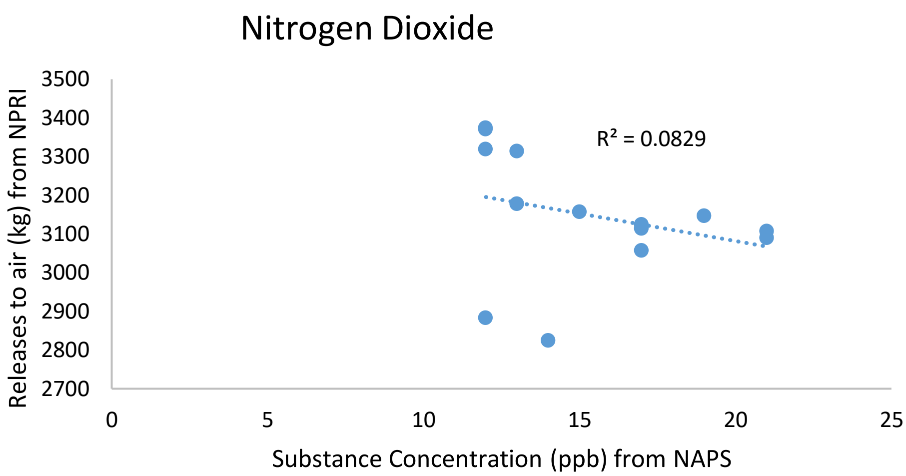

Sulphur Dioxide
Releases to Air (kg)
0
50
100
150
200
R² = 0.6481
2002
2004
2006
2008
2010
2012
2014
2016
Year
Carbon Monixde
Releases to Air (kg)
0
50
100
150
200
250
300
350
400
R² = 0.2296
2002
2004
2006
2008
2010
2012
2014
2016
Year
Nitrogen Dixide
Release to air (kg)
0
20
40
60
80
100
120
140
R² = 0.0962
2002
2004
2006
2008
2010
2012
2014
2016
Year

Fig. 6.


Sulphur Dioxide
Releases to air (kg) from NPRI
Substance Concentration (ppb) from NAPS
R^2 = 0.0306


Nitrogen Dioxide
Releases to air (kg) from NPRI
Substance Concentration (ppb) from NAPS
R^2 = 0.0829

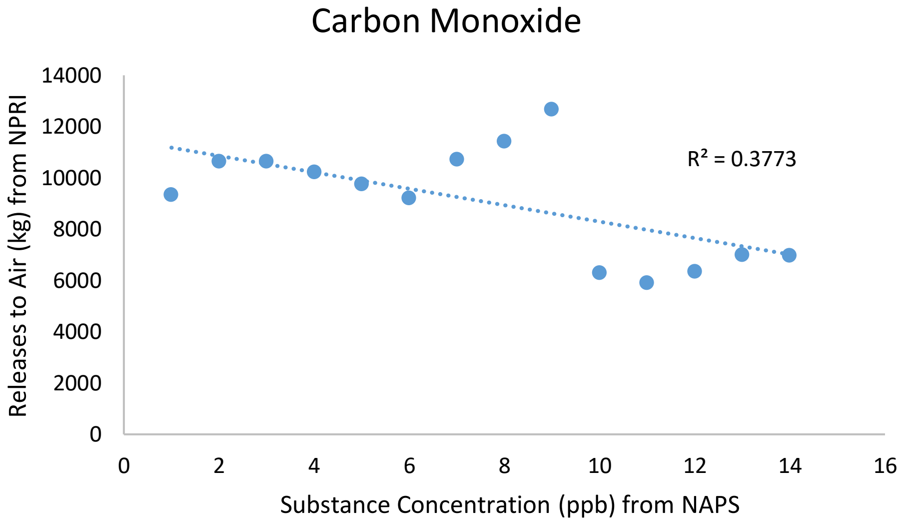
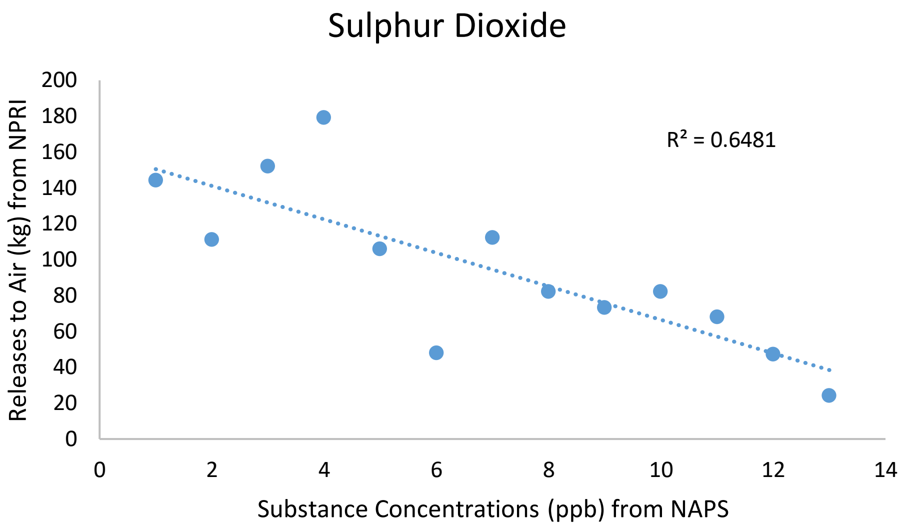

Carbon Monoxide
Releases to Air (kg) from NPRI
Substance Concentration (ppb) from NAPS
R^2 = 0.3773

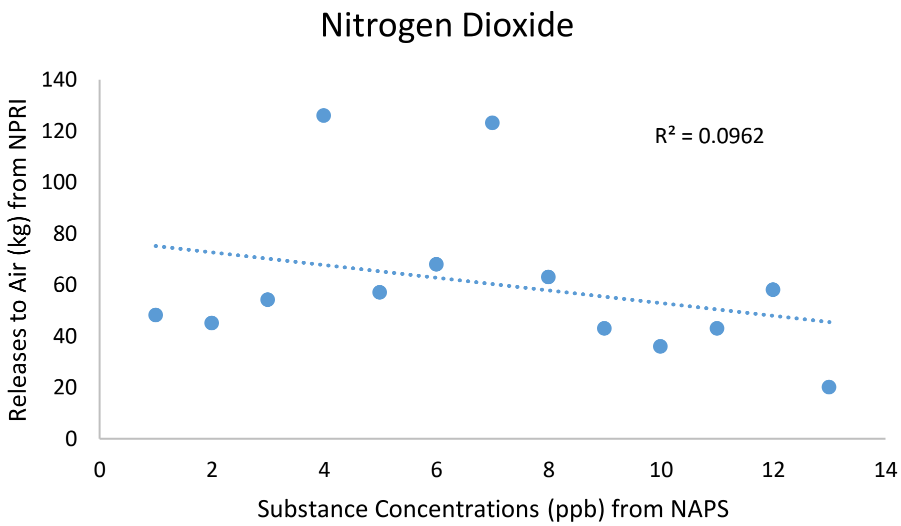
Fig. 7.

(a)



Sulphur Dioxide
R^2 = 0.6481
Releases to Air (kg) from NPRI
200
180
160
140
120
100
80
60
40
20
0
0
2
4
6
8
10
12
14
Substance Concentrations (ppb) from NAPS

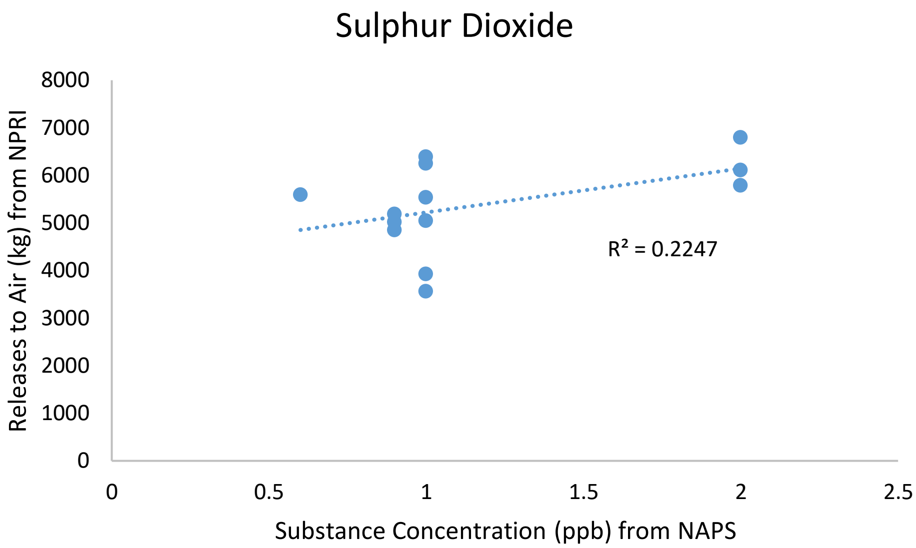
(b)



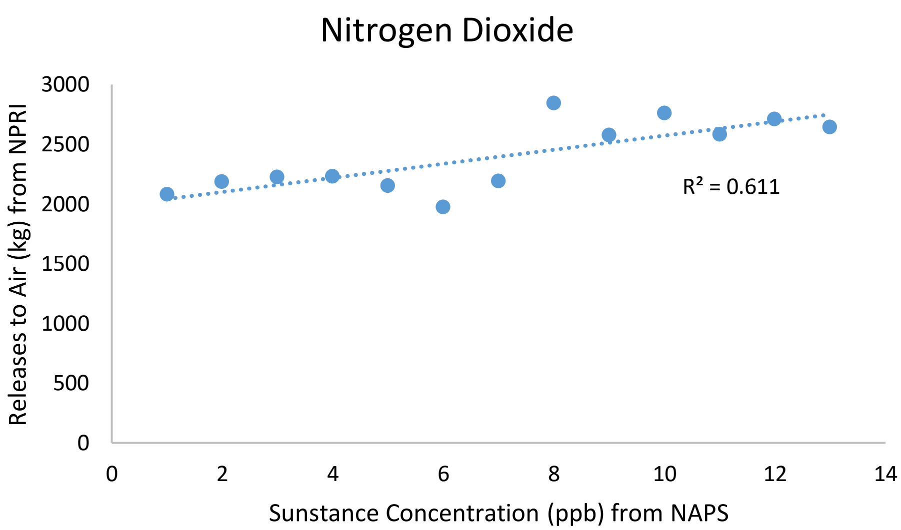
Nitrogen Dioxide
R^2 = 0.0962
Releases to Air (kg) from NPRI
140
120
100
80
60
40
20
0
0
2
4
6
8
10
12
14
Substance Concentrations (ppb) from NAPS

Fig. 8.

(a)


Sulphur Dioxide
Releases to Air (kg) from NPRI
0
1000
2000
3000
4000
5000
6000
7000
8000
0
0.5
1
1.5
2
2.5
Substance Concentration (ppb) from NAPS
R² = 0.2247

(b)


Nitrogen Dioxide
Releases to Air (kg) from NPRI
0
500
1000
1500
2000
2500
3000
0
2
4
6
8
10
12
14
Sunstance Concentration (ppb) from NAPS
R² = 0.611