

Direct Measurement of Tailings Pond Emissions is Reasonable

Submitted by

NGO members of the NPRI Consultative Work Group, Oil Sands Data Quality Sub
Group:

Ian Peace, Friends of Fish Society

Crystal Stamp-Cardinal, Keepers of the Water

Dakota Norris, Canadian Association of Physicians for the Environment

March, 2026

Summary

The magnitude of observed discrepancies between ECCC direct measurement of air emissions and oil sand industry reports submitted to NPRI demonstrates the need for ECCC to continue direct measurements of air emissions in the region to ensure it has relevant information on emissions. This memo advocates that direct measurement of air emissions continue at least until regulated parties demonstrate the ability to report air emissions accurately.

Recommendation: Continue top-down and bottom-up measurements of oil sand facility emissions to inform development of realistic emission factors.

Background

NPRI requires oil sand bitumen production facilities to report pollution emissions to air, water and land. However, since at least 2013, top-down air emission measurements conducted by ECCC have revealed discrepancies between quantified measurements and industry-provided emission estimates. (Li et al., 2017, p. E3756).

This is relevant because the scale of underestimations resulting from industry-derived methods likely compromises multiple public interests. For example, “tracking pollution releases, assessing impacts and hazards, ensuring compliance, taking corrective actions and forecasting air quality” (Li et al., 2017, p. E3756). Furthermore, in order “to predict human and ecosystem exposures” properly, environmental managers, responsible authorities and the public require accurate information about the dose of contaminants released to the environment (Moussa et al., 2021, p. 12832).

ECCC demonstrated top-down and bottom-up direct measurement approaches. Aircraft equipped with air sampling and optical equipment provide the top-down approach and ground-based monitoring devices provide a bottom-up approach. Research revealed several factors that undermine the ability of responsible authorities to properly understand oil sand facility air emissions. Development of detailed conceptual models may be the first step toward a better understanding of the multiple complexities. As noted by ECCC “*underdeveloped spatial allocation of emissions to tailings ponds within models*” [emphasis added] (Moussa et al., 2021, p. 12832) illustrates the value of detailed conceptual models.

In addition, there is a lack of volatile organic compound (VOC) source attribution within oil sand facilities (OS) (*Joint Oil Sands Monitoring Program Emissions Inventory Compilation Report*, 2016, p. 72). “The lack of source-specific VOC emission profiles, including tailings ponds,” means that specific sources of VOC emissions, such as tailing ponds, are included in site-wide annual, emission reports to NPRI. Site-wide reports make it more difficult for environmental managers to develop predictive models or target problematic pollution sources. Concern about

data quality further exacerbates development of predictive models (Moussa et al., 2021, p. 12832).

Bottom-up and top-down approaches are essential to reveal emissions and specific sources that require further scrutiny (He et al., 2024, p. 6). For example, bitumen mining that leaves large oil sand ore (OSO) faces exposed to oxygen-rich atmospheric conditions is certain to volatilize IVOCs and SVOCs. The high temperatures (50 -80 C) required for bitumen extraction in the Clark hot water process (CHWP) are also conditions that are certain to volatilize IVOCs and SVOCs (Liggio et al., 2016, p. 2). Examining the difference between bottom-up and top-down measurements can be a valuable tool to help characterize the formation of SOAs.

Why this is urgent now

Prior to 2024, airborne measurement of VOCs indicated oil sand industry actors reported about half of the air emissions measured by ECCC (Li et al., 2017, Fig. 3). In addition to underreporting the mass of VOC air emissions, “it was found that (depending on the facility) 14-53 discrete VOC species were reportable under NPRI VOC species reporting requirements but were not included in the species emission reports” (Li et al., 2017, p. E3761).

A recent ECCC experiment introduced a sampling methodology that simplifies the complexity related to the detection and measurement of the approximately 10^5 (K. Li et al., 2021, p. 12841) individual chemical species of gas- and particle- phase organic compounds. VOCs, SVOCs and IVOCs are a subset gas phase organic compounds. ECCC scientists are the first to mount total gas-phase organic carbon (TC) equipment on aircraft for the purpose of investigating industrial facilities. Their experiment “revealed an approach to *capture the full range of organic pollutants* [emphasis added] (He et al., 2024, p. 1). In addition, airborne TC measurement “presents a vastly simpler approach with inherent mass closure checks for industry, scientists, and policy makers alike” (He et al., 2024, p. 7). ‘Mass closure checks’ also referred to as a mass balance analysis illustrate how ‘x’ inputs produce a predictable quantity of ‘y’ outputs.

The difference between high-resolution proton transfer reaction time-of-flight mass spectrometer (PTRMS) equipment used in 2013 and the novel application of total gas-phase organic carbon equipment (TC) in 2018 reflects two different approaches to measuring emissions.. PTRMS is designed to detect and quantify specific volatile organic compounds that researchers select in advance. While this method provides high-resolution information for individual compounds, it captures only those compounds included in the measurement protocol.

In contrast, the total gas-phase organic carbon (TC) approach measures the overall mass of organic carbon present in the atmosphere, regardless of the specific chemical species involved. This broader measurement approach captures a wider range of organic emissions, including compounds that may not be included in targeted monitoring methods.

Unfortunately, the results of the newer sampling methodology revealed a significant and , unwelcome finding Namely, “TC emissions observed from oil sand facilities far exceed industry reports (to NPRI) with observed emissions [1.59 million tonnes (Mt) C per year] being equivalent to the total Canadian anthropogenic emissions of organic carbon (He et al., 2024, p. 6).

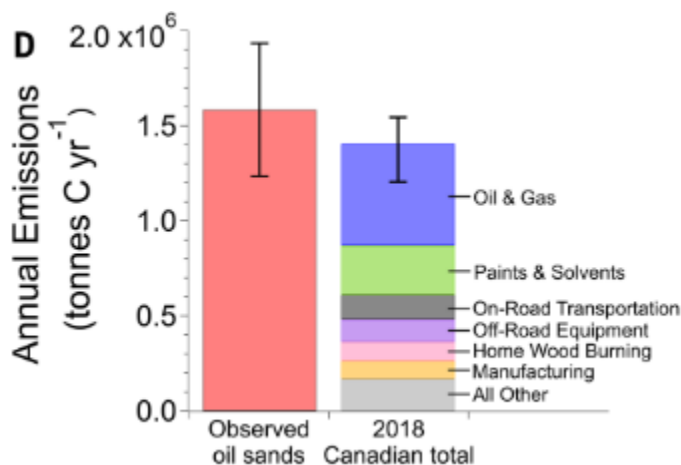


Fig. 1. (D) Observed total gaseous organic carbon emissions for the study area compared with the total Canadian annual inventory for 2018 converted to carbon units (He et al., 2024).

Note that the pink column appears slightly larger than the total gaseous organic carbon emissions for Canada.

Discussion of top-down observations

Notably, ECCC observations in 2018 are about 20 times greater than ECCC measured (using PTRMS) in 2013. Furthermore, the scale of TC emissions observed in 2018 is about 4 times larger than TC emissions in Los Angeles, Ca, a megacity (He et al., 2024, p. 6).

Six of the studied facilities practically surround Fort McKay Indian Reserve No. 174D, population about 400. A rough comparison of the area of Los Angeles reveals that about 4, city of LA footprints would fit within the area of the 6 facilities. Converting 1.59×10^6 Mt C to gas volume at STP suggests the studied facilities release 2.97×10^9 m³ of toxic (Li et al., 2017, p. E3757) VOCs to atmosphere. In other words, the study area releases about 3 cubic kilometres of toxic gas per year.

It is important to note that notwithstanding the relatively recent, 2018 discovery of these toxic (Moussa et al., 2021, p. 12831) VOC emissions; it is very likely that local communities and regional landscape cultures suffered this burden for many years.

Publication of the He et al., study in *Science* acknowledges the merit of the work. It is difficult to imagine a more polarized merit scale. On the one hand ECCC scientists publish astounding results from the application of their novel experimental design in *Science*. The NPRI Oil Sands Air Emissions Data Quality Action Plan means to address the “several thousand percent” between industry reports to NPRI and TC observations (*NPRI Oil Sands Air Emissions Data Quality Action Plan*, 2025, p. 42). Furthermore, Administrative Duties under CEPA direct Canada to “exercise its powers in a manner that (i) protects the environment and human health, including the health of vulnerable populations. The suggestion that tailing pond VOC emissions

“significantly impact residential communities” reinforces the need for accurate air emission reports (Moussa et al., 2021, p. 12838). On the other hand, industry actors continue to report “unrealistic” underestimates of VOC emissions (He et al., 2024, p. 6).

Taken together, the new approach to measuring TC, the scale of newly revealed TC emissions, the pattern of potential discrepancies in emission reports to NPRI, together with administrative duties in section 2 of the Canadian Environmental Protection Act (CEPA), it follows that ECCC continue top-down and bottom-up direct measurements in the OS region.

Bottom-up measurements

In general, industry underestimates VOC species reports to NPRI (Li et al., 2017, p. E3756). Among the reasons are the following: “unaccounted activities, the use of unsuitable emission factors and unverified engineering judgement (Li et al., 2017). Naturally, ECCC anticipates improvement in the accuracy and completeness of emission reports (Li et al., 2017, p. E3761). Consistent with a heuristic approach, ECCC direct measurement of pollutants emitted to air demonstrates reasonable methods for industry to meet NPRI reporting requirements.

In a study designed to address a knowledge gap about fugitive VOC emissions from a tailing pond and assess flux chamber-based method used by Industry, ECCC erected a flux tower and adopted micrometeorological methodologies to quantify emissions (Moussa et al., 2021, p. 12832). ECCC found that the large spatial footprint of tailing ponds renders the flux chamber-based methodology OS facilities rely upon to develop air emission factors from tailing ponds inappropriate. Among the shortcomings of using flux chamber techniques to estimate air emissions are the requirement to disturb the surface under investigation, short periods of data collection and extremely limited sample size area (Moussa et al., 2021, p. 12832).

“Snap-shot flux chambers’ measure air emissions from small spatial areas like, less than 1 m² (Moussa et al., 2021, p. 12832). Since, the area of Suncor Pond 2/3 covers approximately 2.8 km², (Small, Cho, Hashisho, & Ulrich, 2015, Tab. 1) flux chamber measurements are not practical for determining heterogeneity of air emissions across the large area (Moussa et al., 2021, p. 12832).

A comparison of the flux tower and micrometeorological methods (ground-up) with top-down emission measurements showed agreement (Moussa et al., 2021, p. 12835). These results suggest “the need to adopt a more comprehensive technique” than the flux chamber methods (Moussa et al., 2021, p. 12837).

The purpose of CEPA is to prevent pollution. The overall objective of NPRI is to support protection of human health and the environment. In this regard, knowledge about the nature and fate of pollutants is essential. Indigenous communities like, Fort McKay, predate oil sand development. The more detailed study of emissions from Pond 2/3 underlines the importance of source-specific VOC sources and the need for continuous in situ monitoring in the “vicinity of neighbouring residential communities” (Moussa et al., 2021, p. 12838).

Conclusion

Overall, the top-down and bottom-up approaches undertaken by ECCC demonstrate a large improvement over emission factor techniques developed by OS facilities. The discovery of significantly greater VOC emissions in the vicinity of residential neighbourhoods reinforces the duty to mitigate and improve air quality (Moussa et al., 2021, p. 12838).

References

- He, M., Ditto, J. C., Gardner, L., Machesky, J., Hass-Mitchell, Chen, C., ... Gentner, D. R. (2024). Total organic carbon measurements reveal major gaps in petrochemical emissions reporting. *Science*, 383(January), 426–432. <https://doi.org/10.1126/science.adj6233>
- Joint Oil Sands Monitoring Program Emissions Inventory Compilation Report*. (2016).
- Li, K., Wentzell, J. J. B., Liu, Q., Leithead, A., Moussa, S. G., Wheeler, M. J., ... Liggio, J. (2021). Evolution of Atmospheric Total Organic Carbon from Petrochemical Mixtures. *Environmental Science & Technology*, 11. <https://doi.org/10.1021/acs.est.1c02620>
- Li, S.-M., Amy, L., Moussaa, S., Liggio, J., Moran, M., Wang, D., ... Wentzell, J. (2017). Differences between measured and reported volatile organic compound emissions from oil sands facilities. *PNAS*. <https://doi.org/10.1073/pnas.1617862114>
- Liggio, J., Li, S. M., Hayden, K., Taha, Y. M., Stroud, C., Darlington, A., ... Gentner, D. R. (2016). Oil sands operations as a large source of secondary organic aerosols. *Nature*, 534(7605), 91–94. <https://doi.org/10.1038/nature17646>
- Moussa, S. G., Staebler, R. M., You, Y., Leithead, A., Yousif, M. A., Brickell, P., ... Cober, S. G. (2021). Fugitive Emissions of Volatile Organic Compounds from a Tailings Pond in the Oil Sands Region of Alberta. *Environmental Science & Technology*. <https://doi.org/10.1021/acs.est.1c02325>
- NPRI Oil Sands Air Emissions Data Quality Action Plan*. (2025).