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ORIGINAL RESEARCH ARTICLE

Volatile Atmosphere: A Tkaronto Archive

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Abstract

This article delves into the history of petrochemical-derived gas emissions in Toronto, focusing on their emergence and regulation from the end of World War II and up to 1980. Drawing on archival materials, I trace local knowledge production through four loosely defined periods: 1950's nuisance and ephemerality, 1960's threshold thinking, 1960's reactivity and technoscience, and 1970's ambient intensities. Building on feminist science and technology studies perspectives, particularly Max Liboiron's concept of managerial ontologies, and M. Murphy's notion of regimes of perceptibility, I explore key moments when technoscientific logics within a permission-to-pollute system have invisibilized material registers of petrochemical harm, including uneven raced and classed exposures. I reflect on how approaches to air pollution research and governance transitioned from taking citizen sensory knowledge of pollutants seriously through a nuisance complaint framework to increasingly normalizing continuous exposure and treating the atmosphere as a diffusion space for gases. Consequently, I argue that this sets the stage for an enduring belief that long-term, low-level chemical exposures to volatile organic compounds (VOCs) require little mitigation as they self-attenuate. Overall, I underscore the ongoing historical impacts of the notion of the atmosphere as a sink for pollutants on the present governance of petrochemical gases, advocating for further critical engagement with how permission-to-pollute systems are harbored within taken-for-granted atmospheric concepts.

Keywords

petrochemicals; feminist STS; atmospheric pollution; Tkaronto; environmental data justice

Arc of Evidence

Over the second half of the twentieth century, knowledge of air pollutants has undergone significant transformations. As petrochemical emissions from industrial manufacturing increased post WWII,

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technoscientific governance of pollution expanded and gained greater authority. But why are many types of petrochemical gases that volatilize, despite now being known as toxic, are *still* permitted forms of pollution? Using primary archival documents, I compose a case study of the city of Toronto (Tkaronto in Mohawk) to suggest that the first few decades of petrochemical gas emission governance from manufacturing played a significant role in normalizing the subsequent treatment of atmosphere as a sink for invisible pollutants. Eurocentric sink logic persists into the present, systematically obscuring serious attention to the chemical violence that impacts health and undermines care for the land.

In this paper, I trace the histories of petrochemical gas governance in Toronto across three key decades: the 1950s, '60s, and '70s. The evolving ways in which municipal and provincial governments conceptualized and measured the atmosphere was characterized by significant tension between scales of governance. A sequence of conceptualizations have increasingly invisibilized air pollutants; from notions of nuisance and ephemerality through to threshold thinking, followed by reactivity and technoscientific development, and the idea of ambient intensities that solidified a permission-to-pollute system. By the 1970s, a shift occurred that erased citizens' sensory authority and normalized the atmosphere-as-sink approach, which frames the atmosphere as a resource and treats air pollution as something to be managed rather than robustly regulated or prevented.

Crucially, I engage with the concepts of managerial ontologies and regimes of perceptibility to reveal how a permission-to-pollute system for petrochemical gas was, at least initially, questioned and at times contested by municipal-level atmospheric governance. My approach, inspired by M. Murphy's (2006) historical ontology of chemical exposures, chronicles how "imperceptibility" spent several decades in flux, whilst being "produced by limits in the capacities of knowledge practices" of air pollution control actors (ibid., 9). Until the 1970s, municipal actors, more so than provincial, did in fact endeavor *to perceive* the materiality of invisible petrochemical gas – pursuing an epistemological program that technoscientifically engaged with individual emission sources – a regulatory objective whose material interventions would become lost at the provincial scale, and not reemerge until the late 1990s.

Part of the reason for the eventual municipal failure to keep governing authority over petrochemical gas was due to the normalization of what Liboiron (2021) calls the "managerial ontology" of pollution sinks, which I apply to the atmosphere and notions that it can self-attenuate or disperse pollutants. Because many volatile petrochemical gases have short environmental lifespans and often react with sources of oxygen molecules in sunlight, they become conflated with Eurocentric, overdetermined notions of "air." This problem endures: atmosphere-as-sink logic, which imagines the sky and air as spacious areas for pollutants to diffuse due to winds and other meteorological forces, still invisibilizes and normalizes the long-term, low-level violence of potentially toxic exposures, and surpasses a preventative approach seen as too expensive for profit.

Visiting the City of Toronto Archives, the Toronto Reference Library, and using online keyword searches of the Canadian historical newspaper databases for the Globe and Mail and Toronto Star, I gathered an archival "arc of evidence" about petrochemical gases, or volatile organic

compounds from manufacturing industry emissions, long before they were recognized as volatile organic compounds VOCs (Wylie 2018, 60).

This article weaves together several bodies of scholarship. Drawing on feminist science and technology studies (STS), my archival approach is concerned with how technoscience is shaped by ontoepistemologies – material practices that are entangled processes of knowing and being (Barad 2007, 379) – to critically trace how the historical power structures shaping air pollution data (Garnett 2020; Marzecová and Husberg 2022) intersect with the technological failure to "contain" petrochemical gas at the atmospheric scale (Kenner, Mirzaei, and Spackman 2019). I show how the case of Toronto petrochemical gas governance is characterized by epistemic cultures (Knorr-Cetina 1999) that promote distinctive forms of epistemic injustice (Ottinger 2023) with racial and class consequences, including increasingly dismissing how citizens' "sense" pollution (Gabrys 2020; Jaworski 2022; Calvillo 2018) by situating these theories within sensory history scholarship on air pollution (Kiechle 2017, 2022; Spackman 2020; Morag-Levine 2003; Meisner-Rosen 2003; Parr 2006; Novak 1996). In turn, I follow environmental justice scholars who argue that permission-to-pollute systems – assuming to diffuse toxic harm despite the fact "away is not escape" (Jaworski and Wool 2021) – normalize and invisibilize particular kinds of exposure and use air pollution data to enact "data colonialism" (Gray et al. 2024).

Eurocentric scientific data about atmospheric pollution does "not simply attempt to explain but also attempt[s] to claim" (Grossman 2023, 167). In this light, Toronto pollution research and governance has been especially shaped by the city's location as a central geographical node in the period of Canadian domestic manufacturing that immediately followed the Second World War nationalization of chemical production. Key to my story is interrogating how, after World War II, attempts to apprehend atmospheric petrochemical gas emissions shifted following the transition from chemical manufacturing premised on the military industrial complex to consumer product manufacturing. Just as clouds have a long history of "description and classification by omission" (Daston 2016) where a puffy cloud silhouette might seem "dragonish" because of how epistemic genres intersect with perceptual habits (Daston 2008), economic interests tied to the commodification of chemical products bias what is considered perceptible or imperceptible by regulatory authorities, and influence how this imperceptibility is managed, rendering data non-innocent.

While "atmosphere" currently possesses a particular theoretical currency across disciplines as varied as, but not limited to, architecture (Böhme 2017), geography (Colucci et al. 2023), anthropology (Choy and Zee 2015; Simmons 2017) and the environmental humanities (Badia, Cetinić, and Diamanti 2021), I mobilize a feminist STS approach that attends to atmospheric violence (Ahuja 2020; Puar 2020; Sloterdijk [2002] 2009), and "de-invisibilizes air" (Calvillo 2023) by elaborating the material genealogies of petrochemical exposure that remain unmarked or under-theorized within atmospheric theory.

This materialist-inspired snapshot of genealogies aims to invite further critical anticolonial, antiracist, and anticapitalist STS scholarship that traces how petrochemical harm is reproduced by

Eurocentric "aesthetics of atmosphere" (Böhme 2017) and "aesthetics of air," which continue to be thought across wider elemental turns in the environmental humanities (Engelmann 2021). Attending to air pollutant materiality matters because structural inequalities endure in part through how abstracted atmospheric aesthetics depoliticize and dematerialize.

Overall, I intend to spark dialogue around how contemporary theorizations of atmosphere might have the potential to disrupt, rather than reproduce complicity in the ongoing material realities of atmospheric violence.

Regulatory Dealings with Nuisance and Ephemerality in the 1950s

Municipal air pollution control has relied on odor, also termed "nuisance," since the late-nineteenth century as a form of knowledge about chemical gases and fumes. Legal use of the term nuisance began in eighteenth-century France and Britain (Le Roux 2016b), while odor nuisance in nineteenth-century North America gave citizens significant power to prosecute polluting industries (Novak 1996). Toronto's settler government aligned itself with the British common law model, which gave "the legal power to remove, abate, or terminate anything that threatened health," by defining nuisance as a smell or fume that interfered with the enjoyment of private property or public welfare (Kiechle 2017, 61).

In 1926, nuisance complaints arose when a newspaper reported that Ashbridge's Bay had water so corrosive it "eats paint off boats." Responding to resident petitions against odors from a local sewage plant, the works commissioner sought permission for an investigation. Alderman Bob Diddle revealed that mustard gas, a chemical from World War I, had been used to kill germs in the water, causing not only an "injury to boating" but also requiring residents to keep their windows closed due to the odor (PHN 9). This example shows how citizens' sensory experiences of chemical pollution were taken seriously, a practice that continued into 1950's Toronto, where air pollution control relied on citizen complaints to identify new petrochemical gases.

A municipal department of works' (MDW) call centre responded to phone complaints by radioing one of seven mobile units, "dispatched to investigate" what one journalist called "a citizen spy system to report immediately on any neighborhood smoke, odour or fumes." (PHN 5). The concept of a *citizen spy system* reflected the public sentiment that the MDW aimed to cultivate despite eventual failure to intervene; that citizens' nuisance complaints were a source of air pollution data. Metro Toronto Department of Works Air Pollution Control Branch (thereafter MDW) guidelines were written so that inspectors were more likely to initiate a regulatory response if citizens complained of odor leading them to suffer "damage, distress or discomfort" echoing nineteenth-century nuisance law (CTA 15).[1] Yet, distinguishing between odor nuisance and fumes from emerging petrochemical

[1] See Meisner-Rosen 2003 for a more detailed history of nuisance law.

sources (such as paint, pharmaceuticals, cleaning products, pesticides, or personal care products), was inconsistent and subjective.

Dr. A. M. Fisher, a physiological hygiene professor at the University of Toronto who served on the 1950's Toronto Air Pollution Control Committee, wrote in his private notes of concerns about identifying emergent petrochemical emissions: "[gaseous] odor control will come more to the front . . . [it is a] difficult problem." (UTA 4). An influx of hundreds of new petrochemical gases complicated urban aromas, creating a "chemically sublime" discordance between subjective sensation and regulatory objectivity (Shapiro 2015).

While invisible odor nuisances and gases were difficult to identify and intervene into, this was not the case for smoke – which had come to "define air pollution more than odor by the 1890s" in North America (Kiechle 2017, 231). Due to its visibility, smoke had become associated with what was knowable and measurable, complementing officially sanctioned methods of air pollution perception that also enabled permission-to-pollute industrial growth in the Great Lakes region. Residents and citizen groups, by referencing pre-existing definitions of nuisance as something "offensive to the senses," maintained that these new kinds of exposure were like older forms of smoke, as they also included hazards that were "physical, economic, or moral" (Morag-Levine 2003, 73).

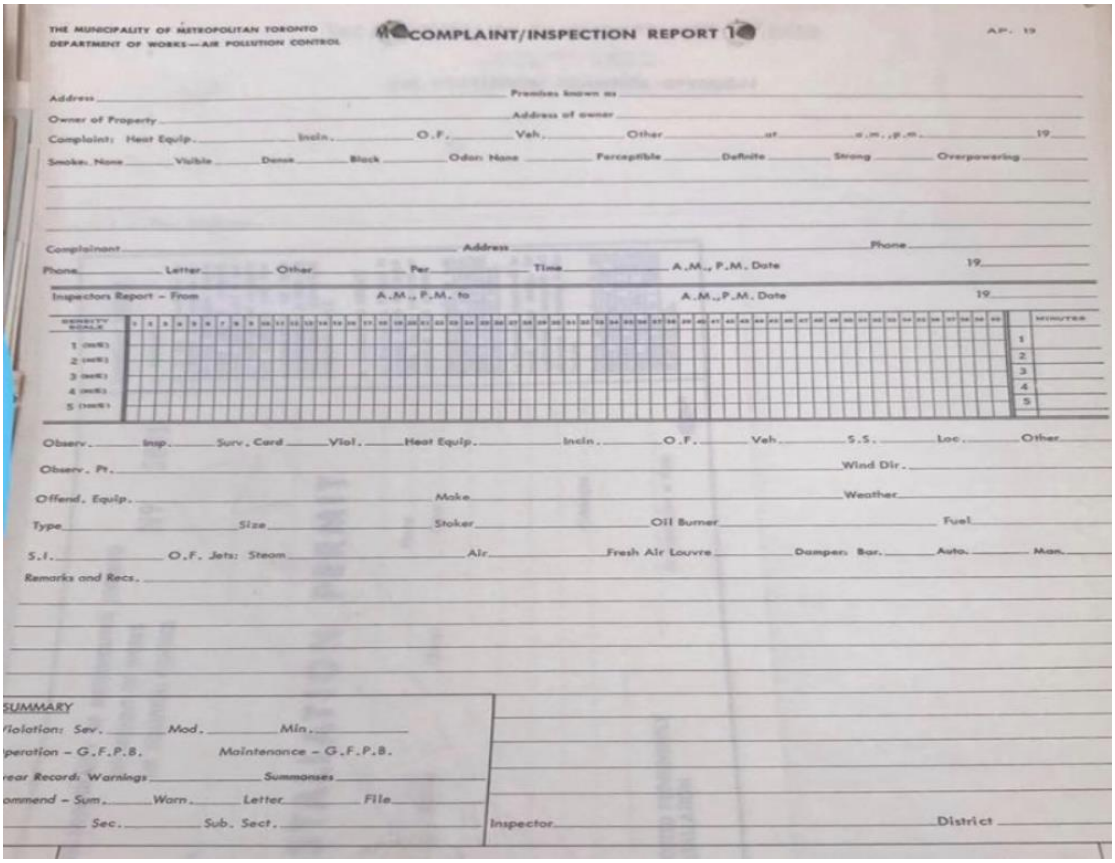
However, in part due to industry lobbying, a 1949 municipal Smoke Bylaw restricted 1950's regulation to the products of combustion (i.e. smoke), severely limiting the city's ability to regulate other ephemeral sources of nuisance. As a partial work-around, city inspectors conducting site visits were equipped with a complaint inspection form that focused heavily on odor alongside visual details (figure 1), asking if odor was "none, perceptible, definite, strong, or overpowering," and about type of equipment and fuel, wind direction, and weather. In a summary box, the inspector ranked the violation as severe, moderate, or minimal, and consulted the facility's three-year record to decide if a summons, warning, or letter should be sent (CTA 10). Regulating emissions via complaints was meant as an approach that could curtail emissions (smoke and gases) with limited resources.

In a 1956 provincial meeting, Ross Clark, in charge of the newly formed MDW, expressed how the greatest problem facing city air quality was ephemeral fumes:

> What we are really worried about is not so much ordinary smoke, but the hundreds of other kinds of air pollution, many of which are invisible. In the last five years, the petrochemical industry has developed in amazing ways, the chemical manufacturing industry has been growing at a faster rate than all the rest of our industries. (Ontario Legislative Assembly and Cowling [1956] 2021)

Into the late 1950s, meetings of the Air Pollution Control Board repeatedly discussed the frustrating lack of municipal capacity to measure and ascertain the presence of air pollution beyond what was visible. A letter from E. A. Allcut, chairperson of the (then pre-MDW) Air Pollution Advisory Board to the provincial Board of Control lauded measurement instruments like dust collectors (and eventually gas chromatographs) possessed by cities like Pittsburgh, New York, and London, but bemoaned Toronto's measurement capacity, writing in all capital letters: "WE HAVE NONE!" (UTA 1) In a

subsequent letter, during the MDW takeover of Air Pollution Control, the chairperson advised the new committee that previous "[Air quality measurement] work had been hindered in the City of Toronto due to lack of equipment" (UTA 2).


THE MUNICIPALITY OF METROPOLITAN TORONTO
DEPARTMENT OF WORKS—AIR POLLUTION CONTROL

COMPLAINT/INSPECTION REPORT

Figure 1. Air Pollution Complaint Inspection Report. Information collected includes: date, time, location, smoke (none, visible, dense, black), odor (none, perceptible, definite, strong, overpowering), type of complaint, observation, wind direction, offending equipment and make (i.e. type, size, stoker, oil burner, fuel, jets, fresh air louvre, damper), weather, remarks and recommendations, summary (i.e. degree of violation, severe, moderate, or minimal, and follow-up via warning or summonses, letter or file), inspector name, and district.

Behind the scenes, MDW member Dr. A. M. Fisher surmised about the gaseous nuisance quandary in his private notes. Acknowledging gasoline refineries, corrosion, construction, oil burning, manufacturing, and incineration (including apartment buildings), as uncontrolled emergent sources of gaseous air pollution, he described quantification of gas as something the MDW was "figuring out," as "to separate gases is a tremendous job." (UTA 3) Fisher knew that gas could be short lived, transitory, and have sudden sporadic effects. He recounted an event where nylon stockings suddenly all dissolved off many citizens' legs during one pollution-heavy afternoon in downtown Toronto, seemingly coming out of nowhere (UTA 4). He described yet another event where "fabric dyed blue

developed a red tinge," writing "oxidants and acidity do this," zeroing in on the material effects of petrochemical gases (ibid.).

Fisher brainstormed a list of interventions into gas pollution that circumvented the need to understand its amount or location. The list re-imagined and built upon older practices of purifying air control circulating since nineteenth-century germ theory, including the use of ozone (Kiechle 2017, 190) to disperse gas via "oxidation of odorous material, the injection of ozone, use of H2O2," or what he termed "counteractants." (UTA 4). Other ideas, such as "masking," meant using other chemical compounds to cover up gaseous odors. More practical techniques included gas "adsorption with activated charcoal, [or] condensation through low pressure." The most dystopian proposition was to construct "adsorption towers that sprayed water or another solvent" into the atmosphere, assuming their widespread reach would encounter the initial pollution emissions (ibid.). There was, in short, a strong desire to understand, measure, and even control ephemeral gases on the part of the MDW.

Despite systematic olfactory data collection and citizen complaints about "obnoxious fumes," MDW regulation continued to be deemed beyond the provisions of the Smoke Abatement Bylaw (CTA 1). An illustrative case involved a cadmium plating plant in the Junction neighborhood, where despite repugnant "blue hazes," illness reports, and city inspections, no evidence could link health issues to the plant's combustion practices. Thus, without a clear link between citizens' sensed fumes (in this case via smell) and combustion products, the city couldn't intervene (CTA 6). While public pressure eventually led the cadmium plating company to adopt pollution abatement technologies, the limit on the city's powers reflected a shifting understanding of nuisance, treating it more as an "irritation" than a health concern (Morag-Levine 2003).[2] Diverting from previous legal approaches (which gave authority to embodied citizen harms from exposure) further normalized the atmosphere as a sink for hundreds of little researched substances.

The Smoke Abatement Bylaw, by excluding petrochemical gas outside of combustion sources, is emblematic of a managerial epistemic culture that willfully obscured the "ontological multiplicities" of petrochemicals, dismissing the potential risks of their new, and under-researched, "ambiguous potencies" (Adams 2022, 36). The coming decade would amplify a regulatory struggle to accommodate new forms of pollution that defied a legal order heretofore defined by material visibility – not in the least because threshold theories would contrive new limits that arbitrarily dismissed many scales of material perception, then naturalize this imperceptibility as almost immutable.

[2] In the 1950s, Toronto tried to emulate Cleveland, Ohio's "Bureau of Industrial Nuisances" (Cleveland Air Pollution Control Division). Many other North American cities (excepting Los Angeles), like Toronto, lacked regulatory authority over gases beyond smoke in the 1950s (Morag-Levine 2003, 125).

Threshold Thinking in the 1960s

By the early 1960s, the city of Toronto prioritized manufacturing and its economic benefits over definitive scientific understandings of pollution exposure and public health (Le Roux 2016a). Local petrochemical-based industries for automotive chemicals, fuels, paints, disinfectants and germicides, insecticides, perfume, beauty products, and pharmaceuticals burgeoned.[3] With the increase in manufacturing came a cacophony of emergent atmospheric emissions.[4] As hundreds of new petrochemical gases soared into the atmosphere, the city scrambled to identify emerging pollutants and determine what regulatory frameworks could contain them. Legally decisive limits and constraints on petrochemical gas release remained elusive. Instead, a managerial ontology began to emerge which decisively treated the atmosphere as a homogeneous receptacle. In this regulatory gap, diffusion was increasingly used to prevent nuisance.

In an undated publication, the MDW drew a number of associations between odor nuisance, petrochemical-derived gas, and a new idea of emission thresholds. It contained a list poetically titled, "Contaminants which can pollute the atmosphere and at the same time be more or less invisible to the naked eye" that included, "aldehydes, benzol, benzopyrene, fumes, hydrocarbons, odors, oil, and vapour," linked to industry and manufacturing (TRL 2, table II). The report then identified and categorized potential pollution sources, assigning separate atmospheric pollution and nuisance ratings (ibid., table III). While pollution sources were mostly moderate or low concern, many nuisances, including diesel, incinerators, oil refineries, asphalt, concrete plants, chemical spray painting, and auto finishing were categorized as high concern. While this demonstrated a growing awareness that odor was much more than just a nuisance and had the potential to be harmful, it also gave new authority to thresholds – measurements that defined odors as "low," "moderate," or "high" concerns – thus reinforcing an idea that odors from petrochemical gases were (at "low" or "moderate" levels) acceptable.

In 1964, Toronto purchased a "Scentometer" in an attempt to quantify industrial odors using a smell threshold. The Scentometer, developed by Norman A. Huey and Louis C. Broering in 1958 (Morag-Levine 2003, 132), was acquired by Toronto early in its career. The device allowed an inspector or technician to breathe gases mixed with odorless air through plastic prongs inserted into their nostrils (TRL 1). It aimed to establish odor standards by teaching inspectors to have a uniform olfactory perception.

[3] For example, between 1932 and 1967 in the Greater Toronto Area (GTA), there were over 25 insecticide producing factories, 68 paint factories, and 42 industrial cleaner and/or disinfectant factories (Author's personal data).

[4] The Department of Property and Building Control, and the Smoke Abatement Advisory Board became restructured into the Air Pollution Abatement Board to reflect the presence of non-smoke forms of air pollution. The earlier By-law 17675 dates to 1949, with the name transition occurring in 1954 (CTA 4).

In the United States, the Scentometer's techno-aesthetic appeal had been ridiculed and likened to "an old radio someone had thrown off their tractor, or out of their car." (PHN 12). Whereas in Toronto, initially, pollution control officers from the Department of Works defended the technology against those questioning its subjective nature. In response to potential criticism, they pointed out analogous issues in interpretation with the Ringelmann Chart, a standard chart for assessing the shade of smoke emissions (TRL 1).

Yet, despite the technoscientific optimism of air pollution scientists, who hoped the Scentometer would enhance the understanding of gases, it proved challenging. The objective to standardize olfactory perception was too difficult, especially in the context of using public funds. Toronto stopping its use of the Scentometer illustrates how the city eventually came to understand odor as a limited mechanism for regulating or monitoring atmospheric gas pollution.[5] The device's attempt to substitute "odour strength" for "odour annoyance" did not clarify nuisance statutes requiring evidence of injury or annoyance caused by fumes (Morag-Levine 2003, 133).

Moreover, the city's attempt to establish a standardized odor threshold for nuisance complaints belied how their interpretation was influenced by a history of public health discourses that saw racialized individuals as having "higher tolerances" to odor. Hsuan Hsu traces the prevalence of odour-based reasoning in early-twentieth-century North America, connecting it to a "genealogy of atmo-orientialist discourse" (2020, 132). This discourse often depicted racialized individuals – in his analytical focus, Chinese citizens – as having a higher tolerance for odorous environmental pollutants. While nuisance complaints were crucial in signaling environmental health risks during this era, they cannot be disentangled from the influence of early-twentieth-century public health discourses that frequently framed issues resulting from structural inequality as racial characteristics (ibid., 126). For example, turn of the century news reports cited "Social Service Workers" finding families "of other racial origins" than "Anglo-Saxon" who lived near "odors from melting asphalt, oiled roads, and rag and bone yards" in the low-income, immigrant Ward neighborhood, as enduring "their lot with greater fortitude" (PHN 2). This public health bias, rooted in biological determinism and scientific racism, may have led white middle-class city officials to erroneously ascribe racialized citizens a higher endurance to air pollution exposures than white, or white-coded settlers.[6]

Toronto's housing policy into the 1960s suggests a persistence of mapping odor tolerance onto scientifically racist notions of ethnicity and class. The city's treatment of the problematic

[5] The Scentometer purchase follows longstanding pollution control practices that used a so-called "sight-and-smell test" to identify contaminated materials dumped in landfill sites (see TRL 4).
[6] The classist treatment of the city as a sink is evident in a "Fresh-Air Fund" operated by the Toronto Star newspaper from the late-nineteenth century (still in existence). It paid for "delicate" children to leave the city, spending extended stays in the country hosted by farming families (PHN 1).

overlap of industrial and residential zoning via urban renewal reflects Hsu's argument that the coordinated governance of air pollution smells produced "differential deodorization," an intentionally uneven act of atmospheric governance that worked by "producing and sustaining a multiplicity of fragmented, hierarchized atmospheres" (2020, 195). Instead of directly regulating petrochemical gas source emissions, city plans incorporated differential deodorization by using zoning ordinances to segregate areas producing odors labelled as "obnoxious" from residential areas, deeming odor as "non-conforming" with zoning regulations.[7]

A 1965 study anticipating areas of urban renewal identified "incompatible land uses" of industry in residential areas as one of the main reasons for "deteriorated housing."[8] This acknowledged the damaging effects of air pollutants on building materials while ignoring their embodied effects on populations living closest to industrial areas. Urban renewal schemes shifted industrial emissions elsewhere, displacing working class and racialized residents. Zoning ordinances thus not only diminished citizen sensory authority over chemical apprehension but also perpetuated racial and class divisions in cities (Kiechle 2022, 81) as the notion of building "nonconformity" served to simultaneously codify social difference.

As the 1960s expanded sink logic that the atmosphere had a large assimilative capacity for petrochemical-derived gases, which would diffuse "away" and render their own potentially harmful effects inert (Liboiron 2021, 39), city interventions focused on creating conditions where no odor was detectable rather than necessarily reducing emissions. The 1965 Metro city plan encouraged sources of industrial air pollution to be located "as far away from residential areas as possible," reconfiguring nuisance through the "transition to industrial use of areas of residential occupancy within industrial districts, and . . . the orderly removal of incompatible industrial uses in predominantly residential districts." (IA 1) When it couldn't be helped that housing redevelopment be proposed near industry, the city recommended researching "safe heights" of new apartment buildings, implying that they should be distanced from tall stacks that dispersed emissions (IA 2). In short, effective dilution and dispersal of odor was conflated with effective dilution of gases, the effective minimization of harm.

During this period, the city's handling of nuisance odors established high thresholds within which the continuous emission of petrochemical gas was deemed acceptable, authorizing an emerging form of imperceptibility which masked uneven exposure, and cumulative emission effects, relying on thresholds to spatially and temporally diffuse accountability for potential environmental harm. As pollutants were emitted on a larger scale than ever before, the atmosphere was treated as "aer nullius," or empty of relations below a threshold of emissions (Todd 2016). By now, a nascent

[7] "Expropriation urged in 21 cases termed most obnoxious in report." (PHN 7). Here, "noxious" is carried forward from Victorian understandings of air pollution as "noxious vapours" (Morag-Levine 2003).
[8] The study found 2,303 "non-conforming uses" many of which "had a definite odor problem," but narrowed them down to the top 85 of concern. "Metro Report Rejects Pocket Renewal as Sought by City." (PHN 7).

permission-to-pollute system showed that perceptibility was not just a result of what could or could not be sensed, but also a consequence of what was legally and institutionally constructed as imperceptible. Thresholds helped obscure the place-based relations of the atmosphere, which has always been full of "beings and becomings, its multiple knowledges and Laws/Lores, its sovereignties and its more-than-human relationships" (Wright and Tofa 2021).

Reactivity and 1960s Technoscience

During peak petrochemical manufacturing in Toronto, expanding MDW scientific research into air pollution focused on reactivity, focusing on continually measuring and managing intensities in place of intervening and regulating polluters. Still, city-led laboratory experimentation would soon reveal, and attempt to challenge, the gaps in existing regulations because they underestimated the complexity of pollution materiality and its combined risks.

The establishment of a laboratory testing branch illustrates a unique use of public funds relative to many other major cities (excepting Los Angeles, and New York's early municipal research labs). The lab gained novel insights into petrochemical gas, while bolstering the authority of municipal air pollution science. Yet, the MDW's turn towards technoscientific quantification and devices, and its potentially political insights into chemical harm, would be short lived.[9]

Beginning in 1958, an MDW-funded Air Quality Sampling and Analysis Laboratory pieced together bits of the sky, investigating samples of the atmosphere and fume clouds emanating from chemical products (figure 2). The lab grew out of a National Research Council funded dust fall study and air pollution survey initiated by chemistry researchers at the University of Toronto. In a 1960 public-facing pamphlet, the MDW presented the study data: a gargantuan 600 tons of dust fall yearly per square mile south of Queen Street in the downtown area and 450 tons per square mile south of Bloor Street (see UTL 1). As coal was increasingly replaced with oil, diesel, and petrochemical manufacturing, glimpses of gas reactivity began to guide subsequent materials testing and sample analysis. Modelled after similar studies in other US cities, early versions of pollution monitoring stations were described as "smoke collecting vessels" (CTA 2). Dust carried in smoke indexed how gases moved, indicating a relationship between particulate matter and aerosols formed in secondary reactions with other meteorological variables, such as heat, moisture, and pressure.

[9] Dimitro Papadopoulos defines technoscience as "when science technology and everyday life fold into each other" (2018, 92).

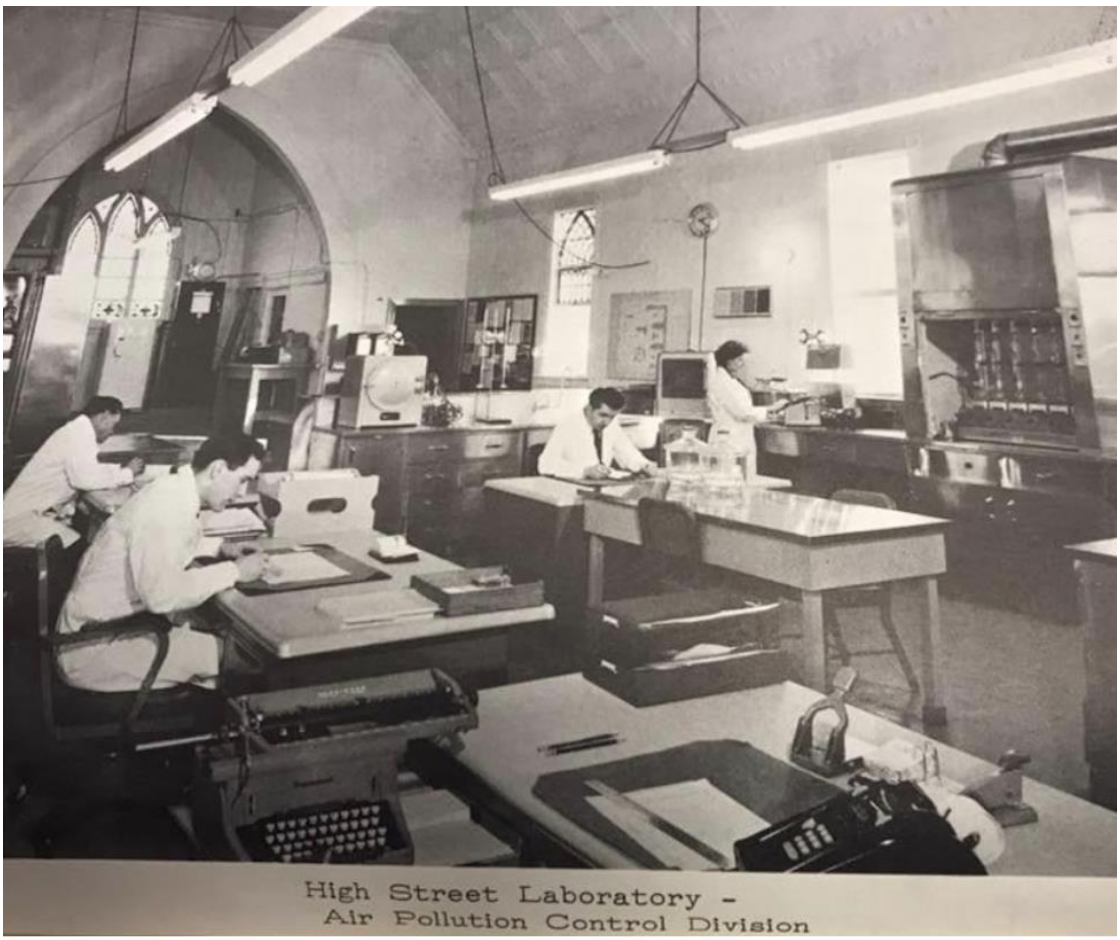


Figure 2. High Street Laboratory-Air Pollution Control Division (CTA 15).

Experiments by the MDW's Research and Standards division used gaseous reactivity to assess and test petrochemical emitting materials that would then be used city-wide. One such experiment from 1963 considered deodorant blocks made from paradichlorobenzene for use throughout Metro Toronto. The city calculated reactivity by weighing the solid blocks before and after 14 days to calculate "loss on evaporation," in relation to "odour retention." Different paradichlorobenzene deodorants were compared from the locally based manufacturing companies: Admiral Sanitation, Canada Floor Service and Acme Chemical Company. All showed a comparable level of reactivity, losing 42–43 percent of their weight and reporting no change in odor retention (CTA 11).

Similar experiments were conducted by the Toronto Transit Commission (TTC) in response to complaints about the diesel fumes from buses, and pressure from the Metro Department of Works. The TTC tested a deodorant specifically meant to smell like sauerkraut (PHN 6). They tested "more than 30 deodorants, special fuels and mechanical devices to mask or eliminate the foul-smelling eye-watering fumes in the exhaust," including a deodorant wick in the exhaust pipe, a pill, and a chemical meant to make buses have a bakery smell, by having employees "scoop handfuls of exhaust" and

sniff, or drive behind buses in their cars, then get out and inspect the interior of the bus (PHN 3; PHN 9). Lasting over ten years, newspaper reports described tests resulting in observers being "made ill from the new smell." (PHN 8). TTC field experiments from 1955 to 1967 marked a key moment in the shift from conceptualizing "bad air" as odors to recognizing that the reactive "aesthetic-industrial complex" of fragrant petrochemical fumes exceeded odor (Shapin 2012, 179). Through the failure of masking petrochemicals to address diesel odor, it became clear that the reactive and combinatory powers of atmospheric gases confounded existing scientific parameters within these new public sites of experimentation.

Other tests also questioned the promise of new petrochemical compounds in unexpected ways. The city was surprised after it received reports that seven paint remover samples from the traffic division were found to dissolve asphalt, and therefore be "detrimental to the surface" of all existing asphalt road pavements (CTA 12). Repeated tests were conducted on the bonding agents used in the growing use of concrete across the city, as well as on coal, oil, brick, paint, soil, air, dust, and other new petrochemicals (CTA 8). City scientists were noticeably concerned about how these substances reacted with each other and the atmosphere. Their research captured how reactivity had long preceded the lab; rather, in the spirit of industrial capital, experimental gaseous materialities, since the advent of petrochemical consumer markets, already constituted the very material culture of the city itself.

Public-facing pamphlets and other publications communicated the city's use of field measurements and laboratory testing research to the Metro Toronto public, conveying a paternalistic sense that the citizens were being protected from any harmful effects of air pollution by the emergent forms of scientific investment. Measurement activities by men in lab coats and cars expanded older practices of air pollution inspectors observing industrial chimneys (rumored to escape detection by 'making smoke' at night), where to do this work, officers had sometimes relied on observation stations established on tall buildings where they stood with binoculars.

One pamphlet boasted a new fleet of pollution control inspectors dressed in long white coats who would drive around in luxurious pastel-toned Ford station wagon cars with "Air Pollution Control Division" stenciled on the side, and a miniature laboratory of air measurement equipment in the trunk (See UTL 2). As industrial pollution was "given special attention by several radio-equipped vehicles located strategically in the Municipality," throughout the 1960s, mobile electrostatic air samplers gathered portions of the atmosphere to analyze and deconstruct into its constituent chemical substances (CTA 8). The samples, labelled "air," were analyzed at air pollution labs such as one established in an old Etobicoke church run by chemist Harold Seren, later located at 9, Sherbourne Street (PHN 4).

Figure 3. Test equipment utilized to determine content of invisible gases emitted from a chimney. (Source CTA 14).

Yet even by the end of the 1960s, the regulation of air pollution, despite repeated attempts to make it otherwise, remained legally divided into two categories, combustion smoke and everything else:

incinerator fly ash, dust, fumes, and vapors. In terms of combustion sources, the city had success regulating industrial, commercial, and apartment building incinerators, cement factories, boiler plants, as well as open fires on dumps (CTA 14, 14). In terms of gas, the city's research laboratory could analyze some gases in atmospheric "air" samples (internal reports listed substances such as sulphur dioxide, nitric acid, and later aldehydes and hydrocarbons).[10] However, despite its best attempts, the laboratory had trouble translating this research back into on-the-ground interventions (figure 3).[11] The MDW lab operated on limited public funding. In practice, many industries perceived pollution interventions as coming at a prohibitive cost with little benefit, preferring to move out of the city into the inner suburbs or elsewhere, then to install expensive pollution control equipment.

In 1966, emboldened by a growing research program, Metro drafted a revised bylaw that would replace Bylaw 601. It ambitiously proposed the city have the power to regulate a much broader range of emissions, especially gas, asking for the "authority to regulate 'non-combustion' sources," such as "the full range of dusts, odors, vapours etc. . . . resulting from innumerable other industrial processes" (CTA 14). The revision would have provided Toronto with the authority to "regulate discharge into the atmosphere of dusts, gases, fumes, vapors or substances of any nature which cause or may cause nuisance or damage, or which otherwise interfere with the health or comfort of citizens . . . for the first time" (ibid., 28). However, primary documents show bylaw drafts full of inky strikethroughs, where either the province or industry refused to accept the new terms of legislation laid out in the proposal. Instead, the city's regulatory powers were substantially curtailed.

By 1966, the MDW testing laboratory was found to be operating at a deficit and shut down (CTA 16). Equipment was sold, and the laboratory at 9 Sherbourne Street closed. The province absorbed municipal powers, first into the Department of Health, and soon after into the Department of Energy and Resources Management. A new provincial 1967 Air Pollution Control Act acknowledged "materials that evaporate at normal atmospheric temperatures and pressures include petroleum derivatives such as gasoline, fuel oil, paint and cleaning solvents," however, it did not address, nor concede powers to address, emission sources (or their reactivity), in practice.[12] The new act dismissed the intentions of the Metro Works Committee Draft bylaw which would have allowed source emission

[10] See CTA 17, in 1959, 963 tests were carried out on non-construction materials (including, "gasoline, oils, greases, soaps, paint and coal etc.") vs. 361 in 1965 (see ibid., 1). The engineering testing services required "materially changed," in-part due to the "now common practice in industry to manufacture . . . products that meet with Governmental Standards or other highly recognized Association certifications" (see ibid., 3). In 1964 there were 441 tests on "air" (see CTA 14).

[11] In one example given by the city of "concerted action for extremely difficult problems," to find the "cause of offensive emissions," research staff worked on a site that had complaints 24 hours per day for five weeks (CTA 13).

[12] In 1966, a provincial Environmental Health Branch was formed, consolidated into the 1969 Department of Energy and Resources Management, and renamed the Department of the Environment after Bill 93 (Temby 2015).

regulation of petrochemical manufacturing. At this point, city laboratory experiments which reverse-engineered products such as paint and fuels to analyze their components, were deemed too expensive to sustain using public funds. The province contracted independent testing companies as replacements for municipal laboratory services (CTA 15).

The MDW's unique scientific program and on-the-ground methods of responding to public concerns of atmospheric exposure via telephone and pastel station wagon thus came to an end, marking a critical juncture. The shortcomings of a sink managerial ontology were suddenly technoscientifically legible when materials evaluated to be used city-wide surprised workers with their unruly reactivity and in some cases material breakdown or defiance. City ambitions were to further expand technoscientific experimentation, continuing to draw on public funds to produce new knowledges and understandings of petrochemical gases. Their union protested that city testing work continue, "as a surety against buck grabbing contractors" (See CTA 18). Yet, when the province shut-down this research – research that was gaining momentum and provocatively revealing the combinatory, and potentially toxic "reactivity" of atmospheric pollution – it diminished the scope of future local intervention and explicitly depoliticized, and invisibilized, petrochemical reactivity, especially that of the consumer products the city tested. The province, much more than the city, aligned with industry interests to maintain a status quo of production processes that emitted novel and reactive combinations of gases whose long-term effects were unknown. This move framed state-led research as a sinkhole for public funds, delegitimizing the questions animating MDW laboratories. The province cutting scientific resources effectively censored this line of inquiry, exposing how regimes of perceptibility are not only sensory but also legally embedded in the managerial foundations of environmental governance.

The MDW's laboratory closures signaled a wider consolidation of power: as the scope of regulation widened to the province from the city, the shift to measuring, rather than identifying and intervening in, pollution positioned the government as a body to manage (but not change) pollution levels, renewing authority of the atmospheric sink managerial ontology. Roughly twenty years into the fully-fledged manufacturing and consumer marketization of petrochemicals, regulatory policy evolved into one of technoscientific surveillance. By the end of the 1960s, environmental governance shifted towards technocratic approaches, progressively endorsing industrial self-regulation, so that managerial ontologies of air pollution became further coordinated with a broader provincial intent to expand extractive industries under a permission-to-pollute system.

Ambient Intensities and Permission-to-Pollute in the 1970s

In the 1970s, the province would align itself more than ever with the intentional production of imperceptibility in the service of industry and capital. The state focused on optimizing the atmospheric sink's attenuating capacity, treating it as a "standing reserve" for emissions as the externalities of industrial profit (Liboiron 2021, 64). In the notion of ambience, wind and air movements were imagined as akin to abatement technologies, a kind of natural management that

eclipsed the development or implementation of other city-led technoscientific intervention into source emissions.

Explicitly co-opting the atmosphere as a resource, the province – and the city, under the pressure of the province – rebranded its efforts under "Air Resource Management." A hallmark of provincial air pollution control and research, "air resource management," was inspired by an approach taken by the city of Chicago starting in 1963 (Stanley and Heller 1966). Air became a commodity to be conserved and used judiciously.

MDW disdain for, and prosecution of, industries responsible for localized air pollution was replaced by a regional-scale regulatory focus concerned with how petrochemical gas emissions from the city and suburbs dispersed across large areas of atmosphere.[13] This led to the establishment of ambient air quality standards that allowed continuous exposure below determined thresholds, imagining pollutants to diffuse across entire atmospheric regions. A 1966 Air Resource Management report endorsed this status quo as a—

> . . . consideration of ambient air standards deemed acceptable by the citizens of an area and capable of achievement in the light of industrial operation alongside optimum dispersion and reduction of gaseous fumes and mists—at the same time recognizing the impracticability of complete elimination. (CTA 14).

The 1970 National Air Quality Index (AQI) reflected the above managerial logic, pairing data prediction approaches with a permission-to-pollute system. New ambient standards for "criteria air contaminants" were detected in a nation-wide network of monitoring stations. The use of algorithms to interpret measurements and calculate the AQI would portend future reliance on managerial modelling. The province began to publish annual reports of the network that guided management of regional atmospheric intensities, or concentrations of pollutants. Framed by the concept of resource, land relations became more managerial rather than reciprocal (Liboiron 2021, 62). "Air" was commodified by economically mandated pollutant exposure.

The 1970s provincial regulation normalized a strategic imperceptibility of petrochemical gas emissions. As the manufacturing of petrochemical-containing commodities continued to proliferate, so did intensified exposure to petrochemical-derived gases from "countless invisible gases and fumes emitted from various industrial plants, such as refineries, smelters, abattoirs, plating plants, plastic fabricators, and others," as well as "gaseous products" that included "aldehydes, nitric oxides and vapors from cars and buses" (CTA 14, 19). Yet, air pollution data only systematized the management of ambience, rendering these new levels of omnipresent intensity imperceptible. New ambient standards and their corresponding measurements were complicit in a "shifting baseline

[13] The 1967 US Air Quality Act was the first to introduce "air quality regions," also referred to as "air basins" (Martin and Symington 1968, 249).

syndrome," whereby the absence of earlier ambient data was used to support an attitude that there could never be a complete removal of air pollution. Constant, low-level exposure became habitual, and the notion there could be effective prevention of air pollution below ambient standards was relegated to anecdote or a naive perspective (Pauly 1995). Continuously measuring ambient pollution levels naturalized the presence of petrochemical gases, even though they had, by 1966, only existed at that scale for around twenty years.

The province increasingly relied on computational modelling to estimate and project the intensities of pollutants and exposures. These included the Air Quality and Meteorological Information System, which calculated an air quality index based on data from ambient air quality monitoring stations (MOE 2). Similarly, the Air Pollution Inventory of major point sources was processed by the Urban and Regional Atmospheric Simulation Modelling system "to evaluate various planning decisions with respect to the impact on the quality of the air," including "developing long-range plans for Metropolitan Toronto" (ibid., 18). City intentions to explore systematic regulatory intervention into actual petrochemical gas source emission materiality fumed away in red tape.

Post-provincial takeover, air pollution outside combustion remained beyond the regulatory purview of many municipal bylaws until the late 1970s. Given this, Toronto pollution control officers had little choice but to carry forward a flawed municipal strategy that had begun to be used for petrochemical gases in the 1950s – raising "nuisance chimney heights" to diffuse gases and odors away from residential areas, in an attempt to render them short-lived, fleeting, and transitory.[14] Industries were advised to carry chimneys "to such a height as may be required to protect adjoining buildings from flame, smoke, odor and gas emanating therefrom," and to "disperse the fumes into the upper atmospheres."[15]

Citizen groups challenged the treatment of the atmosphere as a pollution sink coupled with the use of tall chimney stacks as a deferral tactic for dealing with transient gases. In 1970, "GASP" (Group Action to Stop Pollution) and Pollution Probe, led by Alderman Tony O'Donohue and University of Toronto faculty members, organized a three-day public inquiry at City Hall to protest the construction of a second 700-foot-high stack for dispersing pollutants from the Hearn, a large coal-fired power plant in the Toronto Portlands. Despite unfurling a banner reading "Dilution is not the solution," explicitly addressing the implicit sink logic, they could not prevent its construction (PHN 10). The tall chimney displaced the "uncertainty" of gas harm skyward. It dismissed citizens

[14] CTA 4. City inspectors told a brick company exempt from the by-law (railway, shipping, brick plants, and smelters were all exempt industries), to put "the gases into a tall chimney and disperse the smoke over a wide area." (CTA 3).

[15] CTA5. See also TRL 3. High chimney stacks were seen to mitigate temperature inversions when "gases are trapped under inversions and the lower the inversion level the less is the amount of air under it to dilute or absorb the noxious emissions."

embodied sensory knowledge (Parr 2006) attuned to how petrochemical gas exposures contribute to chronic illness and chemical injury.

In 1971, an Ashbridges Bay residents' pollution task force also rejected chimney heights as one of the only municipal interventions into gaseous emissions. Long after the city abandoned the Scentometer, they organized a sensory campaign, persisting in a push for embodied sensory knowledge, such as smell, to be considered a valid impetus to regulate atmospheric gas pollutants. Using their bodies as meters, they filled out over 91 "Smell Calendars," recording odors from a sewage plant daily over the summer and submitting their results to the city (PHN 11). This example of citizen science used sensory measurements to persuade the city to relocate the plant, but the solution remained a giant 600-foot stack that dispersed odors and fumes across the sky.

After the 1960s entrenchment of threshold thinking and technoscientific quantification of petrochemical gas, by the 1970s, the epistemic authority of odorous nuisance was reduced even further. Harm from petrochemical gas exposures became increasingly attributed merely to sensitive sensory perception or outliers within the reasonable thresholds of a permission-to-pollute system. Provincial and industrial managerial ontologies aligned, quashing city aspirations to critically reverse engineer petrochemical products, which had begun to point to their toxicity. Local pollution control of petrochemical gas was thus largely subdued in the sinks beneath the tall stacks. Municipal regulators, beyond their monitoring of industry self-regulation and virtual monitoring via algorithmic quantification, had little power to intervene, stuck as ineluctable "arbitrators of individual complaints rather than active regulators of the urban environment" (Kiechle 2017, 62).

The newly created Ministry of the Environment (MOE) did increase data production about specific classes of petrochemical-derived gases. A publication accompanying the 1967 provincial takeover explicitly defined volatilization as:

> A by-product of many chemical and manufacturing operations which induce physical changes in substances through the application of heat and pressure, thereby causing some component materials to vapourize into the atmosphere. Vapourization includes the evaporation of volatile materials at normal atmospheric temperatures and pressures. (MOE 1).

"Volatile organic compounds" (VOCs) soon became an emergent category of classification and research, reflecting developments in chemical engineering, toxicological science, and types of technoscientific instruments available. The province established a hazardous substances task force which investigated VOCs such as benzene, toluene, and xylene (MOE 3). A background report was also published on aromatic hydrocarbons, (a subclass of VOCs), reflecting a shift towards prioritizing the collection of "more data" (Shapiro, Zakariya, and Roberts 2017) at the expense of actually tempering

emissions.[16] However, provincially-governed Air Quality Index (AQI) stations in Metro Toronto established in the early 1970s, did not and still do not measure VOCs. Stations focused on assessing the "self-purification" of the atmosphere, gauging success through the calibration of averaged levels of ozone, nitrogen dioxide, sulfur dioxide, carbon monoxide, and particulate matter (Liboiron 2021, 50). By managing ambient averages within fixed thresholds, regulators effectively endorsed a "reasonable" level of pollution. This technoscientific system produced new learned forms of imperceptibility: intentionally missing nuances in air pollution exposure across millions of people with varying levels of marginalization and bodily vulnerabilities and excluding latency effects (see Scott et al. 2015).[17]

By the 1980s, the term "VOC" was established in air pollution control and research vernacular, describing a wide class of petrochemicals that volatilize at room temperature, transforming from solid to gas. The emergence of the VOC category signaled the convergence of lingering influences from prior regimes of invisibility with managerial ontologies about atmospheric sinks, and new types of technoscientific data. Yet, the smog-forming effects of VOC breakdown would only begin to be federally addressed in 1990 by the Canadian Council of Ministers for the Environment (CCME). It would take until 1999 for VOCs to be formally considered toxic substances under the Canadian Environmental Protection Act, after over forty years of largely unregulated release.

Discussion

This paper has traced petrochemical-derived gas emissions in Toronto from the 1950s to the end of the 1970s to reveal how developments in air pollution governance culminated in the logic of treating atmosphere as a sink, invisibilizing chemical harm and deferring interventions to future generations. By the 1980s, even while the concept of volatile organic compounds (VOCs) gained recognition, the consequences of managerial "ontologies of exposure" (Murphy 2006, 108) had by this point long eschewed the material violences of VOCs' atmospheric and embodied fates.

Early conceptions of air pollution as nuisance and ephemerality in the 1950s laid the groundwork for threshold thinking in the 1960s. This era, despite the technoscientific reckonings of the MDW laboratory research program and pastel station wagon pomp, marked the entrenchment of a regulatory framework that prioritized economic benefits over public health, reflecting broader provincial ambitions to expand extractivism under a permission-to-pollute system. The shift towards technoscientific quantification during this period strengthened a managerial ontology that viewed the atmosphere as a sink for pollutants. It further normalized continuous, low-level chemical

[16] Dr. Mastromatteo cautioned, "the important thing is not the application of numbers . . . without a true understanding of what these numbers mean in terms of their biological and health consequences" (UTA 5).
[17] In 2007, this system was explicitly linked to health, as the Air Quality Health Index. Today there are only four stations for the entire Greater Toronto Area (GTA).

exposures, and reproduced a "*here* and *away*" for petrochemical gas that is a "colonial and cartographic imaginary of territorial enclosure that diffusion refuses to abide by" (Jaworski and Wool 2021).

By the 1970s, the establishment of ambient air quality standards institutionalized the concept of atmospheric intensities, allowing for the persistent presence of petrochemical gases below regulatory thresholds. This era's reliance on data prediction and computational modelling perpetuated a "shifting baseline syndrome," wherein the absence of earlier data naturalized a regulatory apparatus of ongoing pollution, obscuring its long-term impacts, and continuing to dismiss forms of sensory knowledge about petrochemical gas exposure.

Overall, archival personal notes, meeting minutes, private communications, internal reports, and public-facing news media reveal the consequences of differing municipal and provincial approaches to atmospheric governance through technoscientific practices. Ultimately, provincial take-over led to measurement and quantification of regional-scale petrochemical gases (later VOCs) prevailing over prevention, or intervention into source emissions. A gradual expansion of managerial ontologies that prioritized control and regulation through statistical thresholds and predictive algorithms rendered the material impacts of uneven atmospheric chemical exposure, and harm, imperceptible. The practice of "sinking" hundreds of petrochemical-derived gases into the sky, can thus be considered "bad relations that exceed scientific evidence of harm," following Liboiron's call for those going with an "overtly anthropological set of value-based definitions of pollution as bad relations, [to] do it and do it loud" (Liboiron 2021, 19, note 72), as it entrenched a regime of imperceptibility that continues to obscure the lived effects of these emissions on marginalized communities.

As a white settler discussing histories of knowledge production, I have intended to "destabilize, rather than reconsolidate Eurocentric stories about the relationship between 'materialism' and 'Science'," when I talk about petrochemical gases (Willey 2016, 994). Permission-to-pollute systems disrespect the atmosphere "as a relational space," because distributions of exposure remain profoundly uneven by design (Ahuja 2015, 370). Despite the atmosphere being a material extension of land and all its relations (Simpson 2014; McGregor 2018), permission-to-pollute systems require gaseous sinks to be weathered in raced, classed, gendered, and ableist ways I have only begun to outline here. The regulatory treatment of atmosphere remains an "idealized juridical space of exceptional rights granted to normative settler citizens and the idealized exceptionalism by which the settler state exerts its sovereignty," and collective atmospheric politics clouded by fossil fuel capitalism and dispossession.[18]

Further scholarship that problematizes the permission-to-pollute design characterizing urban and industrial emission governance of petrochemical VOCs in Canada is needed to support

[18] la paperson 2017, 10, cited in Liboiron 2021, 3, note 10.

environmental data justice (Shadaan and Murphy 2020). Arguing for interventions into source emissions at the level of entire chemical-class is one way to begin meaningfully addressing VOCs' ongoing chronic health effects, as well as growing awareness of their potential contributions to climate change beyond smog and acid rain (Mellouki et al. 2015). But much more needs to be done to reconceptualize, and practice, different ethical relationships with atmosphere. Here, Tiffany L. King is instructive. She notes (2019), regarding the centering of other, non-liberal humanist, settler colonial understandings of land and territory, that "Rather than read these ruptures, dissolving and ephemeral spaces suspiciously, I encourage the reader to engage the nontraditional geographies (visible, uncharted, and invisible) that connect Indigenous and Black diasporic thought reparatively (12)." Unpacking the ontoepistemologies – entangled processes of knowing and being – shaping relationships to such atmospheric violence might then begin to interrogate how VOC exposure is currently rendered imperceptible by the sink logic of managerial ontologies. This is an immense task, as with volatility, the sky is not the limit.

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