Formaldehyde Air Pollution in Houston

Monitoring Shows Plumes of Carcinogenic Formaldehyde in Neighborhoods Along Houston's Ship Channel

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ONE BREATH PARTNERSHIP

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THE ONE BREATH PARTNERSHIP:

One Breath Partnership is a nonprofit, nonpartisan coalition that elevates work for clean air in Houston, Harris County and the surrounding region. The founding members of One Breath Partnership are Air Alliance Houston, Environment Texas, Environmental Defense Fund, Environmental Integrity Project, Public Citizen, and Rice University. Our work is made possible through the Houston Endowment.

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Spanish translation of executive summary available at: https://environmentalintegrity.org/wp-content/uploads/2021/07/Spanish-translation-of-formaldehyde-executive-summary.pdf

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Formaldehyde Air Pollution in Houston

New Monitoring Shows Plumes of Formaldehyde in Neighborhoods of Color along the Houston Ship Channel

Executive Summary

Air pollution monitoring conducted by the Houston Health Department in 2019 and 2020 recorded levels of formaldehyde, a known carcinogen, along the Houston Ship Channel that pose health risks to those living and working nearby. The health department's analysis, funded by the U.S. Environmental Protection Agency (EPA), found that from September 27, 2019, to September 26, 2020, annual formaldehyde concentrations at three monitoring sites exceeded EPA's chronic health screening level of 0.17 parts per billion for risk of one additional cancer case per million people.[1] Prolonged exposure above this concentration would present an increased risk of cancer to local residents. The highest average annual concentration was in the Cloverleaf neighborhood, where the monitor averaged 2.28 parts per billion – more than 13 times EPA's chronic health screening level. In the long-term, this would translate to about 1 additional cancer case per 77,000 people, according to the Houston Health Department's assessment of EPA's cancer risk formulas.[2] Concentrations never exceeded thresholds set by the Texas Commission on Environmental Quality. The people most at risk are primarily low-income, Latino and Black residents of Manchester, Harrisburg, Meadowbrook, Allendale, Northshore, and Galena Park just across the fence lines from oil refineries, plastics plants, and other industrial facilities.

The Shell Chemical Deer Park plant east of Houston releases tons of propylene and isoprene – air pollutants that combine in the atmosphere with other chemicals to form formaldehyde.

Experts have known for decades that the neighborhoods along the Houston Ship Channel face increased cancer risk from a toxic mixture of air pollutants from industry and traffic. According to the 2014 NATA, formaldehyde is the highest contributing chemical to cancer risk in nearly 89 percent of census tracts in Harris County.[3] Formaldehyde is difficult to regulate and control in Houston because the vast majority is formed from other pollutants and multiple sources. In addition to contributing to cancer risk, formaldehyde reacts secondarily to form ground-level ozone, a respiratory irritant responsible for increased rates of cardiac arrest and asthma. The Houston Health Department's research contributes to the understanding of these critical air pollutants allowing for improved modelling and regulation efforts by the Texas Commission on Environmental Quality and EPA. As an emerging chemical of concern in Houston, these recent data present concentrations of

formaldehyde, valuable to regulators in developing controls to better protect health. The vast majority of ambient formaldehyde along the Houston Ship Channel originates from chemical reactions involving formaldehyde precursors which are predominantly emitted from the petrochemical industry.

Formaldehyde is a colorless, flammable gas to which brief exposure can cause adverse health effects, such as irritation of the skin, eyes, nose, and throat, and long-term exposure can cause certain types of cancers. According to EPA's 2014 NATA, formaldehyde is the most potent carcinogen in outdoor air contributing to over half of all increased cancer risk in the United States. While formaldehyde is highly regulated for its use in construction and household products—from which it off-gases into the air—elevated levels of ambient formaldehyde in urban environments remains a major public health problem.

While formaldehyde is highly regulated for its use in construction and household products, ambient formaldehyde in urban environments remains a major public health problem that is largely unregulated.

Less than 5 percent of the formaldehyde present in Houston's air is emitted directly from industrial point sources, with around 4 percent being attributable to on-road vehicle emissions.[4] The point sources that emit formaldehyde have been identified using the National Emissions Inventory and plotted across Houston, with their density being highest in the Houston Ship Channel area.

Secondary formaldehyde (i.e., not directly emitted but formed from other chemicals) makes up almost 95 percent of all the ambient formaldehyde present in Houston Ship Channel neighborhoods. The formaldehyde precursors involved in the secondary formation include ethylene, isoprene, propylene and other volatile organic compounds

Ethylene and propylene are industrially emitted volatile organic compounds that are regularly produced by the petrochemical industry. Isoprene is an organic compound that largely comes from the natural environment but also from industrial sources. While formaldehyde is regulated as a hazardous air pollutant under the federal Clean Air Act, new regulations and mechanisms—such as stronger permits—are needed to address the chemicals that are emitted from industrial sources in Houston that lead to secondary formaldehyde formation, including ethylene, isoprene, propylene and other highly reactive volatile organic compounds.

To help address this problem, the Texas Commission on Environmental Quality could consider amending its existing Highly Reactive Volatile Organic Compounds rules, which were first adopted in 2002.[5] In the interim, TCEQ permit reviewers may also consider

scrutinizing new or amended air permits that authorize the release of the gases that can form into dangerous formaldehyde.

Key Findings:

- The data collected by this study add to the understanding of formaldehyde and its precursors in Houston. Formaldehyde concentrations reported in EPA's National Air Toxic Assessment (NATA) indicate that formaldehyde provides the greatest contribution to increased cancer risk in Houston. Some of the highest cancer risk census tracts associated with formaldehyde are surrounded predominately neighborhoods of color with high rates of poverty.

- The Houston Health Department analysis found that in 2020 formaldehyde concentrations at all three of their monitoring sites exceeded an EPA chronic health screening level of 0.17 parts per billion (ppb) for risk of one additional cancer case per million people. The measurements also showed that concentrations at one of the monitoring sites, located in the Cloverleaf neighborhood, exceeded the EPA health screening level by 13-fold. Additionally, formaldehyde contributes to the secondary formation of ozone, a pollutant associated with respiratory and cardiac health concerns in Houston.

- The Texas Commission on Environmental Quality's formaldehyde fixed ambient air monitoring site data indicate that formaldehyde concentrations are slightly statistically increasing in Houston, while the agency's fixed air monitoring site sampling frequency is decreasing.

- The measured data are consistent with modelled NATA estimates that indicate a potential cancer risk from formaldehyde in the study areas in Houston.

Recommendations:

- This investigation into formaldehyde and its precursors, including ethylene, propylene, and isoprene indicate a need for tightened permitting and control of these chemicals to limit secondary formaldehyde and ozone pollution.

- The Texas Commission on Environmental Quality could consider amending its "Highly Reactive VOC" rules to address the problem of formaldehyde air pollution associated with secondary formation from gases such as ethylene, isoprene, and propylene.

- Federal and state authorities may wish to consider increased formaldehyde monitoring and make any subsequent analysis widely available so that public health risks can be better understood and controlled. Increased monitoring can better inform regulators and legislators on the impact of these atmospheric pollutants.

Background on Formaldehyde

Formaldehyde is a naturally occurring organic compound made up of one carbon molecule, two hydrogen molecules, and one oxygen molecule (HCHO). Formaldehyde was first identified in the late 19th century and by the early 20th century was commonly being used as an embalming agent, food and medical preservative, and disinfectant. In 1907, Belgian chemist Dr. Leo Baekeland used a formaldehyde resin to invent Bakelite, the first plastic made from synthetic components.[6]

One hundred years later, formaldehyde can be found in everything from kitchen tables to nail polish to fabric softeners. It is commonly used in manufactured wood products such as cabinets, furniture, plywood, particleboard, and laminate flooring. It can also be found in household products such as glues, paints, caulks, pesticides, cosmetics, and detergents.[7]

Most formaldehyde exposures occur by breathing indoor air contaminated by carpets, countertops, cabinets, couches, and other furniture that is off-gassing the chemical. This off-gassing from building materials and other products can lead to indoor formaldehyde concentrations far exceeding outdoor levels.[8] Formaldehyde (as urea formaldehyde foam) was extensively used as an insulating material until 1982 when it was banned by the U.S. Consumer Product Safety Commission.[9] Formaldehyde is also a component of tobacco smoke, affecting both smokers and those exposed to secondhand smoke.

Long-term exposure to formaldehyde can cause cancer of the nasal passages and throat, as well as leukemia and other respiratory tract cancers.

Secondary formation of formaldehyde, as is happening in the Houston Ship Channel, occurs in the atmosphere through chemical reactions (oxidation) of natural and manmade volatile organic compounds.[10] Vehicle (including airplane) exhaust is also a major source of formaldehyde in outdoor air. In vehicles, formaldehyde is formed directly in combustion engines as well as through secondary reactions involving VOCs that are exhaust products.

Formaldehyde is also emitted directly into the air at many industrial sites, including power plants, manufacturing facilities, and incinerators.

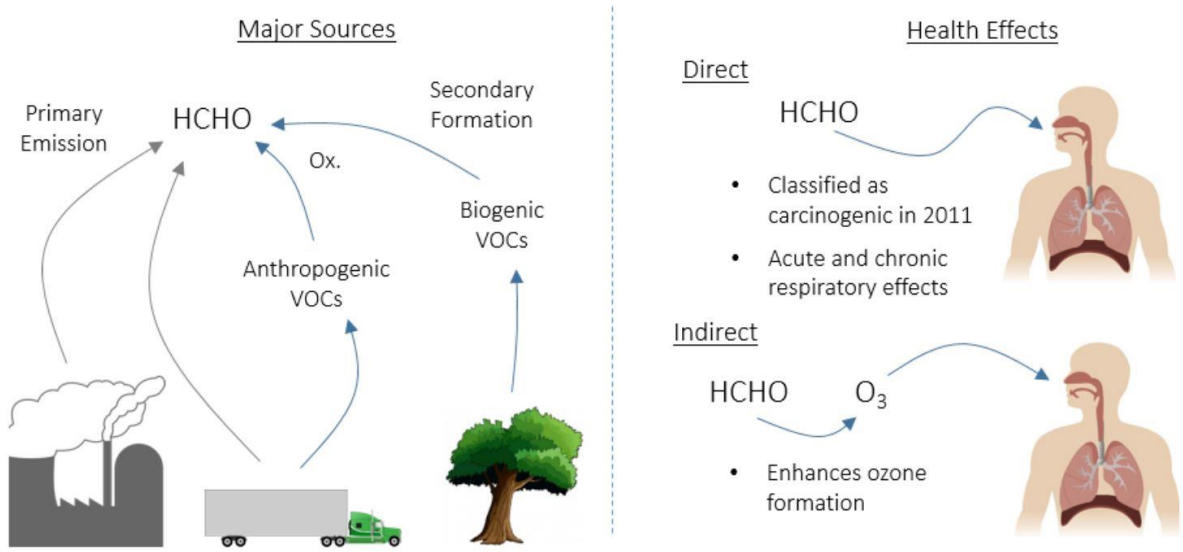
Health Impacts

The U.S. National Toxicology Program listed formaldehyde as a known carcinogen in its 12th Report on Carcinogens in 2011.[11]

Long-term exposure to formaldehyde can cause cancer of the nasal passages and throat, leukemia, and other respiratory tract cancers. Short-term effects of formaldehyde exposure include irritation in the eyes, nose, throat, and skin, nausea, and headaches.[12] Children, older adults, and people with asthma and other breathing problems are more likely to have these symptoms.[13]

Ambient formaldehyde also reacts quickly with other chemicals, including nitrogen oxides (NO_x) and other volatile organic compounds, and drives the production of ground-level ozone (O_3) formation in the air. Breathing ground-level ozone can trigger a variety of health problems including chest pain, coughing, throat irritation, and airway inflammation. It also can reduce lung function and harm lung tissue. Ozone can worsen bronchitis, emphysema, and asthma.[14]

Figure 1: Formaldehyde Sources and Health Effects



Source: Houston Health Department, "Update on formaldehyde monitoring."
http://www.houstontx.gov/council/committees/rma/20180719/HHD%20Formaldehyde%20-%20FINAL.pdf

Demographics

The three census tracts where the formaldehyde monitors were placed by the Houston Health Department had a total population of 8,843 residents as of 2018. Just under 25 percent of the households in these areas lived below the poverty line in 2014-2018, and just under two-thirds of the residents were minorities, as defined by census data, over the same period.

The Clinton Dr. monitor was located within the Galena Park neighborhood. The HRM3 monitor was located within the Cloverleaf neighborhood. The Lynchburg Ferry monitor was located just east of the Channelview neighborhood.

Table 1: Demographic Information and Cancer Risk in Census Tracts Surrounding Monitors

Monitor Location	2014-2018 population	2014-2018 % Below Poverty Level	2014-2018 % Minority	EPA Modeling Estimate* of Formaldehyde Cancer Risk per 1 Million People	EPA Computer Modeling Estimate of Formaldehyde Concentration (µg/m3)
Clinton Dr. census tract (Galena Park)	2,095	40%	97%	49	1.58 (1.29 ppb)
HRM3 census tract (Cloverleaf)	3,779	23%	67%	96	1.56 (1.27 ppb)
Lynchburg Ferry census tract (east of Channelview)	2,969	14%	40%	70	1.22 (0.99 ppb)

Demographics from the American Communities Survey of residents. Cancer risk and HCHO concentration modeling from the National Air Toxics Assessment.
**The EPA computer modeling estimates of cancer risk and formaldehyde concentrations are from the 2014 National Air Toxics Assessment, or NATA, which is the federal agency's review of air toxics in the United States, based on modeled air quality. NATA uses the best science and emissions data available to estimate possible health risks from air toxics. NATA provides screening-level estimates of the risk of cancer and other serious health effects from breathing (inhaling) air toxics. This helps show which air toxics and source types may raise health risks in certain places.*[15]

Regulation

In the Clean Air Act Amendments of 1990, Congress defined formaldehyde as a toxic air pollutant subject to regulatory action by the EPA.[16] Formaldehyde is now designated as a hazardous air pollutant under Section 112 of the Clean Air Act.

In 2010, President Obama signed into law a bill called the Formaldehyde Standards for Composite Wood Products Act, requiring the EPA to regulate formaldehyde in composite wood products. These rules affect manufacturers, importers, distributors, and retailers of products containing composite wood—including fiberboard, particleboard, and various laminated products—who must comply with more stringent record-keeping and labeling requirements.[17]

Categories which formaldehyde is currently regulated under National Emission Standards for Hazardous Air Pollutants as part of the Clean Air Act include:[18]

- Plywood and composite wood products
- Vehicle emissions
- Wet formed fiber glass mat production
- Mineral wool production
- Wool fiberglass manufacturing
- Manufacture of amino/phenolic resins

- Wood furniture manufacturing operations
- Rubber tire manufacturing
- Natural gas transmission and storage facilities
- Synthetic organic chemical manufacturing industry
- Organic liquid distribution operations
- Taconite iron ore processing
- Emissions for polyvinyl chloride and copolymers production
- Oil and natural gas production facilities

While formaldehyde is regulated as a hazardous air pollutant under the federal Clean Air Act, new regulations and mechanisms—such as stronger permits— may be helpful to address the chemicals that are emitted from industrial sources in Houston, that lead to secondary formaldehyde formation, including ethylene, propylene, isoprene, and other highly reactive volatile organic compounds.

Methodology

EPA awarded a Community Air Toxics Monitoring Grant to the Houston Health Department's Environmental Division. The funds paid for a project to conduct 18 months of ambient formaldehyde monitoring in communities directly north of the Houston Ship Channel that have some of the highest cancer risk from air pollution in the city. Beginning on January 1, 2020, the health department began continuously measuring formaldehyde concentrations at three locations across this tract: Clinton Dr., HRM3, and Lynchburg Ferry. The Clinton Dr. monitor was located within the Galena Park neighborhood. The HRM3 monitor was located within the Cloverleaf neighborhood. The Lynchburg Ferry monitor was located just east of the Channelview neighborhood. Two different monitoring tools, Aero-Laser and Picarro, were used to take readings; special calibration and statistical analysis were employed to make the readings comparable.

Continuous formaldehyde measurements were time averaged to 5-minute increments and then into hourly average concentrations. These hourly concentrations were evaluated for percent coverage during the one-year period and an annual mean was calculated. Summary statistics of these measurements are presented in the comparison to annual and chronic levels as well as in Table 3.

Analysis: The Origin of Houston's Formaldehyde

According to the 2012 study "Primary and secondary sources of formaldehyde in urban atmospheres: Houston Texas region" published in the journal *Atmospheric Chemistry and Physics,* approximately 96 percent of the ambient formaldehyde in Houston is from industry and 4 percent is from vehicle exhaust (not including airplanes). Of the 96 percent from industry, 92 percent (±4 percent) is formed secondarily from volatile organic compounds emitted from petrochemical facilities, including ethylene, isoprene, and propylene. Primary emissions from these and other facilities (including airports) account for 2 to 6 percent of Houston's ambient formaldehyde.[19]

Comparison to Annual or Chronic Levels

Annual means were calculated for each monitoring site by aggregating continuous data into 5-minute time averages. These 5-minute averages were further time-averaged into hourly concentrations. Finally, the mean was calculated for an annual formaldehyde concentration at each monitor. During the sample period, the average annual formaldehyde concentrations exceeded 0.17 parts per billion, which is EPA's chronic exposure screening level, at all three monitor sites. That means that people who inhale this concentration on a daily basis over their lifetime will face an estimated increase in their risk of developing cancer of one in one million.

At the Cloverleaf monitoring site (the HRM3 site north of Pasadena), the average (mean) formaldehyde reading from September 27, 2019 to September 26, 2020, was 2.28 parts per billion, which was 13 times the EPA screening level. This means that people living nearby face an increased risk of developing cancer of 1 in 77,000 over a lifetime if this concentration persists, according to the Houston Health Department's assessment of EPA's cancer risk formulas.[20] At the Clinton Dr. monitoring site, the average reading over this period was 1.22 parts per billion – which was seven times the EPA screening level, or one additional cancer case per 140,000 people over a lifetime if this concentration persists. At the Lynchburg Ferry monitoring site, the average reading over a year was 0.79 ppb – about 5 times the EPA screening level or about 1 additional cancer case per 200,000 people if this concentration persists.

Table 2 shows the federal and state formaldehyde health screening levels that the measured formaldehyde concentrations from all three monitors are compared to in Tables 3 and 4. All comparisons to chronic risk indicate the potential increased cancer risk associated with a chronic exposure to these annual averages. Hourly averages were used to compare to hourly screening levels in Table 4.

Table 2: Health Screening Guidelines from Government Agencies

Action Levels	Averaging Time	Concentration (Parts Per Billion)
EPA Health Screening Level ($1x10^{-6}$) [one in one million increased cancer risk]	Chronic	0.17 ppb
EPA Screening Level ($1x10^{-5}$) [ten in one million increased cancer risk]	Chronic	1.79 ppb
TCEQ ESL*	Annual	2.7 ppb
TCEQ ESL	1 Hour	12 ppb
TCEQ AMCV**	Annual	8.9 ppb
TCEQ AMCV	1 Hour	41 ppb

Source: FY20 City of Houston Community Scale Air Toxic: Near-Source Characterization of High Risk Formaldehyde, Precursors and other HAPs Posing Significant Risk in Houston to Inform Evaluation of Emission Reduction Measures Report 07/01/2020-09/30/2020.

** Effects Screening Levels (ESL) are screening levels used in TCEQ's air permitting process to evaluate air dispersion modeling's predicted impacts.[21]*

*** Air Monitoring Comparison Values (AMCV) is a collective term used to describe chemical-specific air concentrations used to evaluate air monitoring data that are set to protect human health and welfare.[22]*

Table 3: Annual Formaldehyde Monitor Readings Compared to EPA Health Screening Formaldehyde Levels

Monitor Location	Percent Complete (Hours Per Year)	Study Annual Mean (Parts Per Billion)	Result
Clinton Dr. census tract (Galena Park)	82%	1.22	Exceeds EPA Chronic Health Screening Level ($1x10^{-6}$) [1 in one million increased cancer risk]
HRM3 census tract (Cloverleaf)*	65%	2.28	Exceeds EPA Chronic Health Screening Level ($1x10^{-6}$) [1 in one million increased cancer risk] and EPA Chronic Health Screening Level ($1x10^{-5}$) [10 in one million increased cancer risk]
Lynchburg Ferry census tract (east of Channelview)	82%	0.79	Exceeds EPA Chronic Health Screening Level ($1x10^{-6}$) [1 in one million increased cancer risk]

Source: FY20 City of Houston Community Scale Air Toxic: Near-Source Characterization of High Risk Formaldehyde, Precursors and other HAPs Posing Significant Risk in Houston to Inform Evaluation of Emission Reduction Measures Report 07/01/2020-09/30/2020.
Annual average concentrations are calculated by averaging continuous data into five-minute averages, hourly averages, and finally an annual average of all valid 1-hour measurements.
** Using a more representative timeframe of when the instrument was physically at the site (8/14/2019 – 5/29/2020) at HRM3 yields 92% completeness and mean of 2.4 ppb*

Table 4: Number of Health Screening Level Exceedances at All Monitoring Sites

Comparison Levels and Source	Averaging Time†	Concentration (Parts Per Billion)	Clinton Dr. Monitor	HRM3 Monitor	Lynchburg Ferry Monitor
EPA Health Screening Level ($1x10^{-6}$) [1 in one million increased cancer risk]	Chronic	0.17 ppb	1	1	1
EPA Health Screening Level ($1x10^{-5}$) [10 in one million increased cancer risk]	Chronic	1.79 ppb	0	1	0
TCEQ ESL*	Annual	2.7 ppb	0	0	0
TCEQ ESL	1 Hour	12 ppb	9	21	4
TCEQ AMCV**	Annual	8.9 ppb	0	0	0
TCEQ AMCV	1 Hour	41 ppb	0	0	0

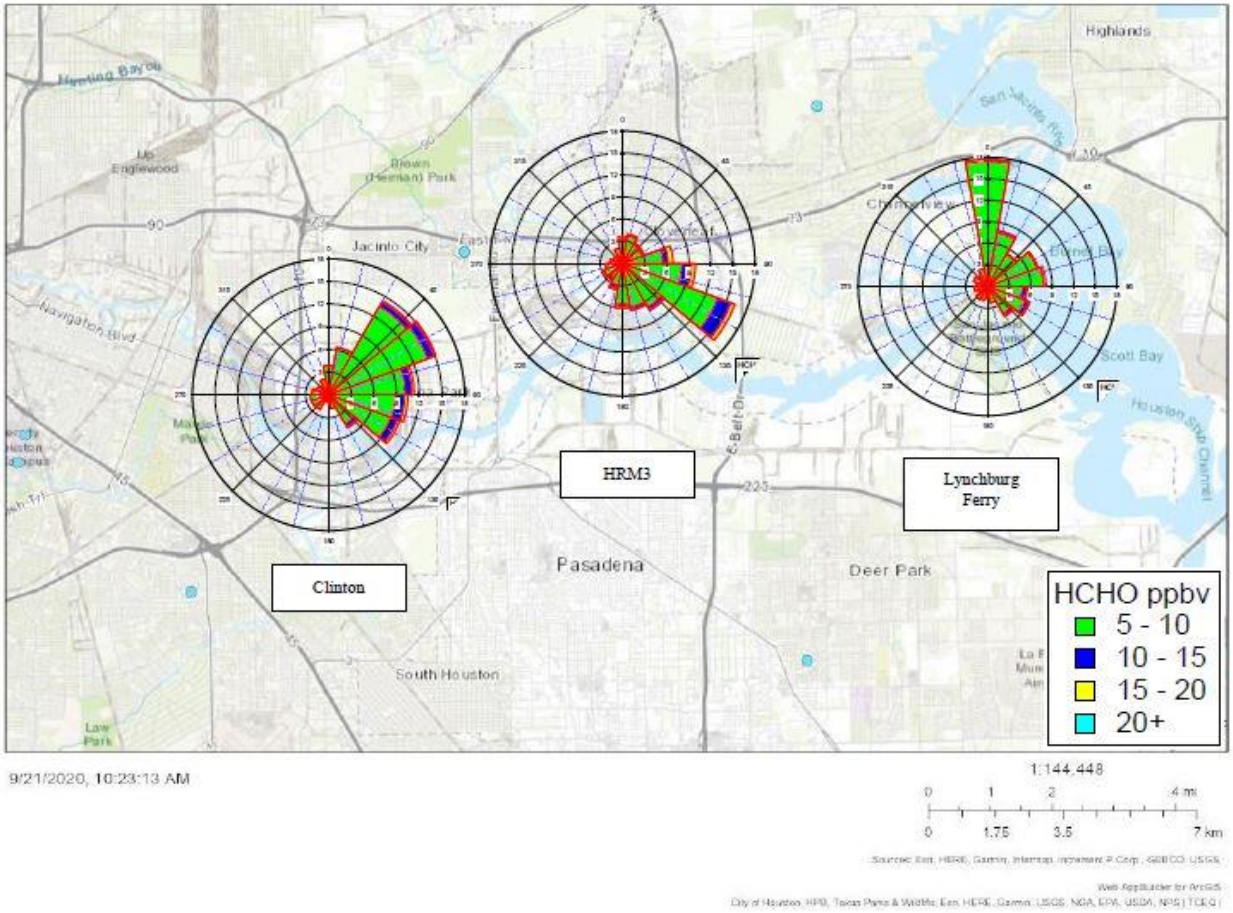
The monitoring was conducted from September 27, 2019, to September 26, 2020. Source: FY20 City of Houston Community Scale Air Toxic: Near-Source Characterization of High Risk Formaldehyde, Precursors and other HAPs Posing Significant Risk in Houston to Inform Evaluation of Emission Reduction Measures Report 07/01/2020-09/30/2020.
† Annual average concentrations are calculated by averaging continuous data into five-minute averages, hourly averages, and finally an annual average of all valid 1-hour measurements. Calculated annual averages are compared to both chronic and annual comparison levels. Calculated hourly concentrations are used for comparison to 1-hour comparison levels.
** Effects Screening Levels (ESL) are screening levels used in TCEQ's air permitting process to evaluate air dispersion modeling's predicted impacts.[23]*
*** Air Monitoring Comparison Values (AMCV) is a collective term used to describe chemical-specific air concentrations used to evaluate air monitoring data that are set to protect human health and welfare.[24]*

Wind Direction Analysis

Compiling formaldehyde measurements from the air monitors, scientists conducted wind direction analyses to identify potential point sources and downwind communities that could be impacted. The analyses examined consecutive five-minute-averaged exceedances of five parts per billion (ppb) formaldehyde, which would indicate a very short-term source of formaldehyde. These measurements from September 27, 2019 through September 26, 2020, are plotted in wind direction indicators as seen in Figure 2. The data do not point to a conclusive source, rather suggesting multiple point sources that create a regional plume of formaldehyde. At both Clinton Dr. and HRM3 formaldehyde instruments, wind direction indicators point toward sources in the Houston Ship Channel. However, the monitor at Lynchburg Ferry indicates formaldehyde concentrations coming from the North.

Identification of precursor locations may improve the understanding of secondary formaldehyde formation, however, precursor analysis of ethylene, isoprene, and propylene at all three sites to-date yield mixed results in terms of identifying sources.

Figure 2: Wind Direction Analysis of Formaldehyde Exceedances, 2019-2020

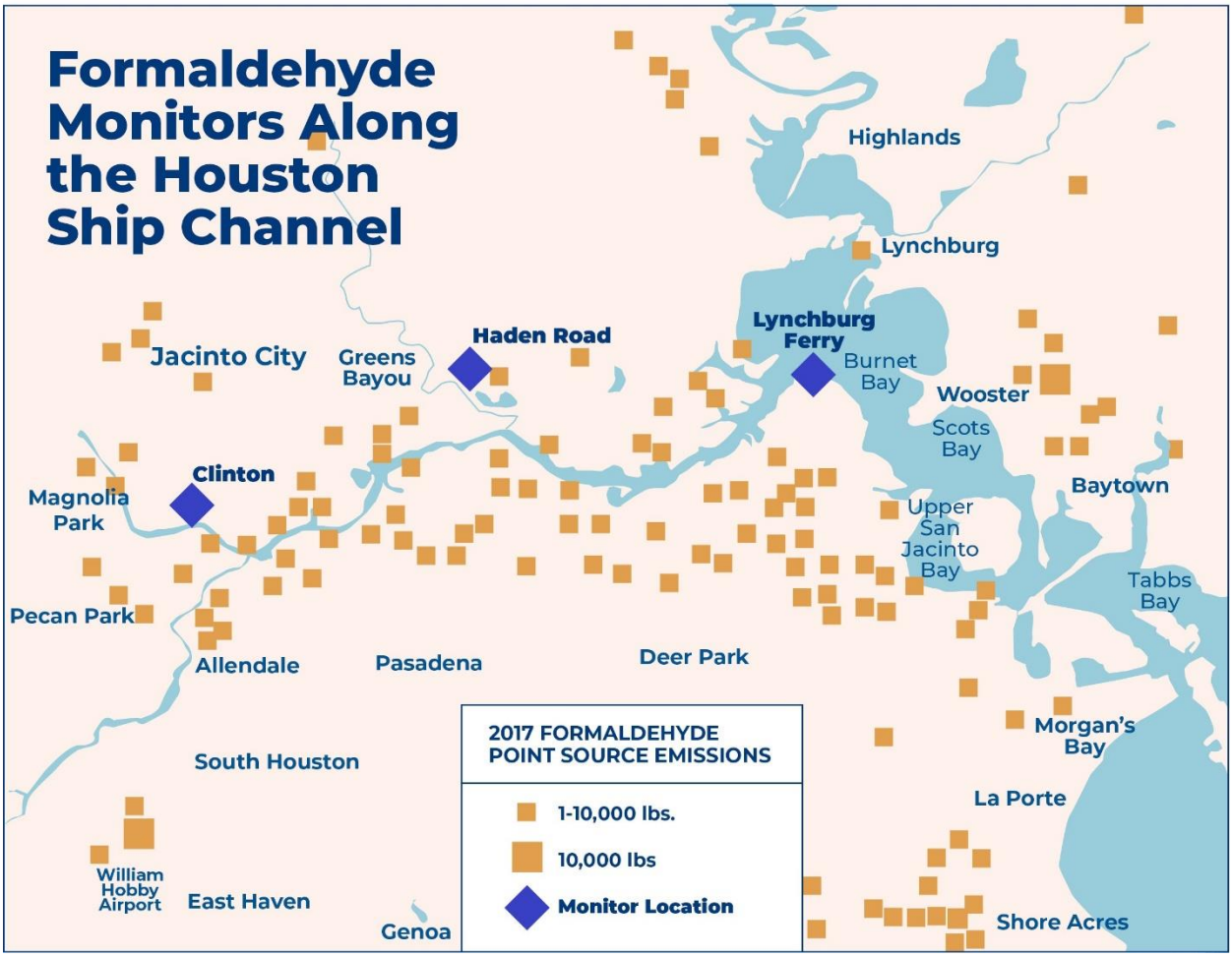


Dates examined were from September 27, 2019 through September 26, 2020. Source: FY20 City of Houston Community Scale Air Toxic: Near-Source Characterization of High Risk Formaldehyde, Precursors and other HAPs Posing Significant Risk in Houston to Inform Evaluation of Emission Reduction Measures Report: 07/01/2020-09/30/2020.

Point Source Analysis

Formaldehyde concentrations in the Houston Ship Channel are due to both primary emissions and secondary formation of formaldehyde. However, less than 5 percent of the formaldehyde present in Houston's air is emitted directly from industrial point sources. Point sources that emit formaldehyde have been identified using the 2017 National Emissions Inventory (NEI) and plotted across Houston. Of all identified formaldehyde point sources in Houston, the density is highest in the Houston Ship Chanel area. Figure 3 outlines the census tracts containing each monitoring location and the density of these facilities. The size of each box represents the amount of annual primary emissions of formaldehyde from fixed sites reported in pounds per year.

Figure 3: Formaldehyde Point Sources Plotted Across Houston Ship Channel



Source: FY20 City of Houston Community Scale Air Toxic: Near-Source Characterization of High Risk Formaldehyde, Precursors and other HAPs Posing Significant Risk in Houston to Inform Evaluation of Emission Reduction Measures Report: 07/01/2020-09/30/2020 (2017 National Emissions Inventory)

Table 5: Top 15 Houston-Area Formaldehyde Point Source Emissions Sources (2017)

Rank	Company Name	Site Name	Site Location	Facility Description	Formaldehyde Emissions (lbs)
1	N/A	George Bush Intercontinental	Houston	Airport	115,759
2	N/A	William P Hobby	Houston	Airport	35,376
3	ExxonMobil Chemical Company	Baytown Olefins Plants	Baytown	Petrochemical manufacturing	27,424
4	Potim Energy Altura Cogen LLC	Altura Cogen	Channelview	Electricity generation	25,605
5	N/A	Ellington Field	Houston	Airport	18,506
6	ExxonMobil Refining & Supply Co	Baytown Refinery	Baytown	Petroleum refinery	18,488
7	EIF Channelview Cogeneration LLC	Channelview Cogeneration Facility	Channelview	Electricity generation	15,218
8	Oxyvinyls LP	Battleground Site	La Porte	Chemical plant	9,318
9	NRG Texas Power LLC	San Jacinto Steam Electric Station	La Porte	Electricity generation	8,979
10	Deer Park Energy Center LP	Deer Park Energy Center	Deer Park	Electricity generation	8,163
11	NRG Texas Power LLC	TH Wharton Electric Generating Station	Houston	Electricity generation	4,936
12	Shell Chemical LP	Deer Park Plant	Deer Park	Petroleum refinery	4,640
13	Air Liquide America Corp	Air Liquide Bayport Complex	Pasadena	Chemical plant	3,702
14	A&AT LLC	La Porte Plant	La Porte	Petrochemical manufacturing	3,667
15	N/A	David Wayne Hooks Memorial	Houston	Airport	2,640

Source: National Emissions Inventory, 2017

Precursor Emitters

Formaldehyde precursors, which include ethylene, isoprene, propylene and other highly reactive volatile organic compounds, account for almost 95 percent of the Houston area's secondary formaldehyde. Secondary formaldehyde makes up almost 95 percent of all the ambient formaldehyde present in Houston Ship Channel neighborhoods, with the rest being directly emitted from industrial sources or vehicles.

Table 6: Top 10 Harris County Ethylene Emissions Sources

Company	Site	Annual Ethylene Emissions 2017 (Tons)
Ineos USA LLC	Polyethylene Plant	25.1
Flint Hills Resources	Ethylene Pipeline Equipment	24.0
Flint Hills Resources	Ethylene Pipeline Equipment	22.6
ExxonMobil Pipeline Co	Bop Meter Station	21.6
Chevron Pipeline Company	TXF633 Induroma Meter Station Pipeline	20.9
Chevron Phillips Chemical Company LP	Pasadena Plastics Complex	19.3
Chevron Phillips Chemical Company LP	Pasadena Plastics Complex	19.3
Ineos USA LLC	Polyethylene Plant	19.1
Equistar Chemicals LP	La Porte Complex	18.3
Equistar Chemicals LP	La Porte Meter Sites	17.8

Source: 2017 data obtained from the State of Texas Air Reporting System (STARS) on March 8, 2019.

Table 7: Top 10 Harris County Propylene Emissions Sources

Company	Site	Annual Propylene Emissions 2017 (Tons)
ExxonMobil Chemical Company	Baytown Chemical Plant	31.7
ExxonMobil Chemical Company	Baytown Chemical Plant	27.2
Equistar Chemicals LP	Bayport Polymers	25.7
ExxonMobil Chemical Company	Baytown Chemical Plant	21.4
Ineos USA LLC	Polyethylene Plant	18.5
Shell Chemical LP	Deer Park Plant	18.2
Ineos USA LLC	Polyethylene Plant	15.8
ExxonMobil Chemical Company	Baytown Olefins Plant	13.4
ExxonMobil Chemical Company	Baytown Chemical Plant	12.9
Braskem America Inc	La Porte Plant	12.8

Source: 2017 data obtained from the State of Texas Air Reporting System (STARS) on March 8, 2019.

Table 8: Top 10 Harris County Isoprene Emissions Sources

Company	Site	Annual Propylene Emissions 2017 (Tons)
ExxonMobil Chemical Company	Baytown Olefins Plant	5.7
Vopak Terminal Deer Park Inc	Deer Park Terminal	4.7
Equistar Chemicals LP	Channelview Complex	3.8
Vopak Terminal Deer Park Inc	Deer Park Terminal	2.9
Vopak Terminal Deer Park Inc	Deer Park Terminal	2.0
ExxonMobil Chemical Company	Baytown Chemical Plant	1.9
Intercontinental Terminals Company LLC	Deer Park Terminal	1.4
Odfjell Terminals Houston INC	Tanker Terminal Bayport	1.1
Shell Chemical LP	Deer Park Plant	1.1
Dixie Chemical Company Inc	Bayport Facility	0.6

Source: 2017 data obtained from the State of Texas Air Reporting System (STARS) on March 8, 2019.

Conclusion

The Houston Health Department's analysis adds evidence to the need to address formaldehyde concentrations in fenceline communities across Houston, specifically the predominately low-income communities of color along Houston's industrial shipping channel including Harrisburg, Manchester, Meadowbrook, Allendale, Northshore, Galena Park, and others. Demographics from the American Community Survey of neighborhoods surrounding each of these facilities show below poverty rates of 3% - 34% and percent minority between 50% and 97%. The formaldehyde present in these communities originates both directly from industrial point sources and vehicle and airplane emissions, though predominantly secondarily through chemical reactions in the air involving formaldehyde precursors, those primarily being volatile organic compounds emitted from the petrochemical industry.

Local, state, and federal lawmakers and agencies may wish to consider doing more to and to reduce formaldehyde concentrations and public exposure along the Houston Ship Channel.

Recommendations:

- The data collected by this study add to the understanding of formaldehyde and its formation in Houston. Further investigation into formaldehyde and its precursors, including ethylene, propylene and isoprene indicate a possible need for enhanced regulatory oversight, much the same way that scientific studies in the Houston area led to the TCEQ's adoption of its Highly Reactive VOC program more than a decade ago. Stricter limits and control of the gases that form into formaldehyde could benefit public health in multiple ways, as formaldehyde is both a carcinogen and an ozone-forming pollutant.

- TCEQ may wish to consider exercising its authority to address formaldehyde precursors in at least two ways. First, TCEQ could consider amending its Highly Reactive VOC rules, 30 Texas Admin. Code Chapter 115. First developed in 2002, these rules are geared at reducing ozone precursors in the Houston area.[25] The same gases that form into formaldehyde (e.g., ethylene, propylene) are already included in TCEQ's HRVOC rules, and it would be reasonable for TCEQ to consider amending these rules based on the new scientific evidence showing that formaldehyde, primarily driven by secondary formation, may increase cancer risk in some of Houston's predominately minority neighborhoods already the most vulnerable to socioeconomic disparities. In addition, TCEQ could consider adopting rules to further address formaldehyde precursor emissions in Houston.

- Federal and state authorities may wish to consider increased formaldehyde monitoring and make any subsequent analysis widely available so that public health risks can be better understood and controlled. Increased monitoring efforts to provide better spatial and temporal coverage can better inform regulators and legislators on the impact of these atmospheric pollutants.

Formaldehyde formed in the atmosphere from other air pollutants – called "secondary formaldehyde" – makes up almost 95 percent of all the ambient formaldehyde detected in Houston Ship Channel neighborhoods. To reduce this ambient formaldehyde, TCEQ should tighten its regulations and limit emissions from petrochemical plants of formaldehyde precursors, such as ethylene and propylene.

End Notes

[1] Source: FY20 City of Houston Community Scale Air Toxic: Near-Source Characterization of High Risk Formaldehyde, Precursors and other HAPs Posing Significant Risk in Houston to Inform Evaluation of Emission Reduction Measures Report 07/01/2020-09/30/2020. Annual average concentrations are calculated by averaging continuous data into five-minute averages, hourly averages, and finally an annual average of all valid 1-hour measurements.

[2] Cancer risk calculation by the Houston Health Department based on EPA's Regional Screening Level (RSL), which assumes 26 years of exposure. https://www.epa.gov/risk/regional-screening-levels-frequent-questions

[3] "2014 NATA: Assessment Results," National Air Toxics Assessment. https://www.epa.gov/national-air-toxics-assessment/2014-nata-assessment-results

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