Where Does Houston's Smog Come From?

The Sources of Houston's Air Pollution and What's Needed to Clear the Air

Most of Houston's air pollution comes from industrial sources and diesel engines, although sources as diverse as school buses and meat cooking also contribute to parts of the problem. In Houston, the health effects of air pollution include:

- Cancer, cardiovascular, respiratory and other disease caused by long-term exposure to diesel particulates, butadiene, formaldehyde and other pollutants; and
- Respiratory distress and eye irritation caused by short-term exposure to ozone, formaldehyde and other pollutants.

One way to measure the health risk of some pollutants is by their potential impact on cancer rates. The Clean Air Act specifies that air pollution should not increase an individual's odds of getting cancer by more than one chance in one million.

Houston's air falls short of this Clean Air Act goal. In the most heavily polluted areas of the Houston Ship Channel, an individual's lifetime cancer risk may be increased by 1,000 chances in one million, or 1,000 times more cancer risk than aspired to in the Clean Air Act. Even in cleaner areas well outside industrial areas, pollution elevates individual cancer risks by more than 100 chances in one million.

While pollution levels clearly indicate that Houston's air pollution elevates the risk of cancer and other chronic health conditions, no health agency tracks how many people have been made sick by air pollution in Houston. For instance, there has never been a regional epidemiological study to establish an association of air pollution with specific health effects.

Efforts to reduce air pollution in the Houston region are underway, but will not be adequate to achieve the goals set out in the Clean Air Act. Furthermore, gaps in our understanding of air pollution make it difficult to fully clean the Houston region's air.

An effective plan to solve these air pollution problems includes additional regulations to control organic chemical and nitrogen oxide emissions from industry. Environmental agencies should place tighter restrictions on emissions of certain hazardous air pollutants that contribute to the region's health risks. To complete the plan, additional monitoring, health and technology research is needed to answer key questions.

Air Pollution Triggers Acute Health Effects

People in the Houston region frequently complain about acute health reactions such as respiratory distress and eye irritation. Houston's air pollution causes millions of acute health reactions each year. Ozone, formaldehyde and acrolein often reach levels where they cause these symptoms almost immediately upon exposure.

The Air Quality Index is the best available measure of the frequency of "bad air days." As illustrated in figure 1, air quality reaches unhealthy levels throughout the year, but air quality problems peak between April and October.

Ozone, chiefly a byproduct of human activity, is formed in midair on warm bright days, when winds are light. Ozone forms most frequently near industrial areas in east Harris County, Texas City and southern Brazoria County, and may be transported in any direction. Plumes of ozone from east Harris County have been observed passing through Beaumont/Port Arthur, Victoria and Conroe.

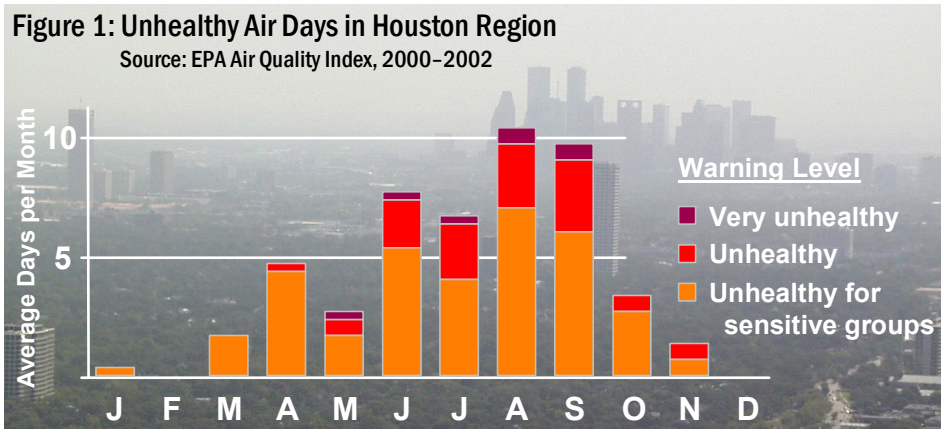
Ozone reduces breathing capacity, which is especially serious in persons with respiratory disease. Exposure to ozone also increases one's susceptibility to allergens (such as pollen), respiratory infections and the effects of other air pollutants. Among asthmatics, exposure to ozone is associated with increased emergency room visits, hospital admissions and deaths.

Several pollutants react chemically to form ozone, particularly nitrogen oxides (NOx), which are products of combustion, and volatile organic compounds (VOCs) such as ethylene and butadiene. Formaldehyde is a key factor in Houston's unusually rapid ozone formation.

Formaldehyde and acrolein are formed by the chemical reactions of other pollutants as well as being directly emitted by industrial plants and combustion engines. Laboratory and occupational studies on the health effects of formaldehyde and acrolein have not been followed up with population studies like those on ozone.

Figure 1: Unhealthy Air Days in Houston Region

Source: EPA Air Quality Index, 2000–2002



Houston's Air Pollution Increases Cancer Risk

Air quality is dangerous everywhere it is monitored in the Houston region. Near the region's industrial areas, long-term air pollution exposure increases cancer risk by as much as 1,000 times more than aspired to in the Clean Air Act (figure 2). Even in urban and suburban areas, carcinogens are concentrated at dangerous levels.

Diesel particulates and industrial chemicals are the air pollutants that increase cancer risk the most in the Houston region. Calculated from risk factors developed by state and federal agencies and long-term averages of monitored pollution levels, the predicted level of added risk may not apply perfectly to every individual's situation. For instance, since most monitoring is in industrial areas, data about pollution levels in suburban areas is scarcer. Even in heavily-monitored areas, the monitoring network may miss pollution "hot spots" near certain sources.

The region's most unhealthy air is in the industrial areas located along the Houston Ship Channel between the 610 East Loop and Deer Park. For instance, butadiene (an industrial chemical) is found at levels that create an exceptionally elevated cancer risk in the Milby Park area. Some other pollutants, such as formaldehyde, are found both inside and outside industrial areas, at similarly unhealthy levels.

. . . and Causes Other Chronic Diseases

While cancer is widely associated with hazardous air pollutants, many of the carcinogens identified in figure 2 are also recognized as contributing to incidence of respiratory, cardiovascular and other chronic diseases.

For some pollutants, environmental scientists identify a benchmark level of exposure that does not seem to cause chronic diseases or disorders.

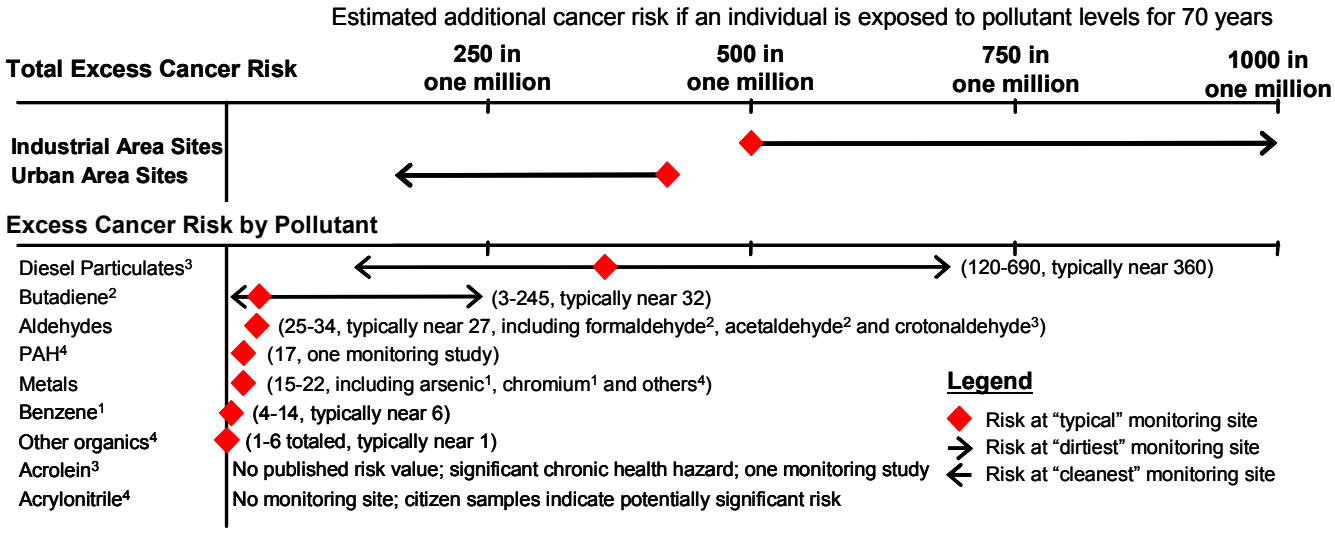
Acrolein, formaldehyde, arsenic, ozone, diesel particulates and a few other air pollutants are of concern for non-cancer chronic disease. Because so few data are available for acrolein and arsenic, and because long-term average formaldehyde and ozone levels vary so little across available monitors, the calculated hazard level does not vary much geographically.

Air pollutants place some human body systems at greater risk than others. In the Houston region, the cumulative chronic disease hazard represented by exposure to all monitored air pollution is a total of:

- . . . five to eight times higher than the benchmark levels associated with respiratory, gastrointestinal, liver, skin and sense-organ diseases and disorders.
- . . . three to five times higher than benchmark levels associated with cardiovascular, neurological, kidney, developmental, reproductive, skin and sense-organ diseases and disorders.
- . . . one to three times higher than benchmark levels associated with reproductive, endocrine, and immune system diseases and disorders.

These estimates may be considered conservative because some toxic pollutants in the Houston region's air are not monitored and many air pollutants have not been adequately screened for health risks. Additional health and monitoring data are needed, especially for acrolein, arsenic, acrylonitrile, crotonaldehyde and PAHs.

Figure 2: Air Pollution and Increased Cancer Risk in Harris County



[n] - EPA classification for evidence of human carcinogenicity: 1-known, 2-probable, 3-possible, and 4-varies (for groups of pollutants).

Sources: Air pollution monitoring data (1997-2002) obtained from the Texas Commission on Environmental Quality, except acrolein, diesel particulates and PAH (polycyclic aromatic hydrocarbons) data obtained from individual research studies. Cancer risk values were collected by Environmental Defense from various state and federal risk assessment sources and are available at the Scorecard.org website. Further details are available in a technical paper available at the GHASP website (www.ghasp.org).

Sources of Particulates, Formaldehyde and Ozone

When air pollutants are traced back to their sources, it becomes clear that industrial activity is the ultimate cause of most hazardous air pollution in the Houston region. The challenge of identifying the original sources of particulates, formaldehyde and ozone is one reason that air quality regulation is so complex. The sources of these pollutants must be traced back through atmospheric chemical reactions that combine several pollutants.

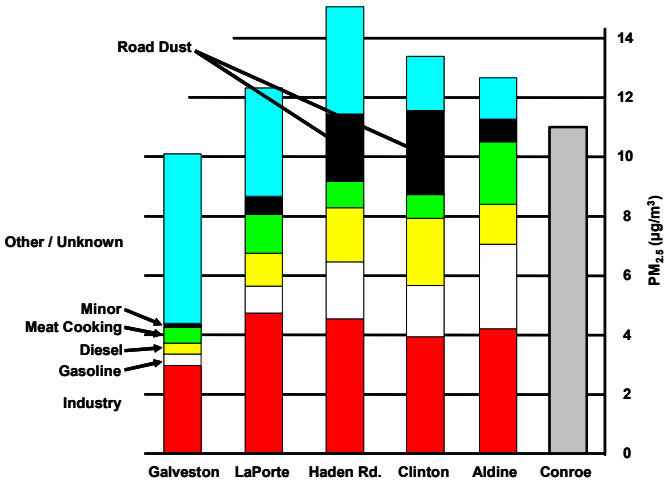
Fine particulate matter is a type of tiny soot that includes a number of different compounds. Industrial sources of ammonium sulfate and many more complex particulates are the largest identified source category of fine particulates (see figure 3). Diesel particulates contribute to cancer risk at any concentration (see figure 2).

Based on the first three years of official monitoring, the Houston region meets the new federal health standard for fine particulates. For 2000-2002, the measured levels are just below the federal standard (15 µg/m^3 for $PM_{2.5}$). Nevertheless, particulates reach levels high enough to trigger health warnings several days each year.

Because long-term exposure to diesel particulates causes cancer and other diseases, pollution reduction is needed to protect public health. Diesel particulates are generated by large trucks, construction equipment, marine vessels, and freight trains. Diesel use is heaviest in industrial areas; for example, near the Haden Road and Clinton Drive air quality monitors (figure 3).

Formaldehyde is a more hazardous outdoor pollutant than previously thought. As discussed above, formaldehyde contributes to cancer risk, is a chronic health hazard, and is an acute health irritant. Formaldehyde is also associated with indoor air pollution because of its use in carpeting and other furnishings.

Figure 3: Fine Particulates in the Houston Region



Sources: Synthesis of various data (1997-1998, 2000-2002). Speciation from Matt Fraser, Rice University. Total $PM_{2.5}$ levels from Texas Commission on Environmental Quality.

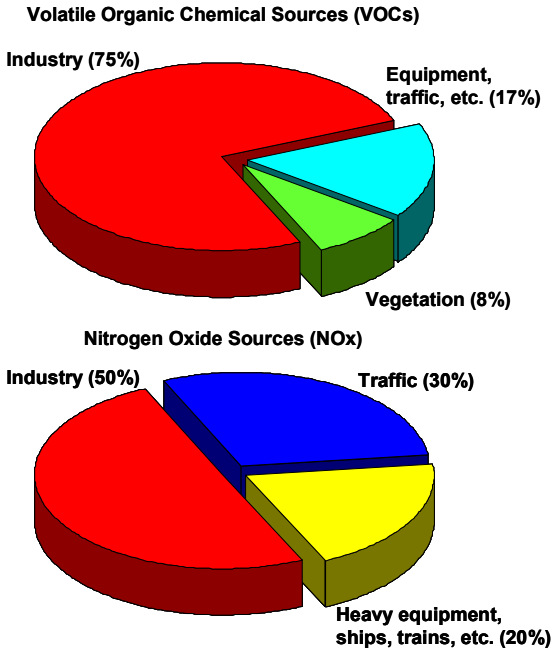
Scientists informally estimate that in the Houston region's industrial areas, more than half and perhaps as much as two-thirds of formaldehyde forms in the atmosphere from ethylene, propylene, butadiene and other industrial organic chemicals. In the presence of sunlight, formaldehyde reacts with NOx to form ozone rapidly and in great volume.

One challenge to reducing formaldehyde is obtaining accurate data. Texas environmental officials conservatively estimate that industrial organic chemical pollution is six times higher than represented in reports from industry. Other studies suggest that some industrial plants may be reporting less than 1/15th of actual organic chemical emissions.

Ozone is formed most rapidly and in greatest volume in the plumes of industrial air pollution. Formaldehyde and associated industrial organic chemicals form far more ozone pound-for-pound than similar VOCs emitted by traffic, equipment or vegetation. When estimated by the potential to form ozone, rather than by mass or concentration, industrial sources account for 75 percent of VOCs in a recent analysis of data from a monitor near the Houston Ship Channel (figure 4).

About half of nitrogen oxide (NOx) emissions in the Houston region are from industrial sources (figure 4). The high concentration of NOx sources in the region's industrial areas make stringent controls on each individual industrial source necessary.

Figure 4: Sources of Ozone-Forming Pollutants



Source (VOCs): Sonoma Technology, *Exploratory Source Apportionment of Houston's Clinton Drive Auto-GC 1998-2001 Data* (2003).
VOC emissions are estimated by reactivity, the potential to form ozone.

Source (NOx): Texas Commission on Environmental Quality, synthesis of various emission inventories for years 2000-02.
NOx emissions are estimated by mass.

What's Needed: Additional Air Pollution Controls

Efforts to reduce air pollution in the Houston region are underway. Grandfathered plants are finally required to obtain permits and install modest pollution control equipment. Diesel emissions are to be reduced by federal and state programs. Yet even if these efforts achieve their goals, the remaining air pollution will continue to contribute to cancer and other chronic diseases and disorders. To fully clean the Houston region's air, regulations should be strengthened in four areas.

- **Expand controls to reduce industrial organic chemical pollution.** Industrial organic chemicals cause cancer and other diseases, react to form fine particulates, and cause hazardous "spikes" of ozone. The particular chemicals involved are those released by refineries and manufacturers of plastics and other synthetic chemicals. In late 2002, Texas tightened up controls, but targeted only four chemicals, and is reconsidering many of those rules. Controls should be stronger, target a wider range of pollutants, and more effectively target "upsets" (accidents).

- **Reinstate controls to reduce nitrogen oxide emissions by industry.** Nitrogen oxides mix with organic chemicals in the presence of sunlight to cause high ozone levels. In 2002, Texas rolled back forthcoming standards affecting industry. Texas should reinstate these standards and require plants in areas near the Houston Ship Channel and Galveston Bay to install the most advanced pollution control equipment available.

- **Increase scrutiny of key hazardous air pollutants when issuing or renewing air pollution permits.** Air pollution permits that include emissions of acrolein, acrylonitrile, formaldehyde, butadiene, benzene, arsenic, lead, mercury and chromium should require the most advanced pollution controls. The cumulative risk of chronic disease and cancer from these chemicals is well above Clean Air Act goals.

- **Inspect and enforce to ensure full permitting.** A number of EPA enforcement cases have demonstrated that many industrial plants lack adequate permits. Even when excess emissions are found, industry often exploits legal loopholes and scientific uncertainty to avoid a citation and fine. Better investigation and enforcement would reduce air pollution and ensure that those companies that follow the law are not at a competitive disadvantage.

What's Needed: Additional Air Pollution Research

Gaps in our understanding of the Houston region's air pollution make it difficult to fully clean Houston's air. Environmental agencies and health research institutions should add three issues to their research agendas.

- **Assess the impact of diesel pollution control devices on hazardous air pollutants.** Texas is funding reductions in nitrogen oxide emissions from diesel, and many of these projects will also reduce fine particulate emissions. Federal regulations will also gradually reduce diesel emissions over the next decade as cleaner engines replace dirtier models.

  However, the effects of this new technology on emissions of pollutants such as acrolein and formaldehyde are uncertain. Because federal and state efforts generally rely on technology, rather than reducing traffic and other polluting activities, agencies should verify that diesel control technologies will reduce all pollutants.

- **Complete an accurate and honest assessment of the region's hazardous air pollutants.** Further steps are needed to remedy the wholly inadequate reports of industrial organic pollution by refineries and chemical plants. These reporting failures are evidence of an environmental accounting crisis.

  Furthermore, environmental agencies should study the sources of acrolein, acrylonitrile, PAH and metals. The US Environmental Protection Agency has identified these pollutants as health risks for the region, and available data support that finding. Yet the information necessary to minimize health risks from these pollutants still needs to be collected and made available.

- **Determine the actual health impacts of pollution.** Measured levels of air pollution indicate that "fenceline" neighborhoods in industrial areas bear the greatest health consequences, but the entire region is at risk. These findings raise questions about how air pollution is affecting health in the Houston region. Limited research investigating ozone and air toxics is underway, but the region's medical institutions should expand their efforts and undertake a regional epidemiological study to establish an association of air pollution with specific health effects.

GALVESTON•HOUSTON ASSOCIATION•FOR SMOG•PREVENTION

The Galveston-Houston Association for Smog Prevention (GHASP) is a community-based environmental organization dedicated to improving the quality of our region's hazardous air through public education, participation in the state and federal planning process, and active advocacy in appropriate venues.

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