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Estimated chemical usage by manufacturers in Connecticut

Jesse Wagner [a], Tim F. Morse [b,*], Nancy Simcox [b]

[a] MPH Program, University of Connecticut Health Center, Farmington, CT, USA

[b] Occupational and Environmental Health Center, University of Connecticut Health Center, 263 Farmington Ave, The Exchange, Suite 262, Farmington, CT 06030-6210, USA

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ABSTRACT

Background: There is little available data on chemical use patterns by companies, with few federal requirements for reporting. This results in difficulties for targeting toxics for possible substitution, assisting employers with complying with newer international regulations, and decreased ability to estimate health and environmental impacts.
Methods: Massachusetts chemical use data for manufacturers required under the Toxics Use Reduction Act (TURA) was acquired, with corresponding information on industrial sector classification and employment levels by sector for both Massachusetts (MA) and Connecticut (CT). The MA chemical data was adjusted based on the ratio of employment levels by sector for CT compared to MA to give estimates of chemical usage by sector in CT.
Results: It was estimated that there was over 660 million pounds of chemicals used in CT, with over 300 million pounds each of carcinogens and reproductive hazards (categories overlap). The most common chemicals estimated to be used were styrene monomer (266 million lbs.), sodium hydroxide (60 million lbs.), and methanol (50 million lbs.). The industrial sub-sectors estimated with the highest chemical usage were chemical manufacturing, plastics and rubber products manufacturing, and fabricated metal product manufacturing.
Conclusion: There is extensive chemical use in CT manufacturing, but little direct information on actual use patterns.

1. Background

The US EPA is responsible for assessing exposure and health risks of industrial chemicals in commercial use under the U.S. Toxic Substance Control Act (TSCA). Unfortunately, TSCA has been heavily criticized for its failure to significantly diminish the chemical impact on human health and the environment, including no requirement for a minimum required set of exposure, hazard and health data (Wilson and Schwarzman, 2009; Denison, 2009; Wilson, 2008; Wilson et al., 2006; GAO, 2005; Schwarzman and Wilson, 2009). In the early 1980s, several initiatives at the federal level and at the state level (e.g. Massachusetts Toxic Use Reduction Act) were implemented to better characterize and understand chemical use patterns within industry (Laden and Gray, 1993).

At the federal level, the National Institute of Occupational Safety and Health (NIOSH) conducted the National Occupational Exposure Survey (NOES) to collect information on occupational exposures to chemical, physical and biological agents (NIOSH, www.cdc.gov/noes) (Sundin and Frazier, 1989; Boiano and Hull, 2001). Although some of the NOES data is currently available to utilize, it has not been updated since 1990, and it does not provide complete chemical usage data by company since it was a sampled survey rather than an inventory. Other federal databases, such as the Toxic Release Inventory (TRI) data, is limited to only very large quantities of stored chemicals (Horvath et al., 1995). Companies that produce more than 25,000 pounds or handle more than 10,000 pounds of a chemical selected by TRI must report. As a result, there is insufficient data available on patterns of chemical use by company, industry sector, and occupational categories in the United States.

At the state level, Massachusetts has collected high quality data on chemical usage for manufacturing facilities through its Toxic Use Reduction Act (TURA) (Mayer et al., 2002). TURA requires reporting on over 1400 chemicals, although only about 250 have been used and reported in practice. Since there is no current system to identify chemicals of concern in Connecticut, and Connecticut has industry patterns somewhat comparable to Massachusetts, the Massachusetts TURA data is used in this study to estimate chemical usage in Connecticut. The data from this model will begin to assist state agencies to better understand chemical use patterns among Connecticut industries, and to provide guidance on how the state may initiate programs and services to promote safer alternatives to toxic chemicals.

* Corresponding author. Tel.: +1 860 679 4720; fax: +1 860 679 1349.
E-mail address: tmorse@uchc.edu (T.F. Morse).

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2. Methods

Under TURA, companies are required to report all of the chemical substances on the federal TRI under Section 313, as well as substances on the federal Comprehensive Environmental Response and Compensation Liability Act (CERCLA), except for delisted chemicals. A Massachusetts TURA (Toxics Use Reduction Act) database of chemical usage organized by company was obtained from the Toxic Use Reduction Institute, including Standard Industrial Classification (SIC) codes of reporting companies. These reports were broken into manufactured amount, processed amount, and "amount otherwise used" to determine the total chemical quantity used. Total chemical use was organized by the chemical name and facility/industry. SIC codes were converted into NAICS codes using the code translator at www.naics.com. NAICS is the modern six-digit industry identification system of coding used by OSHA, which allows greater coding flexibility over the four-digit structure of the SIC system. If old SIC codes could be converted into more than one new NAICS code, databases and websites that provide the current NAICS code such as www.manta.com were utilized to overcome translational problems and acquire the proper NAICS code. Employment by NAICS industry codes for Connecticut (CT) and Massachusetts (MA) was based on Bureau of Labor Statistics data for 2006. The proportion of the CT workforce in relation to MA workforce was calculated by dividing employee numbers using the first 3-digits of NIACS industry sector. This proportion was then applied to the chemical use data for each manufacturing sector in MA to estimate the probable chemical use by sector in CT. There are a number of other approaches that could potentially be used for extrapolating from MA data, such as overall population fraction or number of companies. We felt that since manufacturing sectors often share the same processes and chemicals, that production levels tend to be proportionate to employment, and that MA and CT have roughly similar economies, that the proportion of workers in CT compared to MA by sector would be the most accurate way of estimation for specific chemical use.

3. Chemical groups

Chemical estimates in CT were totaled and organized into seven 'Chemical Group' categories as defined by TURI including reproductive toxins, carcinogens, common solvent, "more hazardous" chemicals, "Persistent, Bioaccumulative, and Toxic (PBT), metals, and organochlorines (TURI, 1999). Reproductive toxins are chemicals defined as reproductive toxins listed by Physicians for Social Responsibility. Carcinogens are taken from the TRI Public Data Release OSHA Carcinogen list (EPA, 1999). The Common Solvents category was developed by TURI and the TURI Surface Cleaning Lab and includes solvents commonly used in industry that are able to dissolve or disperse substances. The "More Hazardous" chemicals category was developed by the TURA Science Advisory Board and published in the report *Categorization of the Toxics Use Reduction List of Toxic and Hazardous Substances*. PBT are chemicals that appear on the *Draft EPA PBT Chemical list (EPA, 1998)*. Metals are any TURA chemical that is a metal (not including zinc which was removed due to an alteration in reporting requirements). Organochlorines are carbon chemicals containing chlorine.

4. Results

There was an estimated total of 675 million pounds of reportable chemicals used in manufacturing in CT based upon the MA reporting figures. The most common specific chemicals are noted below.

Chemicals were put in categories, as noted above (Fig. 1); categories frequently overlap, and so add to more than the above total. Chemicals categorized as *reproductive toxins* totaled to 314 million pounds, with the most common reproductive toxins being styrene monomer, glycol ethers, toluene, epichlorohydrin, lead compounds, and diethyl hexyl PHT, all with over 1 million pounds of estimated usage. Reproductive toxins include 22 chemicals on the TURI list. Carcinogens have extensive overlap with reproductive toxins since they have similar mechanisms of action. *Carcinogens* totaled 304 million pounds, with the most estimated use for styrene monomer, followed by sulfuric acid, formaldehyde, dichloromethane, diethyl hexyl PHT, and lead compounds, all with over 1 million pounds. There are 47 carcinogens on the TURI Carcinogen list. *Common solvents* accounted for an estimated 112 million pounds, led by ethanol, glycol ethers, and toluene, each with over 10 million pounds. There are 26 chemicals on the TURI "Common Solvents" list. *"More hazardous" chemicals*, covering 40 chemicals in the TURI list, totaled 48 million pounds, led by sulfuric acid, formaledehyde, chlorine, epichlorohydrin, and lead compounds, all with over 1 million pounds. *PBT's*, 28 chemicals from TURI, totaled 21 million pounds, led by zinc and compounds, lead compounds, diethyl hexyl PHT, and copper compounds. *Metals*, comprising 27 chemicals from the TURI category, totaled 20 million pounds, led by zinc, antimony, lead (2.5 million lbs), and copper compounds. *Organochlorines*, with 26 TURI chemicals, totaled 8 million pounds, led by dichloromethane and epichlorohydrin.

The industry sub-sector that is estimated to use the most chemicals in Connecticut is Chemical Manufacturing (325000) at an estimated 600 million pounds (Fig. 2). The Chemical Manufacturing sub-sector is defined by NAICS as companies

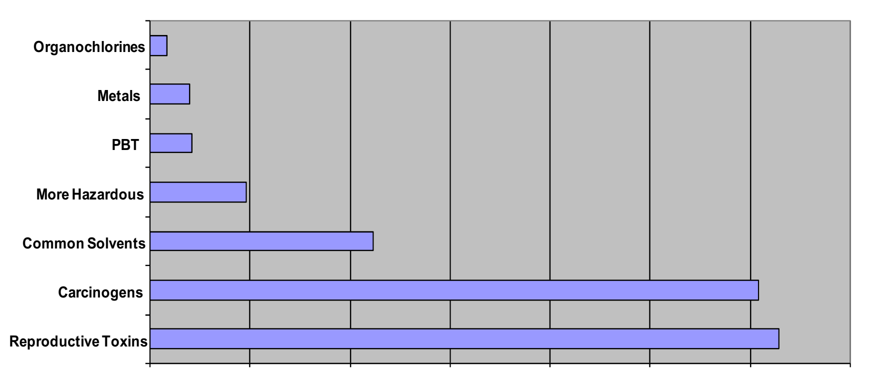

Fig. 1. Chemical usage by chemical group, pounds, estimated for CT.

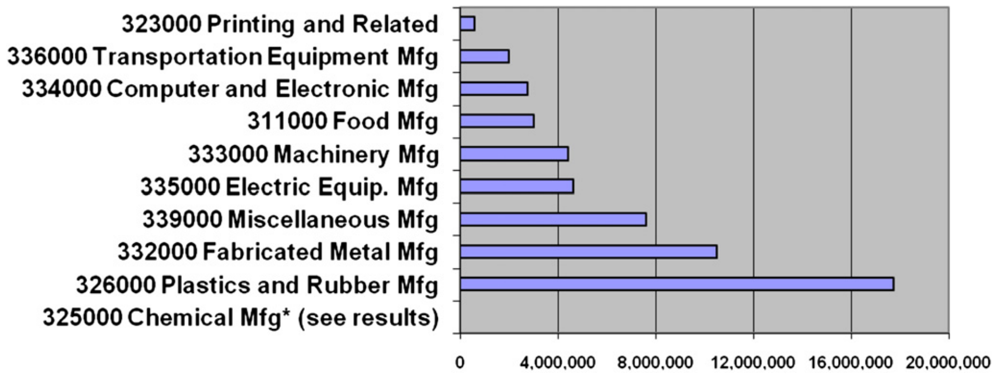

Fig. 2. Chemical usage by industry sector (NAICS code), pounds, estimated for CT.

transforming organic and inorganic raw materials by a chemical process to create a product. Companies in the Plastics and Rubber Products Manufacturing (326000) sub-sector make goods by processing plastic materials and raw rubber, and accounted for an estimated 17 million pounds. Industries in the Fabricated Metal Product Manufacturing sub-sector (332000) were estimated to use over 10 million pounds of chemicals in CT. These industries transform metal into intermediate or end products, other than machinery, computers, electronics, and metal furniture. Important fabricated metal processes are forging, stamping, bending, forming, and machining used to shape individual pieces of metal; and other processes, such as welding and assembling, used to join together separate parts.

5. Most commonly used chemicals

5.1. Styrene

Styrene monomer (Fig. 3), with a total use of 266 million pounds, is estimated as the highest volume chemical in Connecticut. It is primarily used to make plastics and rubber, and is used in insulation, fiberglass, plastic pipes, automobile parts, shoes, drinking cups and other food containers, and carpet backing. The International Agency for Research on Cancer (IARC) has concluded that styrene is a possible human carcinogen, and the US EPA defines it as “a suspected toxin to the gastrointestinal, kidney, and respiratory systems” (ATSDR, 2007a).

5.2. Sodium hydroxide

The amount of sodium hydroxide used in CT is estimated at nearly 60 million pounds. Sodium hydroxide (also known as caustic soda or lye) is used to manufacture soaps, rayon, paper, explosives, dyestuffs, and petroleum products. It is also used in processing cotton fabric, laundering and bleaching, metal cleaning and processing, oxide coating, electroplating, and electrolytic extracting. Sodium Hydroxide is a corrosive chemical and contact can severely irritate and burn the skin, eyes and respiratory system (ATSDR, 2002).

5.3. Methanol

It is estimated that about 50 million pounds of methanol is used in CT. It is a basic building block for numerous chemicals which are used in the construction, housing, or automotive industries. Varnishes, shellacs, paints, windshield washer fluid, antifreeze,

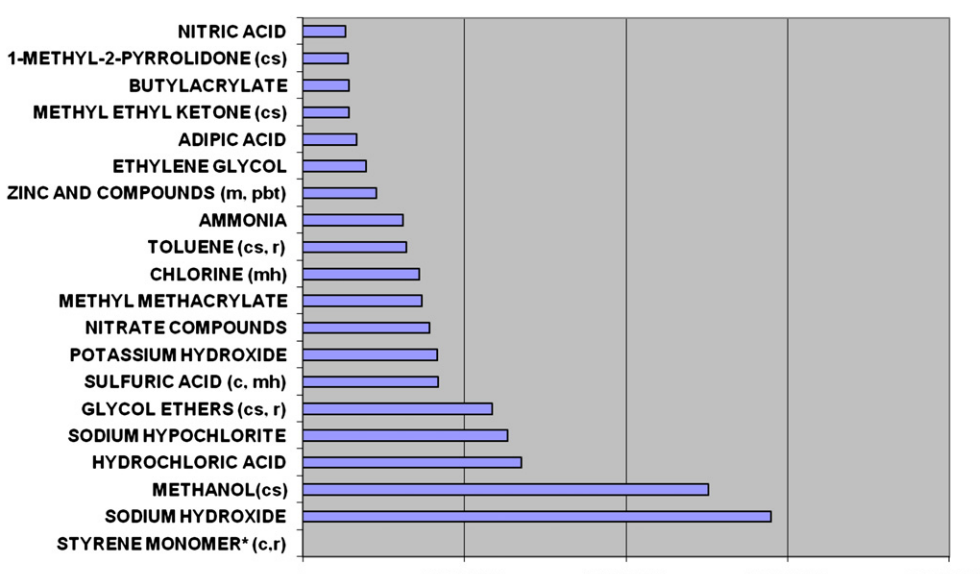

Fig. 3. Most commonly used chemicals in manufacturing, pounds, estimated for CT. Key: c, carcinogen; cs, common solvent; mh, more hazardous list; pbt, persistent, bioaccumulative, toxic; r, reproductive hazard; m, metal. *Styrene monomer was too large for graph: 266 million pounds.

adhesives, and deicers are some of the consumer products that contain methanol. Methanol is very acutely toxic in humans. The U.S. EPA has concluded that methanol is likely to be carcinogenic to humans by all routes of exposure although the mode of action for cancer is unknown. (EPA, 2009).

5.4. Hydrochloric acid

Approximately 25 million pounds of hydrochloric acid is estimated to be used by manufacturers in CT. Hydrochloric acid is used to produce chlorides, fertilizers and dyes in many different industries including electroplating and rubber. It is corrosive to the respiratory organs, eyes, skin, and intestines. (ATSDR, 2007b).

5.5. Sodium hypochlorite

Sodium hypochlorite use is an estimated 25 million pounds in CT per year. Sodium hypochlorite (bleach) is used for bleaching and disinfecting. Significant amounts of sodium hypochlorite is used in agriculture, chemical industries, paint and lime industries, food industries, glass industries, paper industries, pharmaceutical industries, synthetics industries and waste disposal industries. Sodium hypochlorite is corrosive to the eyes, skin, respiratory and gastrointestinal tissues and can be fatal (ATSDR, 2002).

5.6. Glycol ethers

The model estimated that CT uses over 20 million pounds of glycol ethers. Glycol ethers are used as solvents and as an ingredient in cleaning compounds, liquid soaps, and cosmetics. Acute (short-term) exposure to high levels of the glycol ethers in humans results in narcosis, pulmonary edema, and severe liver and kidney damage, and intoxication similar to the effects of alcohol. Chronic (long-term) exposure to the glycol ethers in humans may result in neurological and blood effects, including fatigue, nausea, tremor, and anemia (a shortage of red blood cells). Some glycol ethers have been shown to be a reproductive toxin in laboratory animals where low-level exposure glycol ethers caused birth defects and damaged sperm and testicles (EPA, 2000).

5.7. Sulfuric acid

Over 15 million pounds of sulfuric acid is estimated to be used in CT. Sulfuric acid is a clear, colorless, oily liquid that is very corrosive. It is used in the manufacture of fertilizers, explosives, other acids, and glue; in the purification of petroleum; in the pickling of metal; and in lead-acid batteries (used in most vehicles). The International Agency for Research on Cancer (IARC) has determined that occupational exposure to strong inorganic acid mists containing sulfuric acid is carcinogenic to humans (ATSDR, 1998)

5.8. Potassium hydroxide

CT is estimated to use over 15 million pounds of potassium hydroxide, which is a white crystal, lump, rod or pellet which may be concentrated in a water solution. It is used in many industries such as liquid and soft soaps, fertilizers, and electroplating to make other chemicals. The chemical is extremely corrosive. It can cause serious skin and eye irritation and burns, which may lead to permanent eye damage. Breathing the chemical can irritate the nose, throat, and lungs causing coughing, wheezing and/or shortness of breath, and sores in the nose (NJDHSS, 1995).

5.9. Nitrate compounds

It is estimated that over 15 million pounds of nitrate compounds are used in CT. Nitrate Compounds are used at paper mills, chemical, lighting and large equipment manufacturers. These compounds are a suspected cause of cardiovascular outcomes such as increased blood pressure and irregular heartbeat. They may also affect the immune system (Maine, 2010).

5.10. Methyl methacrylate

Nearly 15 million pounds of methyl methacrylate is estimated to be used in CT. Methyl methacrylate is a colorless liquid with a sharp, fruity odor. It is used to make resins, plastics, and plastic dentures. Methyl methacrylate can irritate the eyes, skin, nose, and throat. It can damage the lungs causing coughing and/or shortness of breath. Higher exposures can cause a build-up of fluid in the lungs (pulmonary edema), a medical emergency, with severe shortness of breath. High exposure can cause dizziness, irritability, difficulty with concentration and reduced memory. It may cause a skin allergy. It may damage the nervous system causing numbness and weakness in hands and feet. It may affect the liver and kidney. There is limited evident that it is a cancer hazard (NJDHSS, 1996).

6. Discussion

There is no current comprehensive state tracking of chemical use by industry sector in Connecticut. We found that there is an estimated 663 million pounds of chemical use in CT manufacturing, underscoring the need for better tracking mechanisms.

It should be underscored that these are estimates for CT based upon MA reporting data, adjusted by workforce/manufacturing sub-sector, and not actual reporting for CT. As such, there are a number of possible inaccuracies in the data. The profile of chemical use in Connecticut may differ from MA companies with the same NAICS code, particularly if one large company dominates in either state. If one company uses a very high amount of a unique chemical, such as a chemical manufacturing plant that focuses on a particular product line in MA, the same sub-sector may focus on an entirely different product in CT. If a company in CT uses a unique chemical in high amounts, this will not be reflected in the MA data and therefore not in our estimates. However, since there is so little data currently available on actual use patterns by industry in CT, these estimates give us at least some idea of the likely magnitude, distribution, and chemicals of concern. Data is still being analyzed, and we will be comparing this data to other existing sources of data.

A comparison with TRI Tier 1 release data (the amount of chemicals released into the environment) for manufacturing by sub-sector was performed to assess whether the method of applying a proportion based upon employment for estimating chemical usage in this paper is valid, since this data was available for both CT and MA. There was a high correlation between the amounts by sub-sector ($r = 0.81$, $p = 0.01$) predicted by our model compared to the actual CT data, indicating that the estimate of the distribution across sectors was good. The overall estimate for CT chemical releases based on the MA data (adjusted by size of workforce for CT) was 17 million pounds, compared to 40 million pounds for the actual CT amounts. This under-estimate could indicate errors from the calculation method or may be due to tangible differences such as that MA has recorded large decreases in chemical use over the life of TURA while CT has not had an equivalent program. It should be noted additionally that our estimates are for stored and used chemicals which may have different patterns than for emissions.

It is acknowledged that estimating chemical usage in Connecticut based on Massachusetts data is a poor substitute for actual data, with a number of assumptions and known inaccuracies such as chemical industry patterns that may differ dramatically depending on product line and the omission of sector uses that may be present in CT that are not present in MA. The need to do such a study underlines the serious policy inadequacies in current law and voluntary reporting. Given the known hazards of many chemicals, the known lack of complete research and standards on most chemicals, and the clearly very high use of chemicals based on this analysis, it is important to find a way to improve our knowledge of chemical usage patterns in the U.S. (since almost all other states share the lack of information characteristic of CT).

There are several potential uses for our estimates of chemical use in CT. Results may be used to establish classes of chemicals of concern, prioritize chemicals for safer alternative assessments or green chemistry research, provide a basis for possible additional chemical reporting or surveys or CT workplaces that would be much more focused (and therefore less costly), and compile a list of industry sectors in CT with likely high chemical use, thus allowing targeted safer alternative education. A newly created Chemical Innovation Institute at the University of Connecticut Health Center (HB 5126 passed by the Connecticut General Assembly) will be attempting to pursue a number of these uses. This should prove helpful in planning for the impact of international regulations such as REACH on Connecticut exports, and also help in targeting safer alternatives to reduce both occupational and environmental impact.

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