pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

DEP Sampling Study at USA TODAY Report Sites
St. Vitus School, New Castle PA

Background

In response to a December 2008 USA TODAY special report titled "The Smokestack Effect – Toxic Air and America's Schools", the Pennsylvania Department of Environmental Protection's (DEP) Bureau of Air Quality (BAQ) conducted air sampling for toxic pollutants at a select group of schools in Pennsylvania. The schools were chosen based on their modeled relative ranking above the reference school (Meredith Hitchens Elementary School in Ohio) cited in the USA Today report. Additional schools were chosen where USA TODAY conducted their own sampling and risk analysis, and proposed the school required further investigation.

The St. Vitus School was one of 38 schools in Pennsylvania where the modeled ranking was above the reference school and in the top 1% of all schools in the United States. The model listed manganese as the major pollutant of concern at this site. No sampling was done by USA TODAY at the school to confirm the modeling results. See USA TODAY's information on their website at http://smokestack.usatoday.com/.

Findings

The total excess lifetime cancer risk based on DEP sampling conducted near the school on October 23, 2009 through November 11, 2009, is 6.1 in 100,000. The risk calculation assumes an adult weighing 70 kilograms (154 pounds) will breathe 20 m^3 (706 ft^3) of air each day for 365 days a year, over a 70-year lifetime of exposure. This level of cancer risk falls within the U. S. Environmental Protection Agency's (EPA) generally acceptable risk range of 1-in-10,000 to 1-in-a-million. This differs from the USA TODAY's determination through modeling that toxic pollution levels may be unacceptable as far as cancer risk. Pollutant concentrations measured through sampling are generally considered more reliable than modeled concentrations.

However, the DEP sampling found the average concentrations of manganese detected at the school to be just under the non-cancer health benchmark (Hazard Quotient greater than 1). While there are no immediate risks of non-cancer health effects, more monitoring will be done by the DEP, in addition to assessing emissions from surrounding facilities.

DEP Sampling

Sampling of the outdoor air was conducted on the roof of the school. The sampling was done to determine the concentrations of toxic metals in particles including arsenic, beryllium, cadmium, total chromium, manganese, lead, nickel and zinc.

Each of the three toxic metals samples were collected over a 96-hour period using a high-volume total particulate sampler (TSP) with quartz-fiber filters, and were analyzed by the DEP Laboratory. The procedure is based on the EPA Compendium Methods IO-2 and IO-3.

The DEP laboratory can detect very low levels of pollutants in the range well below 1 microgram (ug)(one millionth of a gram) per cubic meter (m^3) of air.

Summarizing the Data

In summarizing the sampling data, DEP calculated average concentrations from three samples for each toxic metal compound. If a compound was not detected, or found at a concentration below the Reporting Limit (RL) in all three samples, an average was not calculated. If a compound was detected in at least one sample, the average was calculated using ½ the lab RL for any non-detects.

Note that there are neither state nor national air quality standards for most of the monitored pollutants (except for lead). Therefore, the DEP evaluated the health risks associated with breathing the measured concentrations of these pollutants using risk assessment methods approved by the EPA.

Overview of Risk Factors and Reference Doses

The excess lifetime cancer risk for each compound was calculated using unit risk factors (URFs), and the risk for non-cancer health effects was calculated using reference air concentrations (RfCs). The URF is a measure of the probability of developing cancer from exposure over a lifetime to a specified concentration of a given chemical derived from health studies. The RfC is the estimated concentration below which no (non-cancer) adverse health affects are expected to occur over a lifetime of continuous exposure. The EPA Integrated Risk Information System (IRIS) database was the primary source for the risk factors. In some cases, there were no inhalation risk data for a chemical in the IRIS database, so other sources were referenced.

The URF and RfC are derived by assuming an adult weighing 70 kilograms (154 pounds) will breathe 20 m^3 (706 ft^3) of air each day for 365 days a year, over a 70-year lifetime of exposure.

The excess lifetime cancer risk is calculated for each compound by multiplying its URF by the average concentration. The individual risks for each chemical are added to get the total excess lifetime cancer risk at that site.

The excess lifetime cancer risk numbers are written in an exponential format (e.g. 1.0E-04). Refer to Table 1 when interpreting these numbers. For example, an excess lifetime cancer risk of 1.2E-05 means that 1.2 more people in a population of 100,000 (or 12 more in a million) are likely to develop cancer. This is above and beyond the national lifetime cancer risk of slightly less than 1 in 2 in men, and slightly more than 1 in 3 in women.

Table 1. Interpreting the risk numbers.

Risk	Exponential	Decimal	Read as…
1.0E-08	$1x10^{-8}$	0.00000001	1 in 100 million
1.0E-07	$1x10^{-7}$	0.0000001	1 in 10 million
1.0E-06	$1x10^{-6}$	0.000001	1 in 1 million
1.0E-05	$1x10^{-5}$	0.00001	1 in 100,000
1.0E-04	$1x10^{-4}$	0.0001	1 in 10,000

Any risk estimate is based on a number of assumptions and some of the assumptions DEP made for this study include:

- The average concentration of the three samples collected is the concentration that the student will be exposed to over a lifetime;
- The concentrations measured at the sampling site are representative of exposures to the student population in the school;

- Hexavalent chromium (chrome VI) concentrations are assumed to be 1/7th the total chromium concentration;
- The effects of exposure to multiple chemicals are additive;
- The only excess risk considered in this report is due to inhalation.

The Hazard Quotient (non-cancer health risk) associated with each of the relevant compounds is calculated by simply dividing the compound average concentration by the respective RfC. If the Hazard Quotient is greater than 1, then adverse health effects are possible over a lifetime. However, it is especially important to note that a Hazard Quotient exceeding 1 does not necessarily mean that adverse effects will occur. The Hazard Quotient cannot be translated to a probability that adverse health effects will occur, and is unlikely to be proportional to risk. The individual Hazard Quotients for each compound are summed to get the Hazard Index. Like the Hazard Quotient, if the Hazard Index value is less than 1.0, then those chemicals concentrations are not likely to cause adverse non-cancer health affects.

Excess Lifetime Cancer Risk

The goal of Federal and State Air Pollution Agencies, when dealing with the emission of a toxic pollutant from an industrial source is to limit the risk from that pollutant to the surrounding community to less than one in a million excess lifetime cancer risk (from inhalation). The risk to communities is generally higher due to the fact there are multiple sources and multiple pollutants. In conducting risk assessments at hazardous waste cleanup projects and superfund sites, EPA generally considers a lifetime cancer risk to an individual of between 1-in-10,000 and 1-in-a-million as an acceptable range.

The total excess lifetime cancer risks for inhalation, based on the average concentration of toxic metals from the sampling at the school, is 6.1 in 100,000 (6.1E-05) and is shown in Table 2. This value falls between the 1-in-10,000 and 1-in-a-million range. With the conservative assumptions used by the DEP in conducting this risk assessment, the actual risk may be lower. For the purpose of comparison, Table 2 also shows the excess lifetime cancer risk for inhalation based on the 2007 average annual monitoring data from DEP air toxic monitors across the Commonwealth. The total risk of 6.1 in 100,000 calculated for an individual at the St. Vitus School is approximately six times higher than the statewide cancer risk for toxic metals (0.99 in 100,000). Please note that at least half of the total risk can be attributed to the conservative assumption of the hexavalent chromium concentrations.

Non-Cancer Health Effects

There was one toxic metals 24-hour sample for manganese above the respective RfC resulting in an average concentration that gives a calculated quotient close to the unacceptable limit (a Hazard Quotient greater than 1). When combined with the arsenic Quotient, the overall Hazard Index (the individual Hazard Quotients summed) is 1.2. Consequently, there is the potential for non-cancer health effects from long-term exposure (over a lifetime) to the air at the school. There is no short-term (acute) non-cancer health hazard present that would result from breathing the air at the school.

According to the U.S. Department of Health and Human Services' Agency for Toxic Substances Disease Registry (ATSDR), the most common health problems in workers exposed to high levels of manganese involve the nervous system. These health effects include behavioral changes and other nervous system effects, which include movements that may become slow and clumsy. Other less severe nervous system effects such as slowed hand movements have been observed in some workers exposed to lower concentrations in the work place. The manganese concentrations that cause effects in workers breathing a large quantity of dust or fumes are approximately twenty thousand times higher than the concentrations normally found in the environment. Studies in children have suggested that extremely high levels of manganese exposure may produce effects in brain development, including changes in behavior and

decreases in the ability to learn and remember. According to ATSDR, it is unknown whether these changes were caused by manganese alone and whether these changes are temporary or permanent.

The EPA has set National Ambient Air Quality Standards (NAAQS) for six principal pollutants, including lead, to protect public health and welfare. The NAAQS for lead is a 0.15 ug/m^3 average in any 3-month period (also know as a 3-month rolling average). None of the lead concentrations from the DEP sampling approached this level and therefore are not a concern.

Next Steps

The initial screening conducted by DEP provided monitoring data that shows a potential for a problem with air toxic metals in the vicinity of the St. Vitus School. To completely characterize ambient air emissions in the area, the DEP intends to conduct sampling at the school for at least an additional six months. The sampling will continue with a TSP sampler which collects particles of all sizes. To further characterize the inhalation risk for the metal particles, a size-specific method will also be employed that measures smaller-sized particles (PM_{10}) that are known to reach further into the respiratory tract. A third sampling device will be employed during the six month period to determine actual hexavalent chromium concentrations.

In addition, the DEP regional staff will continue to inspect facilities in the New Castle area and in an effort to reduce potential exposure to metals. DEP will continue to communicate its findings with the School District and the general public throughout the process.

Differences between the DEP and USA TODAY Studies

The USA TODAY report used the Risk-Screening Environmental Indicator (RSEI) model to rank each school relative to one another based on the pollutants likely to be in the air outside the school. The RSEI is a *screening tool* developed by the EPA to put Toxic Release Inventory (TRI) emission data into a health context. The model is used as a priority-setting tool to focus resources in areas that will provide the "greatest potential risk reduction". RSEI results do not provide quantitative risk estimates. TRI emissions data are self-reported by facilities and may contain errors. Pollutant concentrations measured through sampling are generally considered more reliable than modeled concentrations.

Conclusion

Actual sampling of the air at the school by DEP for manganese, the stated pollutant of concern, indicate the potential for unacceptable non-cancer health effects to the students attending the school over the long term (a lifetime of exposure). The monitoring did indicate that the excess lifetime cancer risk was higher than the Pennsylvania average but is still within the acceptable range. DEP will continue to monitor the air and work with local facilities to reduce the source of the pollution.

For additional information on modeled toxic concentrations in the United States down to the census tract level, see the EPA National Air toxics Assessment (NATA) web site at:
http://www.epa.gov/ttn/atw/natamain/.

Table 2. DEP toxic metal sampling results at the St. Vitus School.

CAS #	Metal	USA TODAY Sample[a] ug/m^3	DEP Samples[b] 10/23/09 ug/m^3	11/4/09 ug/m^3	11/11/09 ug/m^3	Average ug/m^3	Unit Risk Factor (URF) m^3/µg	Source URF	Excess Lifetime Cancer Risk[c]	2007 PA Excess Lifetime Cancer Risk[d]	Reference Air Conc. (RfC) µg/m^3	Source RfC	Hazard Quotient[e]
7440-38-2	Arsenic	no	0.00319	0.00575	0.00227	0.00374	4.3E-03	IRIS	1.6E-05	3.6E-06	1.5E-02	CalEPA	0.25
7440-41-7	Beryllium	sampling	<RL	<RL	<RL		2.4E-03	IRIS			2.0E-02	IRIS	
7440-43-9	Cadmium		0.00085	0.00214	0.00117	0.00139	1.8E-03	IRIS	2.5E-06	4.6E-07			
7440-47-3	Chromium (Total)		0.02057	0.02615	0.00995	0.01889							
18540-29-9	Chromium VI (Assumed)[f]					0.00270	1.2E-02	IRIS	3.2E-05	5.0E-06	1.0E-01	IRIS	0.03
7439-92-1	Lead[g]		0.01408	0.02622	0.02042	0.02024	1.2E-05	CalEPA	2.4E-07	8.9E-08			
7439-96-5	Manganese		0.03283	0.06434	0.03966	0.04561					5.0E-02	IRIS	0.91
	Nickel[h]		0.09536	0.01968	0.00527	0.04010	2.4E-04	IRIS	9.6E-06	6.3E-07			
7440-66-6	Zinc		0.04725	0.13401	0.12605	0.10244							
								Total	6.1E-05	9.9E-06		Hazard Index	1.2

[a] Samples were collected over a 96-hour period on 37mm filters.

[b] Samples were collected over a 96-hour period beginning on the date shown using EPA Method IO-2 and IO-3.

[c] Risk due to inhalation is based on the average of three samples (ELCR = Avg x URF). Risk is not calculated for compounds that were not detected in all three samples.

[d] Calculated by averaging data collected in 2007 at the Chester, Erie, Lancaster, Lewisburg, Marcus Hook, Reading and Swarthmore toxic monitoring sites.

[e] A Hazard Quotient < 1 indicates no expected non-cancer health effects (HQ = Avg / RfC). The HQ is not calculated for compounds that were not detected in all three samples.

[f] Chromium VI concentration assumed to be 1/7th the Total Chromium concentration by DEP for study purposes.

[g] The NAAQS standard for lead is 0.15 ug/m^3 (rolling 3-month average).

[h] The URF for Nickel is the IRIS value for Nickel (Refinery Dust).

<RL - Compound not detected, or less than the Lab Reporting Limit (RL), in all three DEP samples.

IRIS - EPA's Integrated Risk Information System

CalEPA - California EPA