DEP SAMPLING STUDY
AT USA TODAY REPORT SITES
ST. VITUS SCHOOL, NEW CASTLE, PA

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

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St. Vitus School, New Castle, PA

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Background

In response to a USA TODAY special report titled "The Smokestack Effect – Toxic Air and America's Schools", the Pennsylvania Department of Environmental Protection (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 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 one percent 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/.

An initial three air samples were taken at the St. Vitus School in October and November, 2009. The samples were analyzed for toxics metals and the results published in a report dated Jan. 8, 2010. The DEP initiated an additional six months of air sampling after analysis of the original three samples indicated a potential for adverse non-cancer health effects over the long term, mainly due to manganese concentrations. Sampling was also conducted specifically for hexavalent chromium, the most toxic form of chromium, to confirm concentrations of this metal were acceptable. The results for this second round of sampling, including the hexavalent chromium data, are presented in this report.

Findings

The total Excess Lifetime Cancer Risk based on DEP's second round of sampling is 0.31-in-10,000. 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. Most of the risk (0.14-in-10,000) is driven by an assumed amount of hexavalent chromium, derived from the average total chromium concentration.

DEP sampling found the average concentrations of manganese and nickel near the school to be elevated but under the non-cancer health benchmark (Hazard Quotient of 1.0) for each. The average manganese concentration produced a Hazard Quotient of 0.72. The average nickel concentration produced a lower Hazard Quotient of 0.40.

The results of specialized sampling for hexavalent chromium show very little cancer risk (0.014 in 10,000) and a negligible non-cancer risk from this toxic. In fact, the measured hexavalent chromium concentrations were found to be 10 times lower than the assumed levels in the second round of sampling. Therefore, DEP's assumption of hexavalent chromium levels based on total chromium levels (assumed to be $1/7^{th}$) is very conservative and appropriate for use in this study.

DEP Sampling

Air sampling at the school looked for concentrations of toxic metals in particles including arsenic, beryllium, cadmium, total chromium, manganese, lead, nickel and zinc. Particulate samples were collected on quartz-fiber filters over a 96-hour period using two different samplers; a high-volume Total Suspended Particulate sampler (TSP) and a size-selective particulate sampler that captured only particles 10 microns or less in size (PM_{10}). The filters from both samplers were analyzed by the DEP Laboratory in Harrisburg. The procedure is based on the EPA sampling and analysis methods IO-2 and IO-3. The DEP Laboratory can detect very low levels of pollutants in the range well below one microgram (ug)(one millionth of a gram) per cubic meter (m^3) of air.

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

Hexavalent chromium samples were collected using a separate specialized sampler. Samples were collected over a 24-hour period using the same collection and analysis methods developed for the EPA National Air Toxics Trends Stations.

Note that there are neither state nor national air quality standards for most of these 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. Only the results from the PM_{10} sampling were used in the risk characterization. The PM_{10} data is a better representation of dose since smaller particles are more likely to be inhaled deep into, and retained by, the respiratory tract.

Overview of Risk Factors and Reference Doses

The Excess Lifetime Cancer Risk for each metal detected 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 an estimate of a daily inhalation exposure of the human population (including sensitive subpopulations) that is likely to be without appreciable risk of deleterious effects during a lifetime. The Department of Energy's Risk Assessment Information System (RAIS) database was used as a source of URF and RfC values. The values in the database are compiled from a variety of federal and state sources using a selection hierarchy accepted by the DEP.

The URF and RfC's values that are to be used are based on the time period of the sampling. If one sample was taken, then short-term (acute) values are used. If a year's worth of samples are collected, long-term (chronic) values are used. For this project that spanned seven months, intermediate-term (sub-chronic) values could be used. However, because there are few sub-chronic values available for metals, an assumption is being made that the levels found over the seven months of sampling are equal to lifetime exposures, and therefore, chronic URF and RfC's are to be used in the risk analysis.

The Excess Lifetime Cancer Risk is calculated for each metal by multiplying the average concentration by the URF. The individual risks for each chemical are added to get the total Excess Lifetime Cancer Risk at that site. In conducting risk assessments at hazardous waste cleanup projects and superfund sites, EPA generally considers a lifetime cancer risk between 1-in-10,000 and 1-in-a-million as an acceptable range. The Excess Lifetime Cancer Risk is in addition to the average national lifetime cancer risk of about 40 percent. The 40 percent figure represents a cancer risk slightly less than 1-in-2 in men, and a cancer risk of slightly more than 1-in-3 in women.

The Excess Lifetime Cancer Risk numbers in this report are written in a 1-in-10,000 format. Refer to Table 1 when interpreting these numbers. For example, an Excess Lifetime Cancer Risk of 0.12 means that 0.12 more people in a population of 10,000 (or 1.2 more people in a population of 100,000)(or 12 more in a million) may develop cancer through inhalation of this pollutant at the given concentration over a lifetime.

Table 1. Interpreting the excess lifetime cancer risk numbers.

Risk (in 10,000)	Exponential	Decimal	Read as…
0.001	$1x10^{-7}$	0.0000001	1 in 10 million
0.01	$1x10^{-6}$	0.000001	1 in 1 million
0.1	$1x10^{-5}$	0.00001	1 in 100,000
1.0	$1x10^{-4}$	0.0001	1 in 10,000

The Hazard Quotient (non-cancer health risk) associated with each relevant metal is calculated by simply dividing the metal average concentration by the respective RfC. If the Hazard Quotient is greater than 1.0, then adverse health effects are possible. The Hazard Quotient cannot be translated to a probability that adverse health effects will occur, and is unlikely to be proportional to risk. It is especially important to note that a Hazard Quotient exceeding 1.0 does not necessarily mean that adverse effects will occur. To gauge possible additive effects of multiple pollutants, the individual Hazard Quotients for each metal can be summed to produce the Hazard Index. If the Hazard Index value is less than 1.0, and inhalation is the only source of exposure, then the combined chemicals concentrations are not likely to cause adverse non-cancer health affects.

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 samples collected is the concentration that the student will continually 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 concentrations are assumed to be 1/7th the total chromium concentration when calculating the cancer risk based on the toxic metal results;
- The only excess risk considered in this report is due to inhalation.

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 a 1-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 an Excess Lifetime Cancer Risk to an individual of between 1-in-10,000 and 1-in-a-million as an acceptable range.

The results of toxic metal sampling can be found in Table 2. The total Excess Lifetime Cancer Risk for inhalation, based on the average concentration of toxic metals from the sampling, is 0.31-in-10,000 and is shown in Table 3. This value falls within the 1-in-10,000 and 1-in-a-million acceptable range. The results of specialized sampling for hexavalent chromium are shown in Table 4 with very little cancer risk (0.01 4-in-10,000) and a negligible non-cancer risk from this toxic. With the conservative assumptions used by the DEP in conducting this risk assessment, especially in the assumed hexavalent chromium concentration, the actual cancer risk is most likely lower.

Non-Cancer Health Effects

DEP sampling found the average concentrations of manganese and nickel near the school to be elevated but under the non-cancer health benchmark (Hazard Quotient of 1.0) for each. The average manganese concentration produced a hazard quotient of 0.72. The average nickel concentration produced a lower Hazard Quotient of 0.40. Even though the manganese and nickel Hazard Quotients help to push the Hazard Index (of 1.4) above the benchmark (1.0), the two metals target different systems in the body (manganese the nervous system, nickel the respiratory and hematopoietic) and therefore additive effects are unlikely.

For informational purposes, the manganese RfC value of 0.05 ug/m^3 is derived from a workplace study where the Lowest Observed Adverse Effect Level (LOAEL) during the study was 150 ug/m3, and where an uncertainty factor of 1,000 and other exposure factors were applied. The LOAEL is defined as the lowest exposure level, at which there are biologically significant increases in frequency or severity of adverse effects between the exposed population and its appropriate control group. The average manganese concentration of 0.03576 ug/m^3 at the St. Vitus School site is approximately 4,200 times lower than the LOAEL.

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

Conclusion

Based on the sampling conducted in 2009 and 2010, adverse health effects are not expected from the inhalation of metals in particulates.

DEP will continue to inspect nearby sources of manganese and nickel to ensure their compliance with all applicable Air Pollution Control Act requirements. If in compliance, DEP will continue to seek and push for voluntary measures by industry to improve the air quality in New Castle. DEP will not continue sampling at the St. Vitus School unless a change in emission rates is suspected, either through expansion by current sources or the addition of new sources.

Table 2. DEP toxic metal PM_{10} sampling results at the St. Vitus School.

	DEP Samples (ug/m^3)							
Date	Arsenic	Beryllium	Cadmium	Total Chromium	Lead	Manganese	Nickel	Zinc
1/21/10	0.00074	<RL	0.00027	0.00167	0.00349	0.00631	0.00128	0.01925
1/26/10	0.00154	<RL	0.00049	0.00606	0.00720	0.04071	0.01733	0.06806
2/7/10	0.00219	<RL	0.00054	0.00568	0.00928	0.02567	0.01122	0.08627
2/20/10	0.00163	<RL	0.00037	0.00413	0.00938	0.02516	0.01035	0.05996
2/25/10	0.00232	<RL	0.00072	0.01314	0.02410	0.09352	0.02905	0.19673
3/3/10	0.00333	<RL	0.00050	0.01110	0.01108	0.05506	0.03083	0.09915
3/9/10	0.00365	<RL	0.00056	0.00844	0.01898	0.03522	0.04028	0.08122
3/15/10								
3/21/10	0.00288	<RL	0.00048	0.00535	0.01148	0.03354	0.01017	0.12674
3/27/10	0.00216	<RL	0.00044	0.00335	0.01454	0.02324	0.00425	0.07024
4/2/10	0.00201	<RL	0.00167	0.00584	0.01539	0.04186	0.00637	0.10373
4/8/10								
4/14/10								
4/20/10								
4/26/10								
5/2/10	0.00209	<RL	0.00064	0.00790	0.01913	0.04669	0.02568	0.12158
5/8/10	0.00200	<RL	0.00083	0.00800	0.02372	0.06458	0.03043	0.12955
5/14/10	0.00093	<RL	0.00017	0.00198	0.00899	0.01731	0.00183	0.02578
5/20/10	0.00201	<RL	0.00038	0.00236	0.00922	0.01259	0.00624	0.03726
5/26/10	0.00321	<RL	0.00103	0.00369	0.02066	0.03333	0.00752	0.09273
6/1/10								
6/7/10	0.00269	<RL	0.00062	0.00810	0.01776	0.04721	0.03366	0.14790
6/13/10	0.00234	<RL	0.00037	0.00856	0.00838	0.03709	0.01396	0.07746
6/19/10	0.00303	<RL	0.00061	0.01021	0.01041	0.04055	0.02768	0.06467
6/25/10	0.00278	<RL	0.00053	0.00981	0.01278	0.03326	0.02468	0.06201
7/1/10	0.00453	<RL	0.00108	0.00909	0.02324	0.02437	0.01546	0.09472
7/7/10	0.00242	<RL	0.00092	0.01634	0.01463	0.02773	0.03839	0.07998
7/13/10								
7/19/10								
7/25/10								
7/31/10								
8/6/10	0.00304	<RL	0.00110	0.00572	0.01289	0.02575	0.00693	0.06754
8/12/10	0.00164	<RL	0.00048	0.00527	0.00731	0.02016	0.01293	0.04787
8/18/10	0.00424	<RL	0.00216	0.01529	0.01525	0.03541	0.05536	0.10562
8/24/10	0.00269	<RL	0.00062	0.00882	0.01574	0.04279	0.02996	0.06535
9/1/10	0.00310	<RL	0.00098	0.02110	0.02056	0.04057	0.02476	0.12689
Average	0.00251	<RL	0.00071	0.00796	0.01406	0.03576	0.01987	0.08686

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

Table 3. Summary of DEP toxic metal PM_{10} sampling results at the St. Vitus School.

CAS #	Metal	USA TODAY Sample[a] ug/m³	DEP Average[b] ug/m³	Unit Risk Factor (URF) m³/µg	Source URF	Excess Lifetime Cancer Risk[c] (ELCR) (in 10,000)	Reference Air Conc. (RfC) µg/m³	Source RfC	Non-Cancer Hazard Quotient[e]
7440-38-2	Arsenic	no	0.00251	0.0043	IRIS	0.108	0.015	CalEPA	0.17
7440-41-7	Beryllium	sampling	<RL	0.0024	IRIS		0.020	IRIS	
7440-43-9	Cadmium		0.00071	0.0018	IRIS	0.0128	0.010	ATSDR	0.07
7440-47-3	Chromium (Total)		0.00796						
18540-29-9	Chromium VI (Assumed)[f]		0.00114	0.012	IRIS	0.14	0.10	IRIS	0.01
7439-92-1	Lead[g]		0.01406	0.000012	CalEPA	0.002			
7439-96-5	Manganese		0.03576				0.05	IRIS	0.72
	Nickel[h]		0.01987	0.00024	IRIS	0.048	0.05	CalEPA	0.40
7440-66-6	Zinc		0.08686						
					Total ELCR:	0.31		**Hazard Index:**	1.4

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

[b] Average of 26 samples collected between 1/21/10 and 9/1/10 using EPA Method IO-2 and IO-3.

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

[e] A Hazard Quotient < 1 indicates no expected non-cancer health effects (HQ = Avg / RfC). HQ not calculated for metals not detected in all 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/m³ (rolling 3-month average).

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

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

IRIS - EPA's Integrated Risk Information System
CalEPA - California EPA
ATSDR - Agency for Toxic Substances & Disease Registry

Table 4. Summary of DEP hexavalent chromium sampling results at the St. Vitus School.

Date	DEP Samples ug/m^3
4/28/10	0.000157
5/2/10	0.000053
5/4/10	0.000125
5/6/10	0.000147
5/10/10	0.000208
5/12/10	0.000187
5/16/10	0.0000266
5/18/10	0.0000013
Average	0.000113

CAS #	Metal	USA TODAY Sample ug/m^3	DEP Average[a] ug/m^3	Unit Risk Factor (URF) m^3/µg	Source URF	Excess Lifetime Cancer Risk[b] (in 10,000)	Reference Air Conc. (RfC) µg/m^3	Source RfC	Hazard Quotient[c]
18540-29-9	Chromium VI	no	0.000113	0.012	IRIS	0.014	0.10	IRIS	0.00

[a] Samples collected over a 24-hour period beginning on the date shown using method developed for EPA's National Air Toxics Trends Stations.
[b] (ELCR = Avg x URF) An ELCR less than 1-in-10,000 is considered acceptable by EPA.
[c] (HQ = Avg / RfC) A Hazard Quotient < 1 indicates no expected non-cancer health effects.
\# - Metal not detected. DEP substituted 1/2 the Reporting Limit to calculate average.
IRIS - EPA's Integrated Risk Information System

**For more information, visit www.depweb.state.pa.us,
keyword: School Air Toxics Study.**

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