Evaluation of Metals and Carbonyls in Outdoor Air at Woodson Middle School (2014–2016)

Woodson Middle School

HOPEWELL, VIRGINIA

March 27, 2023

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Dear Charles Turner,

Thank you for the opportunity to review the air monitoring results from 2014–2016 at Woodson Middle School in Hopewell, VA. As requested, the Virginia Department of Health (VDH) has finished reviewing the metals and carbonyl air monitoring results for public health implications and concludes that the metals and carbonyl air monitoring results collected at Woodson Middle School from 2014–2016 are not expected to harm people's health. VDH does not have any recommendations at this time and will evaluate any additional air monitoring results for public health implications. Sampling methodology used and site descriptions have been described in previous risk assessments prepared for you and will not be discussed here.

DISCUSSION

Results

The following section contains results and comparison values (CVs) for metals (Table 1) and carbonyls (Table 2) monitored in 2014–2016 at Woodson Middle School. CVs are discussed in more detail in the public health implications section. The number of samples collected each year and the percent detection for each metal and carbonyl is presented in the attachment (Tables 3 and 4).

VDH compared the yearly maximum and average concentrations of each metal with its respective CV. The yearly maximum and yearly average concentrations of arsenic and chromium (total) exceeded their CV. In 2010 and 2011 the maximum cadmium concentration exceeded its CV; however, there were no exceedances in 2014–2016.

Table 1. Maximum and yearly average metal concentrations and comparison values (2014–2016)

Analyte	2014		2015		2016		CV	CV Type
	Max	Avg	Max	Avg	Max	Avg		
Arsenic	**0.00355**	**0.000671**	**0.00387**	**0.000857**	**0.0043**	**0.000944**	0.00023	CREG
Beryllium	0.0000430	0.00000489	0.000036	0.00000238	0.000016	0.00000243	0.00042	CREG
Cadmium	0.000507	0.0000971	0.000432	0.000102	0.000535	0.000106	0.00056	CREG
Chromium	**0.00400**	**0.00189**	**0.00375**	**0.00195**	**0.00486**	**0.00187**	0.000052	CREG*
Lead	0.00486	0.00197	0.00528	0.00239	0.00611	0.00209	0.15	NAAQS
Manganese	0.0312	0.00669	0.0255	0.00846	0.0201	0.00699	0.3	EMEG
Nickel	0.0155	0.00116	0.00278	0.000857	0.00179	0.000651	0.09	EMEG

(*Source:* DEQ) All concentrations in micrograms/cubic meter. **Max** – maximum; **Avg** – average; **CV** – comparison value; **CREG** – cancer risk evaluation guide; **NAAQS** – National ambient air quality standard; **EMEG**– environmental medium evaluation guide; *CREG is for hexavalent chromium; **bold face** – values that exceed the comparison value

VDH compared the yearly maximum and average concentrations of each carbonyl with its respective CV. The yearly maximum and yearly average concentration of formaldehyde and acetaldehyde exceeded their CV. This is consistent with what was reported for these two carbonyls in 2009–2013.

Table 2. Maximum and yearly average carbonyl concentrations and comparison values (2014–2016)

Analyte	2014		2015		2016		CV	CV Type
	Max	Avg	Max	Avg	Max	Avg		
Acetaldehyde	**2.91**	**1.24**	**3.12**	**1.35**	**3.43**	**1.47**	0.45	CREG
Acetone	12.9	4.18	12.1	4.00	14.8	3.71	19000	EMEG
Formaldehyde	**7.47**	**2.64**	**7.48**	**2.38**	**7.51**	**2.37**	0.077	CREG
Methyl isobutyl ketone	0	0	0	0	0	0	3000	RMEG
Methyl ethyl ketone	1.14	0.516	0.783	0.401	1.03	0.402	5000	RMEG
Propionaldehyde	0	0	0.622	0.035	0.532	0.195	8	RMEG

(*Source:* DEQ) All concentrations in micrograms/cubic meter. **Max** – maximum; **Avg** – average; **CV** – comparison value; **CREG** – cancer risk evaluation guide; **EMEG**– environmental medium evaluation guide; **RMEG** – reference media evaluation guide; **bold face** – values that exceed the comparison value

Public Health Implications

Contaminants in the environment can only impact human health if individuals are (1) exposed to contaminants and (2) if contaminants are present at sufficient concentrations. Residents can potentially be exposed to contaminants in ambient air whenever they spend time outdoors. Evaluation of the metals and carbonyl compounds with air concentrations above their respective CV are discussed below. The CV is a concentration based upon toxicological studies of humans and animals that is intended to be well below what might cause health effects, and is used as a screening level. Concentrations of chemicals that exceed the CV are evaluated further to determine the potential health risk.

Contaminants evaluation

CVs used to evaluate contaminants at the sampling sites:

- Reference media evaluation guides (RMEGs) are Agency for Toxic Substances and Disease Registry (ATSDR)-derived CVs based on non-cancer health effects for chronic exposure duration only. RMEGs represent the concentration in a specific medium (e.g., water or soil) at which daily human exposure is unlikely to result in adverse non-carcinogenic effects. For air, RMEGs are the same as corresponding U.S Environmental Protection Agency's (EPA's) inhalation reference concentrations (RfCs).
- Cancer risk evaluation guides (CREGs) are ATSDR specific CVs that are used to identify concentrations of cancer-causing substances that are unlikely to result in a significant increase of cancer rates in an exposed population. ATSDR develops CREGs using EPA's cancer slope factor or inhalation unit risk, a target risk level (10^{-6}), and default exposure assumptions. The target risk level of 10^{-6} represents an estimated risk of 1 excess cancer case in an exposed population of 1 million.
- Environmental media evaluation guides (EMEGs) are ATSDR specific CVs that are based on ATSDR's MRLs for non-cancer health effects. They represent estimated contaminant concentrations below which humans exposed during a specific timeframe (acute, intermediate, or chronic) are not expected to experience noncarcinogenic health effects. Air EMEGs are the same as their corresponding inhalation MRLs.

In addition to these CVs, the national ambient air quality standard (NAAQS) was used to evaluate lead concentrations.[1]

Two metals (arsenic and chromium) and two carbonyls (acetaldehyde and formaldehyde) were evaluated further because their yearly average concentrations exceeded their respective CV. General information including reported air concentrations, source, and health effects of acetaldehyde, arsenic, chromium, and formaldehyde can be found in Table 5 in the attachment.

Cancer risk

The average concentrations of the carcinogens, acetaldehyde, arsenic, chromium, and formaldehyde exceeded their cancer CVs in multiple years. The average of each reported yearly average concentration for each contaminant was multiplied by the inhalation unit risk (IUR) to calculate the cancer risk. (See Box 1). The additional cancer risk for each contaminant is within EPA's generally acceptable target risk range (1 in 10,000 to 1 in 1,000,000) and is considered low. The risk assessment also assumes that the individual is breathing the same concentration of contaminants for 70 years.

1 https://www.epa.gov/criteria-air-pollutants/naaqs-table last accessed September 2022.

Box 1. Cancer risk calculation for carcinogens discussed

To estimate cancer risk from inhaling carcinogens discussed, the inhalation unit risk (IUR) factor in $(\mu g/m^3)^{-1}$ for each carcinogen is multiplied by the air concentration of the contaminant in $\mu g/m^3$. See Equation 1 below.

Equation 1

Cancer Risk = IUR × Concentration

Acetaldehyde (Average 2014–2016 concentration = 1.35 µg/m³)

$3.0 \times 10^{-6} = 2.2 \times 10^{-6}$ $(\mu g/m^3)^{-1} \times 1.35$ $\mu g/m^3$ = 3 additional cancers in 1,000,000

Arsenic (Average 2014–2016 concentration = 8.2×10^{-4} µg/m³)

$3.5 \times 10^{-6} = 4.3 \times 10^{-3}$ $(\mu g/m^3)^{-1} \times 8.2 \times 10^{-4}$ $\mu g/m^3$ = less than 4 additional cancers in 1,000,000

***Chromium (total) (Average 2014–2016 concentration = 1.9×10^{-3} µg/m³)**

$2.2 \times 10^{-5} = 1.2 \times 10^{-2}$ $(\mu g/m^3)^{-1} \times 1.9 \times 10^{-3}$ $\mu g/m^3$ = less than 3 additional cancers in 100,000

Formaldehyde (Average 2014–2016 concentration = 2.46 µg/m³)

$3.2 \times 10^{-5} = 1.3 \times 10^{-5}$ $(\mu g/m^3)^{-1} \times 2.46$ $\mu g/m^3$ = less than 4 additional cancers in 100,000

*The IUR for chromium VI was used in this calculation.

Chromium is found in the environment in two oxidation states, chromium III and chromium VI. Chromium VI is a known carcinogen. Because total chromium, which contains both chromium III and chromium VI, was reported, VDH calculated the additional cancer risk assuming that the reported chromium only contained chromium VI. This assumption is likely to overestimate cancer risk for the total chromium concentrations reported because it is unlikely that all chromium at Woodson Middle School is chromium VI.

This additional excess cancer risk to individuals living near Woodson Middle School represents a small incremental risk above background cancer levels in the U.S. population which is between one in three and one in four. The risk assessment also assumes that the individual is breathing the same concentration of contaminants for 70 years. People who live in the area for shorter time periods will have a lower risk.

CONCLUSIONS

VDH concludes that the metal air concentrations at Woodson Middle School from 2014–2016 are not expected to harm people's health.

VDH concludes that the carbonyl air concentrations at Woodson Middle School from 2014–2016 are not expected to harm people's health.

RECOMMENDATION

VDH does not have any recommendations at this time.

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ATTACHMENTS

Table 3. Metals and percent detected for total samples collected each year (2014–2016)

Analyte	2014 (61 total samples)	2015 (60 total samples)	2016 (61 total samples)
Arsenic	93	100	98
Beryllium	49	40	61
Cadmium	93	100	98
Chromium	93	100	98
Lead	93	100	98
Manganese	93	100	98
Nickel	93	100	98

(*Source:* DEQ)

Table 4. Carbonyls and percent for total samples collected each year (2014–2016)

Analyte	2014 (60 total samples)	2015 (60 total samples)	2016 (61 total samples)
Acetaldehyde	95	98	97
Acetone	95	98	97
Formaldehyde	95	98	97
Methyl isobutyl ketone	0	0	0
Methyl ethyl ketone	82	72	97
Propionaldehyde	0	7	56

(*Source:* DEQ)

Table 5. Air concentrations, potential sources, and health effects for selected contaminants[2]

Volatile Organic Compound	Reported Air Concentrations (average levels)	Source	Health Effect(s)
Acetaldehyde	outdoor air: 1.6 to 44.1 µg/m^3 (one hour samples) rural air: 1.4 µg/m^3	industrial vehicles	*humans*: irritation of the eyes, nose, throat, and central nervous system; delayed pulmonary edema *animals:* nasal cancer, kidney and reproductive effects
Arsenic	Concentration of arsenic in the air generally range from less than 0.001 to 2 µg/m^3 depending on location, weather conditions, and level of industrial activity urban air: 0.020 to 0.030 µg/m^3	industrial agricultural	*humans:* sore throat, irritated lungs, nausea, vomiting, increased risk of skin, liver, bladder and lung cancer
Chromium	rural air: <0.010 µg/m^3 urban air: 0–0.030 µg/m^3 As a result of smoking, indoor air contaminated with chromium can be 10–400 times greater than outdoor air concentrations	industrial	*humans:* irritation of nose, coughing, shortness of breath, wheezing, increased risk of lung cancer *animals:* cancerous tumors in the stomach, intestinal tract, and lungs
Formaldehyde	Outdoor air concentrations in urban environments vary and depend on local conditions: 1–20 µg/m^3	industrial	*humans:* irritation of the eyes, nose, and throat; continuous exposure can cause nose and throat cancer *animals:* irritation and damage to lining of the nose and throat; high concentrations can irritate lungs and stomach

2 Agency for Toxic Substances and Disease Registry, California Environmental Protection Agency, Hazardous Substances Data Base Last accessed November 2015