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Dear Dr. Avula:

From August to October 2012, Richmond City Public Schools (RPS) provided the Virginia Department of Health (VDH) with multiple indoor air sampling results for A. V. Norrell Elementary School in Richmond, Virginia. Under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), VDH has reviewed and evaluated the data. Thank you for the opportunity to assess the impact these findings may have on the students' health.

BACKGROUND

A. V. Norrell Elementary School is located at 2120 Fendall Avenue in Richmond, Virginia, 23222. The elementary school is on the east and northeast portion of the Fells Street landfill. According to an environmental site assessment report prepared by Virginia Department of Environmental Quality (DEQ) in June 2007, prior to building the school in 1964, the landfill was excavated from beneath the building footprint and replaced with clean fill material. In 1975, methane gas sensors were installed and upgraded in 1994. The school was closed in 1975 because methane was detected outside and reopened in 1977 (1).

In March 2006, ATSDR received a request from a concerned citizen to determine if gases emitted from nearby landfills posed a health threat to the students at Norrell Elementary. At that time, the U. S. Environmental Protection Agency (EPA) requested that ATSDR review indoor and outdoor air sampling results collected from Norrell Elementary. In ATSDR's Record of Activity report released in February 2007, ATSDR categorized the school's air quality sampled in 2002 as "no apparent public health hazard." This means that the chemicals measured in the indoor air at the school were not at levels expected to impact the children's health. In an abundance of caution, and because formaldehyde and naphthalene were detected above health-

based screening levels in 2002, ATSDR recommended to retest for those chemicals if the school reopened. ATSDR also recommended addressing any mold problems, and ensure proper functioning of the methane detection system if the school was reoccupied (2). City officials closed the school in September 2006 because Tropical Depression Ernesto flooded the area surrounding the school.

In 2012, the school reopened and was attended by approximately 250 pre-kindergarteners, aged three to five. Prior to admitting students in 2012, RPS hired France Environmental Consulting (FEC) to inspect the school. On August 31, 2012, RPS forwarded FEC’s inspection report to VDH. Sample results reported included mold, relative humidity, carbon monoxide, carbon dioxide, temperature, and methane. The results were unremarkable, and VDH recommended that RPS follow FEC’s recommendations made in their report (See Attachment) (Andy Hawkins, Personal communication, August 2012).

In response to ATSDR’s recommendation to resample the indoor air at Norrell Elementary for formaldehyde and naphthalene, RPS provided sampling results for formaldehyde and naphthalene collected in September 2012 (Table 1). FEC collected samples using methodology approved by the National Institute for Occupational Safety and Health for assessing worker exposure. The formaldehyde and naphthalene results reported were below the detection limits of the occupational sampling technique employed. These detection limits, however, were higher than the environmental health-based screening levels ATSDR and VDH use to evaluate potential impact to public health, including children. VDH recommended additional formaldehyde and naphthalene testing using sampling methodology with lower detection limits. VDH also recommended that repeat samples be taken in areas of the school that are representative or where the students spend the most of their time. Additional samples were collected during the fall of 2012.

The formaldehyde results in September were reported as “less than.” This is because the concentration of formaldehyde was below the detection limit of the methodology used. To be conservative, VDH used the formaldehyde detection limit as the “actual” concentration when evaluating its potential impact on health. Likewise, naphthalene was reported as “less than” and VDH used the detection limit as the “actual” concentration. This overestimates the risk because the actual concentration of formaldehyde and naphthalene would be between zero and the detection limit. See Attachment for a discussion on using detection limits.

Table 1. Maximum formaldehyde and naphthalene indoor air concentration results reported in 2002 and 2012.*

| Chemical | August 2002 | September 14, 2012 | September 28, 2012 | October 2012 |
|--------------|-------------|--------------------|--------------------|--------------|
| Formaldehyde | 26.4 | <63.86 | <26.7 | |
| Naphthalene | 9.2 | <13,253 | <926 | <40.28 |

(Source: ATSDR, RPS) *All units in $\mu\text{g}/\text{m}^3$. Shaded box = not collected.

DISCUSSION

To determine if exposure to formaldehyde and naphthalene in Norrell Elementary may adversely impact the students, VDH compared the reported concentrations to comparison values (CV). CVs are health-based environmental concentrations at which a chemical is not expected to adversely affect the public. Where possible, comparison values are generally available for three specified exposure periods: acute (14 days or less), intermediate (15 to 365 days), and chronic (more than 365 days). Because RPS indicated that the children will attend Norrell Elementary for 164 days this school year, VDH used the intermediate exposure (15 to 365 days) CV if available.

When CVs are derived, additional safety factors are used to account for special populations, such as children. When a chemical is present in the environment below its respective CV, it is not expected to result in adverse health effects, and is not evaluated further. Chemicals in the environment above their respective CVs require additional consideration to determine the likelihood of possible harmful effects. Although concentrations at or below the relevant CVs may reasonably be considered safe, it does not automatically follow that any environmental concentration that exceeds a CV would be expected to produce adverse health effects. Mold, methane, formaldehyde, and naphthalene, and their potential public health impact to students attending Norrell Elementary are discussed below.

Methane

Methane is a colorless, odorless, flammable gas that is produced by bacterial decomposition of organic matter. Methane presents two threats to people: explosion and asphyxiation. When methane gas is present in the air at concentrations between 5 and 15% it is explosive. Methane gas can collect in buildings or confined spaces reducing the amount of oxygen necessary to support life. An oxygen deficient environment caused by methane can produce health effects ranging from headaches to death depending on the amount of oxygen displaced. Landfills typically stop producing methane gas between 20 to 30 years after waste is dumped. Recent sampling results report that methane gas was not detected inside the school.

Mold

Molds are microscopic organisms that are found indoors and out. They are essential to the environment because they break down organic matter and recycle nutrients in the environment. Exposure to mold may trigger an allergic reaction resulting in asthma, itchy watery eyes, hay fever, and irritate the nose, throat, and lungs. Molds produce tiny spores to reproduce that travel through the air. When mold spores land on a damp spot indoors, they may begin growing and digesting whatever they are growing on in order to survive. When excessive moisture is present mold growth will often occur, particularly if the moisture problem remains. There is no practical way to prevent being exposed to all types of mold and mold spores in the indoor environment; however, mold growth can be prevented by eliminating excessive moisture indoors.

There are no regulations or standards for airborne mold contaminants in the indoor air. Theoretically, the concentration of airborne mold contaminants should be higher outdoors than indoors except during periods of snow fall. Other indicators that mold may be present in the

indoor environment include: the presence of a musty odor, high humidity, visible mold growth, water intrusion, and condensation on surfaces. According to the report the school submitted to VDH in August 2011, the concentration of mold contaminants in the indoor air was less than the concentration outside. The report also identified areas where mold was found on ceiling tiles and air conditioning units that were being replaced or cleaned.

Formaldehyde

Formaldehyde is a colorless, flammable gas at room temperature with a distinct pungent odor. It is produced by both human activity and natural sources. Sources of formaldehyde include power plants, automobiles, building materials, tobacco smoke, and consumer products. Consumer products that contain formaldehyde include carpets, cosmetics, fertilizers, paints, varnishes, and manufactured wood products (i.e. furniture, plywood, bookcases, and particle-board). The upper 95% confidence concentration of formaldehyde in 267 classrooms samples in California was 26.2 parts per billion (ppb) or $32.2 \mu\text{g}/\text{m}^3$ (3). The primary route of exposure is inhalation. Formaldehyde may cause eye, nose, and throat irritation at elevated levels. The Department of Health and Human Services (DHHS) has characterized formaldehyde as a human carcinogen (4).

Because the results reported in October 2012 were “less than $26.7 \mu\text{g}/\text{m}^3$,” VDH conservatively assumed the air concentration to be the limit of detection, $26.7 \mu\text{g}/\text{m}^3$. Children are only expected to attend Norrell Elementary for one school year or approximately 180 days. Therefore, VDH compared the recent formaldehyde air concentrations with ATSDR’s intermediate CV, $37 \mu\text{g}/\text{m}^3$. Because the formaldehyde concentrations at Norrell Elementary are less than the CV, the adverse health effects of formaldehyde do not need to be assessed further.

Naphthalene

Naphthalene is white solid that easily produces vapors that can burn when mixed with air. It has a mothball odor and can easily be detected by the human nose. Natural sources of naphthalene include fossil fuels. Consumer products that contain naphthalene include moth repellents and toilet deodorant blocks. Naphthalene dissolves in water and is weakly attracted to soil; therefore, if present in landfills it will pass through the soil into underground water. The primary route of exposure is inhalation. Exposure to large amounts of naphthalene can damage or destroy red blood cells. Naphthalene damaged the cells in the nose and lung of mice exposed to naphthalene vapors daily for their entire lives. DHHS has classified naphthalene as reasonably anticipated to be a human carcinogen (5).

The naphthalene air concentration in samples collected on October 10, 2012 was “less than $40 \mu\text{g}/\text{m}^3$.” VDH conservatively assumed the air concentration to be the limit of detection, $40 \mu\text{g}/\text{m}^3$. An intermediate exposure CV for naphthalene is not available; therefore, VDH used ATSDR’s chronic CV, $3.7 \mu\text{g}/\text{m}^3$, to assess naphthalene’s impact on student health. The chronic CV is approximately 10 times lower than what was measured at Norrell Elementary. This finding prompted VDH to further evaluate naphthalene.

Chronic inhalation CVs are derived for continuous, long-term 24-hour a day exposures. In most instances, exposure will be for less than 24 hours per day. When actual exposure information is

known, it can be used to calculate a hazard quotient (HQ). The HQ is the ratio of the actual exposure dose to the reference dose. If the ratio is greater than one, then the potential for adverse health effects is possible.

VDH calculated the HQ for naphthalene exposure at Norrell Elementary using the following exposure factors: students attend Norrell Elementary school for 5.5 hours per day, 180 days per year, for one year, have an average body weight of 18.6 kg, and breathe 10.1 m³ of air per day (Andy Hawkins, Personal communication, September 2012; 6). The ratio of the exposure dose to the reference dose was 1.2 (See Attachment for calculations). Because the HQ is approximately one (1), the adverse health effects of naphthalene at Norrell Elementary do not need to be assessed further by VDH. Adverse health effects are not anticipated. The derivation and discussion of the hazard quotient and the applicable naphthalene CV are presented in the Attachment.

Soil and soil gas

Soil and soil gas sampling is useful for identifying environmental contaminants in soil in addition to those discussed above. Volatile and semi volatile organic compounds, metals, pesticides, and persistent organic compounds such as polychlorinated hydrocarbons can be identified by soil and soil gas sampling. VDH is aware that the community is concerned about children being exposed to contaminants in soil and soil gas at the school playground. The school playground is upgradient of the landfill, making it highly unlikely that any soil contaminants could be transported in landfill leachate uphill to the playground. VDH is also unaware of any environmental data that indicate leachate is pooling on the school property or that the surface soil at the playground is contaminated. In addition, VDH has not been provided any soil or soil gas sample results from Norrell Elementary School to review.

VDH is available to participate in discussions with concerned citizens, local, state, and federal environmental agencies to determine if environmental conditions exist that warrant additional testing.

CONCLUSIONS

VDH concludes that the concentration of methane in the indoor air at Norrell Elementary is not expected to adversely affect the students.

VDH concludes that the concentration of formaldehyde in the indoor air at Norrell Elementary is not expected to adversely affect the students.

VDH concludes that the concentration of naphthalene in the indoor air at Norrell Elementary is not expected to adversely affect the students.

RECOMMENDATIONS

Additional methane monitoring guidance should be sought from DEQ or other appropriate authorities.

VDH encourages the school district to continue to proactively address indoor air quality concerns at Norrell and other schools in the district as feasible, as consistent with EPA's national guidelines for maintaining healthy indoor air quality inside schools (<http://www.epa.gov/iaq/schools/>).

I trust that the above information will be of help to you. Should you have any additional questions please contact the VDH Division of Environmental Epidemiology at (804)-864-8182 or at 109 Governor Street, Richmond, VA 23219.

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REFERENCES

1. Virginia Department of Environmental Quality. *Site assessment of Fells Street Landfill*. Richmond, VA. June 2007.
2. Agency for Toxic Substances and Disease Registry. Record of Activity for *Whitcomb Court and A.V. Norrell Elementary School Sites*. Philadelphia, PA. February 2007.
3. RTI International. *California portable classrooms study. Phase I: mailed survey. Final Report, Volume I*. Research Triangle Park, NC. May 2003.
4. Agency for Toxic Substances and Disease Registry. *Toxicological Profile for Formaldehyde*. Atlanta, GA. July 1999.
5. Agency for Toxic Substances and Disease Registry. *Toxicological Profile for Naphthalene, 1-Methylnaphthalene and 2-Methylnaphthalene*. Atlanta, GA. August 2005.
6. U.S. Environmental Protection Agency. *Exposure factors handbook* 2011.
<http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=236252> Last accessed September 2012.

Attachment

Equations and exposure parameters used to determine Hazard Quotient

Equations

Average Daily Dose

$$ADD = \frac{C * IR * EF * ET}{BW * CF_1 * CF_2}$$

Reference dose

$$RD = \frac{MRL * IR}{BW}$$

Hazard Quotient

$$HQ = \frac{ADD}{RD}$$

Where:

Exposure Parameters

| Abbreviations | Value & Units | Comments and Definitions |
|-----------------|--------------------------|---------------------------------------------------|
| ADD | µg /kg/day | Average Daily Dose |
| BW | 18.6 kg | Average weight of child |
| C | 40 µg/m ³ | Naphthalene concentration |
| CF ₁ | 24 h/day | Number of hours in a day |
| CF ₂ | 365 days/year | Number of days in a year |
| EF | 180 day/year | Number of days students attend Norrell Elementary |
| ET | 5.5 hours/day | Number of hours students attend school |
| HQ | Unit less | Hazard Quotient |
| IR | 10.1 m ³ /day | Volume of air a child breaths each day |
| MRL | 3.7 µg/m ³ | ATSDR minimal risk level |
| RD | µg/kg/day | Reference Dose |

Naphthalene's comparison value derivation and discussion

Naphthalene's CV was derived from two chronic inhalation studies. The lowest-observed-adverse-effect-level (LOAEL) in both studies was 10 parts per million (ppm) or $\sim 52,000 \mu\text{g}/\text{m}^3$. The toxic endpoint was non-neoplastic lesions in the nasal olfactory epithelium. A human equivalent LOAEL (0.2 ppm or $\sim 1,000 \mu\text{g}/\text{m}^3$) was used for determining the CV. An uncertainty factor of 300 was applied (10 for using a LOAEL, 3 for extrapolating from animals to humans, and 10 for human variability) to yield a CV of 0.00066 ppm ($0.2 \div 300 = 0.0007 \text{ ppm} = 3.7 \mu\text{g}/\text{m}^3$). The highest possible concentration ($40 \mu\text{g}/\text{m}^3$) at Norrell Elementary reported is 25 times less than the lowest human equivalent exposure concentration ($1,000 \mu\text{g}/\text{m}^3$) causing adverse health effects in animals in a chronic exposure study (5).

Detection limit discussion

By definition, the detection limit is the lowest level of chemical that analytical methodology can differentiate from the "noise" inherent to scientific measurements. When laboratories report that a chemical was not detected in a sample, that does not mean that the chemical was not present. Rather, it means the chemical was not present at levels that can be reliably measured by the analytical method, and the only conclusion that you can draw is that the actual concentration is somewhere between zero and the reported detection limit.

If an analytical method has detection limits for a chemical higher than the corresponding CV, the method is not sensitive enough to measure concentrations of potential concern. In such a case, a "less than" result will not tell you if concentrations are above or below a CV, and further sampling using more sensitive methods might be necessary to evaluate the levels of contamination at the range of interest.

Summary of France Environmental Consulting Recommendations

Clean all wall mounted A.C units in the north end of the building with a fungicidal spray and or use a HEPA vacuum. Also clean and or replace the pre-filters in these units.

Clean all ceiling mounted chiller mounted units' diffusers fins and intake areas with a HEPA vacuum and or fungicidal spray.

Chiller units in rooms that had warm temperatures and high humidity readings should be serviced.

Repeat potentially false positive mold sampling results.

City of Richmond should see if the school building has had a lead survey report done, or have the areas in the school where the wall paint is showing damage analyzed for lead based paint.