Health Consultation

VAPOR INTRUSION PATHWAY AT
KENOSHA BRASS COMMUNITY SCHOOL

CITY OF KENOSHA, KENOSHA COUNTY, WISCONSIN

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

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HEALTH CONSULTATION

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CITY OF KENOSHA, KENOSHA COUNTY, WISCONSIN

Prepared By:

Division of Public Health,
Wisconsin Department of Health Services
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Summary and Statement of Issues

The Wisconsin Department of Health Services (DHS) was requested by the Wisconsin Department of Natural Resources (DNR) and Kenosha Unified School District (KUSD) to assess the potential for vapor migration and intrusion of soil vapors to indoor air of the recently constructed Kenosha Brass Community School, at 6400 15th Street, in the City of Kenosha. In 2007, DHS recommended construction measures at the planned school to address this pathway, and these were implemented when the school was built in 2008. Recent air testing indicates the passive ventilation system at the school is addressing the pathway, and vapor intrusion is a "no public health hazard." However, DPH recommends testing the effectiveness of the passive system by assessing pressure gradients between the system and indoor air at the school. Should such testing raise questions about the system's effectiveness, the school district should consider upgrading the system from passive to active and retest the upgraded active system to rule out completion of the pathway.

Background

The 30-acre, former Outokumpu property, in the City of Kenosha, Wisconsin, was recently targeted for a mixture of retail and residential redevelopment, and included a school. Between 1886 and 1999, several different corporations owned and operated a brass and copper manufacturing facility on the site. This site was most recently owned by Outokumpu of Finland and, as a result, is commonly referred to as the Outokumpu Kenosha property. Environmental investigations of the Outokumpu Kenosha property found that soils and groundwater in the western portion contained elevated levels of volatile organic compounds (VOCs). Polycyclic aromatic hydrocarbons and metals including lead and copper were also found only in soils (Olson 2005).

In 2005, DHS was requested by DNR to review and comment on a remediation and redevelopment plan for western portions of this property. DHS provided guidance related to redevelopment and answered questions about chemical vapor intrusion. After reviewing site investigation data and the remedial action plan DHS determined that the proposed remedies and the redevelopment plan greatly reduced the potential for vapor intrusion into buildings planned for the western portion of the property and that the plan was protective of public health, and would pose "no public health hazard." DHS's response was described in an ATSDR health consultation (ATSDR 2005).

In 2007, KUSD requested advice from DHS on the human health implications of constructing an elementary school on the eastern portion of the former Outokumpu property. DHS reviewed site investigation data, remedial action plans, the materials management plan, and redevelopment plans. The investigations indicated that no contaminant sources remained in the eastern portion of the property and only residual levels of contaminants were present in sub-surface soils. DHS concluded that such contamination was not likely to pose a future health risk to children, workers, or the general public using this proposed facility (DHS 2007).

Due to the presence of low levels of residual chlorinated VOCs in sub-surface soils at the proposed Kenosha Brass Community School, DHS pointed out to KUSD officials there was a

very low potential for a completed pathway by vapor migration and intrusion to indoor air. However, as a precaution, DHS suggested to KUSD that the school be constructed with a vapor barrier beneath the building and a passive sub-slab vapor ventilation system.

In 2008 KUSD constructed the Kenosha Brass Community School on the property, and implemented the recommended vapor control system. Shortly after, coarse base material was placed on the building footprint, a network of 4 inch perforated PVC pipes was installed. This network included three inlet and three outlet stacks to allow any sub-slab soil vapors to be passively collected and dispersed directly to the atmosphere. Prior to pouring the slab-on-grade concrete foundation, a 10-mil plastic sheet was placed directly on top of the sub-slab venting network and base material.

Once construction was completed on the Brass Community School, KUSD decided to assess the effectiveness of this vapor control system for mitigating the vapor intrusion pathway. KUSD sought advice from DHS and DNR on the approach for conducting this investigation. DHS suggested collecting air samples from within vapor control system and testing for VOCs. KUSD and DHS would then evaluate data for whether VOCs within the vapor control system posed a potential concern for the vapor intrusion pathway at the school.

Methods

In late 2008, to assess the effectiveness of this vapor intrusion mitigation system, KUSD planned to collect air samples from inside of the vapor ventilation system and requested DHS to assess the results. During December 2008, KUSD's consultant, in verbal consultation with DHS, collected air samples from inside the ventilation system stacks to test for solvents associated with contaminated media on the property. All inlet and outlet ventilation stacks were sealed for 10 days prior to sampling to allow soil vapor to accumulate to highest potential concentrations in the sub-slab network. Prior to sealing the outlet stacks, Tygon tubing was threaded down to the base of the stack, with the end of the tubing clamped shut where extending to the outside of the sealed vent stack. This would permit the drawing of a sample without unsealing the vent stacks and preventing sample mixing and dilution with outdoor air. After 10 days ventilation system air samples were collected after unclamping and purging an appropriate volume from the external Tygon tubing sample locations. An upwind, outdoor air sample was also collected to determine the background concentrations of VOCs in ambient air around the school. Air samples were drawn over 30 minutes into 6-liter SUMMA® canisters and submitted for analysis of VOCs by EPA method TO-15 (ChemReport 2009).

Results

The analytical results (Table 1) showed elevated levels of two solvents in the vapor ventilation system air samples and were above their respective soil vapor screening values. It should be noted that methylene chloride was not identified as a chemical of concern during prior environmental investigations of the site. Prior public health documents regarding this site (ATSDR 2005, DHS 2007) described the solvents 1,1,1-trichloroethane (TCA) and trichloroethylene (TCE) in other environmental media at the site. However, TCA and TCE were

each found in the ventilation system air samples to be less than their respective soil vapor screening values and will not be further evaluated.

Table 1: Volatile Organic Compounds Inside of a Soil Vapor Ventilation System
Brass Community School, City of Kenosha, Wisconsin
December 2008
All concentrations in parts per billion by volume (ppbv)

Chemical	Soil Vapor System Air Sample			Outdoor Air Sample	Sub-Slab Soil Vapor Screening Value
	Vent Stack-1	Vent Stack-2	Vent Stack-3		
Benzene	nd	44.2*	nd	nd	10
Methylene Chloride	3.1	3.7	470.0*	2.1	150
1,1,1-Trichloroethane	nd	0.91	nd	nd	953,800
Trichloroethylene	nd	3.0	nd	nd	22

nd – not detected
* – exceeds screening value

Discussion

DHS was requested to assess the potential for vapor migration and intrusion of soil vapors to indoor air at the Kenosha Brass Community School. DPH concludes that the existing sub-slab soil vapor ventilation system is effective at addressing the potential "sub-slab to indoor air" pathway, and there is "no public health hazard" from vapor migration and intrusion. This is based on DPH's assessment of VOC levels measured in vent stack samples at the Kenosha Brass Community School, DPH's experience and knowledge from investigating the vapor intrusion pathway at many sites, and supporting information from current national dataset on vapor intrusion (RTI 2009).

The highest levels of benzene and methylene chloride in the vent stack samples exceeded their sub-slab soil vapor screening values by 4.4 and 3.1 times, respectively. The sub-slab soil vapor screening value for each solvent was derived from its respective residential indoor air comparison value, which appears on the U.S. EPA regional risk-based concentration tables (EPA 2008). The screening values for benzene and methylene chloride were based on their respective 1-in-100,000 excess lifetime cancer risk levels. These residential indoor air comparison values were then converted to a soil vapor screening value by applying a conservative "sub-slab to indoor air" attenuation factor of 10, which is recommended by the draft 2002 EPA guidance on vapor intrusion (EPA 2002). When a VOC in sub-slab soil vapor exceeds its screening value, this means the next step should be taken in evaluating whether the vapor intrusion exposure pathway is completed. This should not be directly interpreted that there is an unacceptable indoor air inhalation exposure and that a public health hazard exists.

While the levels of benzene and methylene chloride each exceeded their sub-slab soil vapor screening values, there are several strong reasons why a similar level of these VOCs, resulting from vapor intrusion, are not likely be found in indoor air of the Kenosha Brass Community School. First, the sub-slab soil vapor screening value was derived from indoor air comparison value by applying the default attenuation factor of 10. This attenuation factor presumes there will be ten-fold decrease in a VOC concentration when sub-slab vapors move into indoor air. A 2008 draft EPA report that evaluated attenuation factors examined over 2,900 sets of paired sub-surface and indoor air measurements from 913 buildings at 41 sites with a completed vapor intrusion pathway (EPA 2008). This data found that a sub-slab to indoor air attenuation factor of 10 dramatically overestimated the potential of vapor intrusion for 95 percent of these buildings (none of these buildings had an existing sub-slab mitigation system). Second, the Kenosha Brass Community School already has a passive soil vapor ventilation system and vapor barrier, which already provides an open pathway for sub-slab soil vapors to be vented to outdoor air and further minimizes the chance that soil vapors can migrate into indoor air.

Sample data from the ventilation/mitigation system probably resulted in an accurate estimate of the higher range of VOCs that occur in soil vapors beneath the Kenosha Brass Community School. For buildings that are in very close proximity to VOC-contaminated soils and groundwater, the testing of soil vapors from beneath the building floor can be a very reliable for assessing the potential of a completed "sub-slab to indoor air" pathway. Often, sub-slab soil vapor samples are collected from stainless steel ports that are installed through the concrete floors and draw from the coarse, gravel base material. There can be a wide variability in sub-slab soil VOC levels from a single building, therefore an appropriate number of sub-slab soil vapor sampling locations are needed to adequately characterize soil vapor VOC concentrations beneath the entire building. Alternatively, such as at the school, sub-slab soil vapor samples collected from an existing sub-slab ventilation network will provide data that is fairly accurate of soil vapors under the building's footprint.

To obtain the worst-case or highest level of soil vapors beneath the school building, it was important to allow vapor levels in the ventilation network to stabilize and reach equilibrium with nearby soil vapors. Minimizing air exchanges between sub-slab network with outdoor or indoor air was important and, as a result, DPH recommended sealing the ventilation stacks for a minimum of 24-hours to achieve such equilibrium, and waiting 10 days would be more likely of reaching this condition.

Collecting the vent stack samples at the Kenosha Brass Community School during the winter probably resulted in slightly higher VOC concentrations than what would be observed from a similar sample collected during the summer. When buildings are heated during the winter, warm air rises up inside the building and tends to create a modest pressure gradient, with a slightly lower pressure in the basement and a slightly higher pressure in the upper levels of the building. This "chimney effect" can also slightly increase the flow of sub-slab soil vapors being drawn into the basement and moving up through the rest of the building. Frozen surface soils around the building can also enhance the "chimney effect" because sub-surface soil vapors near the building have fewer pathways for escaping to the atmosphere. As a result, during winter months soil vapors captured beneath a frozen surface can migrate laterally much longer distances than during summer months.

At this time, DPH does not recommend indoor air sampling at the Kenosha Brass Community School as a means of evaluating the effectiveness of the ventilation/mitigation system. First, the data indicates that this pathway is not occurring inside of the school. Second, the school was recently constructed and many studies show that the indoor air of newly constructed buildings typically contains very elevated levels of many solvents that are commonly emitted from a wide-array of construction materials. The likely presence of such solvents in the indoor air of the school will make it difficult to assess the impact of the ventilation/mitigation system and possibly will be at levels that mask out the chemicals detected in sub-slab soil vapors.

Alternatively, DPH recommends testing the effectiveness of the existing ventilation/mitigation system by assessing the pressure gradient between the indoor air of the school and the sub-slab system. The air inside of the school should consistently have a higher pressure than soils directly beneath foundations, such that any solvent vapors within sub-slab soils or the ventilation/mitigation system are kept away from indoor air and vented to outdoor air. Should testing not clearly demonstrate that such a pressure gradient is present, the school district should upgrade the existing passive sub-slab ventilation/mitigation system to become an active system. Should this active system upgrade occur, then the adjusted system should be subsequently tested to ensure that such a pressure gradient exists.

Studies of vapor intrusion and migration clearly demonstrate that for buildings with a completed vapor intrusion pathway, the sub-slab mitigation systems are very effective at halting the "sub-slab to indoor air" pathway. This is also consistent with many other studies on radon mitigation, and was the basis of DPH previously recommending the installation of such a ventilation/mitigation system during the construction of the Kenosha Brass Community School. The national dataset shows that for buildings with a completed vapor intrusion pathway, the installation of such systems typically results in a decrease of indoor air solvent concentrations between 1,000 to 10,000 times. DPH has also observed similar post-mitigation reductions of indoor air VOC levels at specific vapor intrusion cases in Wisconsin.

Child Health Considerations

In communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults; this means they breathe dust, soil, and vapors close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus adults need as much information as possible to make informed decisions regarding their children's health.

The primary question that DHS was asked to address by this consultation involved the potential for indoor air impacts to the school from vapor intrusion. Physiologically, children are more

highly exposed and dosed to air pollutants than the adult population. Younger children also tend to spend a greater amount of time in the home than do adults who may leave for a significant part of each day to work. Childhood exposures to the contaminants of concern for indoor air at this school would result in similar levels of increased health risk (USEPA 2002). Each of these concerns, combined with concerns about increased exposure periods, are effectively addressed by the measures taken to address the potential for a completed vapor intrusion to the indoor air pathway at the Kenosha Brass Community School.

Conclusions

Based on recent air testing, DPH concludes that the existing sub-slab ventilation/mitigation system at the Kenosha Brass Community school is likely addressing the potential "sub-slab to indoor air" pathway, and vapor intrusion is a "no public health hazard" in the school.

Recommendations

DPH does not recommend conducting indoor air sampling at the Kenosha Brass Community School to evaluate the effectiveness of the ventilation/mitigation system.

DPH does recommend evaluating the effectiveness of the existing ventilation/mitigation system by assessing the pressure gradient between the indoor air of the school and the sub-slab system. If such testing does not demonstrate the clear presence of such a pressure gradient, the school district should upgrade the existing passive sub-slab ventilation/mitigation system to become an active system. Should this active system upgrade occur, then the DPH recommends that this system is tested to ensure that such a pressure gradient exists to ensure the pathway is confidently ruled out.

Public Health Action Plan

DPH has provided guidance to DNR and KUSD on the human health implications of redeveloping the Outokumpu Kenosha properties by preparing a 2005 health consultation on the western portion of the property and a 2007 technical assistance memorandum for the eastern portion, where the Kenosha Brass School was recently constructed.

In 2008, DPH has also provided technical assistance to DNR and KUSD by assessing sub-slab ventilation system and sampling data.

DPH will continue to assist DNR, KUSD and Kenosha County Health Department in responding to community health concerns and questions related to environmental health and redevelopment issues associated with the Outokumpu Kenosha properties.

Preparers of Report

Henry Nehls-Lowe
Epidemiologist
Bureau of Environmental and Occupational Health
Division of Public Health
Wisconsin Department of Health Services

ATSDR Regional Representative
Mark Johnson
Division of Regional Operations, Region V
Agency for Toxic Substances and Disease Registry

ATSDR Technical Project Officer
Jennifer Freed
Cooperative Agreement and Program Evaluation Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

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CERTIFICATION

This Health Consultation for the Kenosha Brass Community School was prepared by the Wisconsin Department of Health Services under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved methodology and procedures existing at the time the Health Consultation was begun. Editorial review was completed by the Cooperative Agreement partner.

Jennifer Freed
Technical Project Officer
CAT, CAPEB, DHAC, ATSDR

The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this Health Consultation and concurs with the findings.

Alan Yarbrough
Team Leader
CAT, CAPEB, DHAC, ATSDR