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March 14, 2013

William Wiley
Air Monitoring Manager
Maricopa County Air Quality Department
Air Monitoring Division
2145 S 11th Ave #170
Phoenix, AZ 85007

Dear Mr. Wiley:

RE: [redacted] Hydrogen Sulfide (H_2S) Preliminary Study: Chronic Health Effects

The Arizona Department of Health Services (ADHS) received your request to conduct a health assessment to determine if the exposure to the measured levels of hydrogen sulfide (H_2S) at the [redacted] could result in any chronic adverse health effects. We received two sets of data from Maricopa County: The first sampling activity was conducted by the URS Corporation (URS) in January 2011, and the second sampling activity was conducted by the Maricopa County Air Quality Department (MCAQD) in February 2013. Both data sets were used in this assessment. The following summarizes our methodology and assessment results.

General Assessment Methodology

ADHS generally follows a three-step methodology to assess public health issues related to environmental exposures. First, ADHS obtains representative environmental data for the site of concern and compiles a comprehensive list of site-related contaminants. Second, ADHS identifies exposure pathways, and then uses health-based comparison values to find those contaminants that do not have a realistic possibility of causing adverse health effects. For the remaining contaminants, ADHS reviews recent scientific studies to determine if exposures are sufficient to impact public health.

Available Environmental Data

From January 23, 2011 to January 29, 2011, URS and VSI Environmental (VSI: a sub-consultant hired by URS) conducted a six-day ambient air monitoring activity at the [redacted] They recorded the ambient H_2S concentrations, wind speed and wind direction. They used a potable Jerome® J605 Hydrogen Sulfide Analyzer (Jerome Meter) to measure the H_2S concentrations. The equipment can measure H_2S concentrations within the following ranges: (1)

0.003 parts per million (ppm) to 0.1 ppm; (2) 0.1 ppm to 1 ppm; (3) 1 ppm to 10 ppm. The auto range is set to record the H_2S concentrations every 5 minutes (i.e. the instrument will automatically switch upward or downward from one operating range to the next adjacent range as the concentration increases or decreases). With this setting, the minimum detection limit is 0.003 ppm (recorded as 0 on the data sheet), and the maximum detection limit is 10 ppm (1 ppm = 1,000 parts per billion, ppb). When the sample concentration exceeds the maximum detection limit of 10 ppm the value will be displayed as "Hi Conc." A total of 22 "Hi Conc" results were recorded in the URS investigation.

From February 11, 2013 to February 15, 2013, MCAQD Air Monitoring Division conducted a five-day ambient air monitoring activity at the [redacted]. MCAQD measured the ambient H_2S concentrations, wind speed and wind direction. MCAQD used a Jerome® J605 Hydrogen Sulfide Analyzer to measure the hydrogen sulfide (H_2S) concentrations with the same settings used by the URS. A total of 15 "Hi Conc" measures were recorded. NOTE: For the purpose of the assessment, ADHS assumed it to be 10 ppm when the data point shows as: Hi Conc. Due to this limitation, the actual extent of potential adverse health effects, if there are any, cannot be fully assessed.

Exposure Pathway Analysis

Identifying exposure pathways is important in a health consultation because adverse health impacts can only happen if people are exposed to contaminants. The presence of a contaminant in the environment does not necessarily mean that people are actually coming into contact with that contaminant. Exposure pathways have been divided into three categories: completed, potential, and eliminated.

There are five elements considered in the evaluation of exposure pathways:

1) a source of contamination
2) a media such as soil or ground water through which the contaminant is transported
3) a point of exposure where people can contact the contaminant
4) a route of exposure by which the contaminant enters or contacts the body
5) a receptor population

Completed pathways exist when all five elements are present and indicate that exposure to a contaminant has occurred in the past and/or is occurring presently. In a potential exposure pathway, one or more elements of the pathway cannot be identified, but it is possible that the element might be present or might have been present. In eliminated pathways, at least one of the five elements is or was missing, and will never be present. Completed and potential pathways, however, may be eliminated when they are unlikely to be significant.

The residents can breathe in H_2S from the ambient air. The resident filed a complaint about foul odors, rotten egg smell on their property. ADHS further evaluated the completed exposure pathways to determine whether realistic exposures are sufficient in magnitude, duration or frequency to result in chronic adverse health effects.

Comparison to Health-based Comparison Values for Ambient Air Samples

The health-based comparison values (CVs) are screening tools used with environmental data relevant to the exposure pathways. The health-based CVs are concentrations of contaminants that the current public health literature suggests are "harmless." These comparison values are quite conservative, because they include ample safety factors that account for the most sensitive

populations. ADHS typically uses comparison values as follows: if a contaminant is never found at levels greater than its CV, ADHS concludes the levels of corresponding contamination are "safe" or "harmless." If, however, a contaminant is found at levels that are greater than its comparison value, ADHS designates the pollutant as a *contaminant of interest* and examines potential human exposures in greater detail.

Comparison values are based on extremely conservative assumptions. Depending on site-specific environmental exposure factors (e.g. duration and amount of exposure) and individual human factors (e.g. personal habits, occupation, and/or overall health), exposure to levels greater than the comparison value may or may not lead to a health effect. Therefore, the comparison values should not be used to predict the occurrence of adverse health effects.

Two health-based comparison values were used in this assessment: intermediate Minimal Risk Level (MRL) and Reference Concentration (RfC). The Agency for Toxic Substances and Disease Registry (ATSDR) developed an intermediate MRL of 0.02 ppm for intermediate-duration (15-364 days) inhalation exposure to hydrogen sulfide. The Environmental Protection Agency (EPA) established an RfC of 0.002 mg/m^3 (0.0014 ppm) for chronic-duration ($\geq$ 365 days) inhalation exposure to hydrogen sulfide. The approximate average H_2S concentration of each air-monitoring event was used to represent the intermediate exposures to hydrogen sulfide. The results were 0.35 ppm and 0.2 ppm for URS samples and MCAQD samples, respectively. For chronic exposure, ADHS assumed that seasonal change has minimum effects on the ambient H_2S concentration, and used all data points to calculate the approximate average concentration (0.29 ppm) to represent the exposure level. Note: the actual values for all calculated average concentrations may be higher because of the assumption mentioned previously. All the calculated values exceeded their respective health-based CVs; therefore, ADHS conducted further analysis to determine if the exposures were sufficient to impact public health.

***Public Health Implications**: This section will provide general toxicological information and site-specific exposure evaluation.*

Hydrogen sulfide has a characteristic rotten-egg odor that is detectable at concentrations as low as 0.5 ppb. Individuals' ability to detect H_2S odor varies. The threshold ranges from 0.5 ppb to 300 ppb. Hydrogen sulfide concentrations range from 0.11 to 0.33 ppb in ambient air. However, individuals may not detect H_2S odor at higher concentrations ($\geq$ 100 ppm) due to damage to olfactory tissue. Higher concentrations (> 90 ppb) are often detected in communities near natural or industrial sources of hydrogen sulfide (ATSDR 2006).

Inhalation is the primary exposure route for hydrogen sulfide exposure. Adverse health effects on respiratory tract and nervous systems are commonly observed among human and animal studies. At very high concentration, H_2S can cause respiratory arrest and/or pulmonary edema. At lower concentration, H_2S is a respiratory irritant. Increased numbers of emergency room visits and individuals with cough and/or nasal symptoms have been reported among people living near an industrial source. In general, significant changes in lung function are not expected when people are exposed to hydrogen sulfide (ATSDR 2006).

ATSDR established an intermediate MRL of 0.02 ppm based on the study conducted by Brenneman et al. (2000). In the study, 12 male rats were exposed to 0, 10, 30 or 80 ppm hydrogen sulfide for 6 hours/day, 7/days/week for 10 weeks. Loss of olfactory neurons and basal cell hyperplasia in the nasal olfactory epithelium (decreased ability of basal cells to regenerate) were observed in rats exposed to 30 ppm or 80 ppm H_2S. No adverse health effects were observed at 10 ppm. The observed adverse health effects were concentration related. The

incidence and severity of the olfactory neuron loss increased with increasing exposure levels; yet, the ability of basal cells to regenerate decreases with increasing exposure levels. In this study, the identified No-Observed-Adverse-Effect-Level (NOAEL) and Lowest-Observed-Adverse-Effect-Level (LOAEL) were 10 ppm and 30 ppm, respectively. The NOAEL was adjusted to obtain a human equivalent concentration (HEC) of 0.46 ppm. The intermediate MRL was established based on the $NOAEL_{HEC}$ and an uncertainty factor of 30 (3 for interspecies extrapolation and 10 for individual variability). EPA used the same study to derive the RfC of 0.014 ppm. The RfC was established based on the $NOAEL_{HEC}$ and an uncertainty factor of 300 (3 for interspecies extrapolation, 10 for sensitive populations, and 10 for using sub chronic exposure) (ATSDR 2006, IRIS 2006).

The calculated exposure concentrations (0.35 and 0.2 ppm for intermediate exposure and 0.29 ppm for chronic exposure) indicated that residents at the [redacted] were exposed to hydrogen sulfide at a constant level on a daily basis. Although these levels were below the $NOAEL_{HEC}$, they are within an order of magnitude of the $NOAEL_{HEL}$ (1.38 ppm). Adverse neurological effects were observed in laboratory animals at a lower concentration (20 ppm) (Hannah and Roth 1991; Skrajnu et al. 1992). In addition, the actual exposure level could be higher due to the assumptions mentioned previously. Taking all factors into consideration; ADHS determined that there is an increased risk of developing adverse health effects in people exposed to the measured levels of hydrogen sulfide over a long period of time.

Based on the findings, ADHS makes the following recommendations to the residents, responsible party and/or Maricopa County Air Quality Division:

1. The residents should consult with their physician to discuss their symptoms.
2. Take immediate steps to help control (prevent or reduce) the release of H_2S from potential emission sources.
3. Monitor the levels of H_2S to verify that the control measures are effective.

If you have any questions, please contact me at (602) 803-3740 or linh@azdhs.gov.

Sincerely,

Hsini Lin, ScD, MSPH
Environmental Toxicologist

References:

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2. Brenneman KA, James RA, Gross EA, et al. 2000. Olfactory neuron loss in adult male CD rats following subchronic inhalation exposure to hydrogen sulfide. Toxicol Pathol 28(2):326-333.
3. Hannah RS, Roth SH. 1991. Chronic exposure to low concentrations of hydrogen sulfide produces abnormal growth in developing cerebellar Purkinje cells. Neurosci Lett 122:225-228.
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