Letter Health Consultation

Asheboro Wastewater Treatment Plant

Asheboro, Randolph County, North Carolina

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Asheboro Wastewater Treatment Facility

Purpose
DPH received a request for assistance from the City of Asheboro. Elevated blood aluminum levels were identified for some employees in the quality control laboratories at the municipal wastewater and (drinking) water treatment facilities. In addition to analyzing samples from the municipal drinking water and waste processes, the facility tests industrial wastes prior to accepting the material at the waste treatment facility. The safety director requested assistance evaluating the employees' biological monitoring data and identifying the source of the exposure. The purpose of the health consultation is to identify potential sources of the exposure.

Background
Biological monitoring of laboratory staff for heavy metals is performed periodically by the city. Routine blood samples were collected on February 8, 2011. Five employees work in the two quality control laboratories. Two of the employees and the lab manager work at the wastewater treatment plant and two employees primarily work at the water treatment facility. Workflow sometimes dictates the employees at the water treatment plant work at the wastewater treatment plant. A total of four employees had elevated aluminum levels. The highest aluminum levels were among employees at the wastewater treatment plant. The last air monitoring performed at the wastewater treatment facility was in 1996.

The wastewater quality control laboratory and the wastewater control room are located in the same brick building but they have separate heating, ventilation, and air conditioning (HVAC) systems. The wastewater quality control laboratory HVAC system was replaced in 2010. It is located on the roof and has a fresh air intake 2 feet above the roof deck on the south side of the unit. The HVAC system for the wastewater control room is located in the center of the facility and has a fresh air intake with a 10 foot snorkel (vertical extension) on the roof.

Method
The investigation was divided into three components: validation of the biological monitoring process, identification of products/work activities, and investigation of building contaminant control systems. Literature reports indicate that aluminum can leach from some vials used to collect blood samples and inflate the aluminum levels in the samples. The collection and laboratory analysis processes were discussed with the city nurse and contract service providers to understand the sample collection process. The sample analysis process was discussed with the manager of the contract laboratory that analyzed the blood samples.

The Safety Director for the City of Asheboro provided material safety data sheets (MSDS) for products that contain aluminum that are used at the facilities. Bulk quantities of aluminum sulfate (alum) are used at the water treatment plant. However, the alum is a solution and not a powder. The use of an alum solution decreases the inhalation risk to employees.
The laboratory quality control (QC) staff was interviewed to obtain a list of specific work activities and dietary patterns that could contribute to elevated aluminum levels. The building ventilation system was also reviewed during the visit to the site. The performance of the laboratory hoods are tested annually by a contractor.

Discussion

Aluminum Health effects

Aluminum is one of the most common naturally occurring metals in soil. Elevated levels of aluminum in the environment can be caused by human activities such as mining and processing of aluminum ores or releases from coal-fired power plants. Work related exposures include activities such as welding or exposures to aluminum dusts.

Unprocessed foods like fresh fruits, vegetables, and meat contain very little aluminum. However, aluminum may be present in tea, flour, baking powder, coloring agents, cosmetics, infant formula, non-dairy creamers, and anti-caking compounds. The average adult in the United States consumes about 7–9 mg of aluminum per day in their food. People are also exposed to aluminum in products such as cosmetics, antiperspirants, antacids, and buffered aspirin [U.S. DHHS].

In general, aluminum is poorly absorbed by the body. However, the absorption rate can be increased by citrates present in juices and antacids. Some data suggests aluminum absorption can be enhanced by vitamin D. Studies indicate that approximately 60% of the aluminum body burden is in the bone, 25% in the lung, 10% in muscle, 3% the liver, and 1% in the brain [Krewski].

There is limited information on potential health effects related to ingestion of aluminum by humans. Studies of patients with reduced kidney function indicated that aluminum is an important factor in dialysis-related health disorders. There are also reports of skeletal changes in healthy adults and children that are associated with long-term ingestion of antacids.

Occupational and animal inhalation studies suggest that the lungs and nervous system are the organs most likely affected by breathing aluminum. Studies of welders and workers exposed to aluminum dusts produced some evidence that chronic inhalation of aluminum may cause asthma. Studies examining the potential association between neurological symptoms and aluminum exposure produced mixed results. Two case-control studies did not find a significant association between occupational exposure to aluminum dust or fumes and the risk of Alzheimer's disease. Another study of former aluminum dust-exposed workers found some impairment in tests of cognitive function [ATSDR Aluminum].

A number of animal studies focused on the impact of aluminum exposure to the nervous system. Behavioral tests conducted in rats and mice identified a decrease in limb grip strength and a decrease in thermal sensitivity. Changes in body weight were also observed in animal studies. There was also evidence that aluminum exposure in pregnant females resulted in developmental effects (low body weight) of the offspring.

Building systems

The quality control laboratory space includes an office, storage room, and open area with hoods and benches. The laboratory has six fume hoods and two canopy hoods that are operated on the tasks performed. The hood performance is evaluated annually by a vendor. The hoods exceeded the minimum performance recommendations. The fume hood on the northwest corner is used for cyanide testing and a hood located on the east side is used for Total Kjeldahl Nitrogen (TKN) tests.

The atomic absorption spectrophotometer (AAS) is located in a separate room on the south east side of the building and has a dedicated exhaust hood. The ductwork extends through the ceiling to a fan on the roof. Make-up air is provided to the hoods.

The AAS exhaust stack extended approximately 18 inches above the roof deck and was equipped with a weather cap. It is approximately 10 feet (horizontal) away from the air intake of the HVAC system. All of the hood exhaust stacks had inadequate stack height and were not properly configured. The exhaust stacks for other hoods were horizontal to the roof deck, pointed downward toward the roof deck, or equipped with weather caps.

The exhaust system design flaws allow contaminants to pool on the roof deck and re-enter the building through fresh air intakes. Depending on the wind conditions, the design flaws will also allow contaminants to pool at the ground because the exhaust does not exit the building envelope. Visible damage to the roof deck is also evident from the acids present in the Total Kjeldahl Nitrogen (TKN) fume hood exhaust. Smoke testing of the atomic absorption spectrophotometer exhaust system and fume hoods confirmed the pooling of air on the roof deck and recirculation into the building HVAC system.

Biological monitoring

A physician from the N.C. Division of Public Health was contacted regarding the February 2011 blood samples of the four employees with elevated aluminum levels. The physician recommended the city perform 24 hour urine tests to confirm the aluminum levels. Urine samples are thought to reflect more recent exposures while blood samples reflect the aluminum body burden and more long term exposures [Krewski]. Approximately 90% of the aluminum excreted in urine occurs within 48 hours of exposure [Zeager].

Discussions with the nurse who collected the blood samples and the contract laboratory manager confirmed that certified metal-free vials were used in the blood collection process. The contract laboratory manager also reviewed the sample analysis data and calculations. The laboratory manager confirmed the accuracy of the February 8, 2011 sample results.

The aluminum levels (24-hour urine) were elevated in one of the employees' follow up (May 2011) samples. However, 3 employees had elevated aluminum levels in samples collected in January 2012. The final changes in the laboratory hood exhaust stacks were instituted in July 2012. The biological monitoring results are summarized in Table 1.

It is important to note there are no health based aluminum bio-monitoring guidelines. There is no adequate data to correlate aluminum exposures to aluminum levels in blood or urine because aluminum is poorly absorbed by the body [Zeager]. The laboratory reference ranges are based on what is considered a normal range and can vary between laboratories. In addition, the National Health and Nutrition Examination Survey (NHANES) did not include aluminum. Therefore, we do not have national average background aluminum blood or urine results for comparison.

Table 1: City of Asheboro Laboratory Staff Aluminum Bio-monitoring Data

Date	Type Test	Employees		Range Reported	Reference Range
		Elevated	Tested		
Mar 11, 2008	Blood	1	4	ND[1] – 21 µg/L[2]	0 to 9 µg/L
Feb 6, 2009	Blood	0	5	3 – 8 µg/L	0 to 9 µg/L
Feb 8, 2011	Blood	4	4	19 – 24 µg/L	0 to 9 µg/L
May 5, 2011	24 hr. urine	1	5	14 - 169 µg[3]	0 to 32 µg
Jan 27, 2012	24 hr. urine	3	5	16 - 78 µg	0 to 32 µg
Jan 17, 2013	24 hr. urine	0	4	8 – 26 µg	0 to 32 µg
July 24, 2013	24 hr. urine	3	5	7 – 89 µg	0 to 32 µg
Sept 5, 2013	Blood	0	3	5 - 8 µg/L	0 to 9 µg/L
Nov 4, 2013	24 hr. urine	0	4	9 - 11 µg	0 to 32 µg

[1] Not Detected
[2] Micrograms per liter of blood
[3] Micrograms per 24 hours

µg/L = Micrograms per liter
µg = Micrograms

Air monitoring results

A consultant hired by the City of Asheboro performed personal air sampling for laboratory staff in November 2012. Changes in the ventilation system configuration and stack exhaust velocity that were recommended by DPH staff were implemented prior to the air monitoring. The activities performed by laboratory staff are detailed in Table 2. The personal air monitoring aluminum concentrations were less than recommended occupational exposure guidelines.

Table 2: City of Asheboro Laboratory Staff Aluminum Air Monitoring Results

Employee	Staff's Laboratory Activities	Aluminum Concentration	Guidelines	
			TLV[1]	RfC RSL[2]
# 1	Solids, chlorine, TKN, ammonia	< 1 µg/m^3	1000 µg/m^3	5 µg/m^3
# 2	Office work	< 1 µg/m^3	1000 µg/m^3	5 µg/m^3
# 3	Metal digestion and atomic absorption	< 1 µg/m^3	1000 µg/m^3	5 µg/m^3

[1] Threshold Limit Value, American Conference of Governmental Industrial Hygienists (ACGIH)
[2] Reference Concentration, U.S. Environmental Protection Agency (EPA) Regional Screening Level Industrial Exposures
µg/m^3 = Micrograms per cubic meter

Drinking Water Samples

Drinking water samples were collected from the drinking water fountain and the sink used to fill the coffee pot. The purpose of the sampling was to eliminate drinking water as a source of aluminum exposure. The aluminum levels were significantly below the Agency for Toxic Substances and Disease Registry's (ATSDR) health-based comparison values for adults. There is no federally regulated level of aluminum in drinking water. EPA has a secondary standard for aluminum in drinking water. Secondary standards are not health based and are set to give public water systems some guidance on removing these chemicals to levels that are below what most people will find to be noticeable because of color, smell, or taste. The aluminum secondary standard is based on color changes to the water. The aluminum levels were within the EPA guidelines.

Table 3: Drinking Water Results

Location	Aluminum Concentration	EPA MCL[1]	ATSDR EMEG[2]
Water fountain	56.8 µg/L	50 -200 µg/L	35,000 µg/L
Laboratory Sink	47.9 1 µg/L	50-200 µg/L	35,000 µg/L

[1] EPA Maximum Contaminant Level Secondary Standard
[2] ATSDR Chronic Environmental Media Evaluation Guide
µg/L = Micrograms per Liter

Conclusions

The fume hood and atomic absorption spectrophotometer exhaust system configurations and low exhaust velocities allowed the contaminants to pool on the roof deck. This created a path for the recirculation of contaminants into the building through the HVAC system and under some conditions a path for exposure of people on the ground. Smoke tests confirmed the recirculation of hood exhaust into the building HVAC system.

Aluminum is a common substance that is present in soil, food, cosmetics, and medications. Therefore, personal habits can contribute to aluminum levels in the blood and urine.

We do not know all of the sources of the aluminum exposure. Elevated aluminum levels occurred in one set of biological samples collected after the flaws with the laboratory hood exhaust system were corrected. Information was provided on specific sources of aluminum in foods, medications, and personal care products. The staff tried to minimize or eliminate the use of these products. Elevated aluminum was not detected in the next 2 sets of biological samples. It is possible that consumer products containing aluminum may have contributed to employee exposure or accidental contamination of the 24 hour urine samples.

The air sampling performed after changes to the laboratory hood exhaust ventilation system did not detect aluminum levels above exposure guidelines. Drinking water samples collected in the building were also below recommended guidelines. The staff wore gloves during the preparation and testing process. Dermal contact or subsequent ingestion from hand to mouth activities were not observed.

Recommendations

DPH staff offered several recommendations during the course of the investigation. The City of Asheboro implemented the recommendations during the investigation. The recommendations included:

- Perform 24-hour urine tests for QC laboratory personnel and track specific tasks performed by the staff in the week preceding biological monitoring.

- Remove weather caps, increase exhaust stack height to a minimum of 10 feet, and increase exhaust air velocity to at least 2500 feet per minute.
- Perform air monitoring of personnel performing atomic adsorption analysis.
- Review non-occupational sources of aluminum exposure (food, medicine, and cosmetics) with staff.

Additional recommendations are to:
- Repeat the 24-hour urine tests annually.
- Evaluate laboratory exhaust systems in other city facilities to confirm the exhaust systems are appropriately configured.

References

[ATSDR Aluminum]. Agency for Toxic Substances and Disease Registry, *Toxicological Profile for Aluminum*, U.S. Department of Health and Human Services, September 2008. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=191&tid=34

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[ESP Air monitoring] Environmental Safety Professionals, Asheboro Wastewater Plant Air Quality Test, November 2012

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[U.S. EPA]. Environmental Protection Agency, Secondary Drinking Water Regulations Guidance for Nuisance Chemicals. http://water.epa.gov/drink/contaminants/secondarystandards.cfm

[Zeager]. Wide Variation in Reference Values for Aluminum Levels in Children, Journal of American Academy of Pediatrics, Dec 2011. http://pediatrics.aappublications.org/content/early/2011/11/30/peds.2010-3481

Attachment A: Photographs

Figure 1: Smoke test of Atomic Absorption Spectrophotometer (AAS) Hood

Note: Photograph was after modifications were completed.

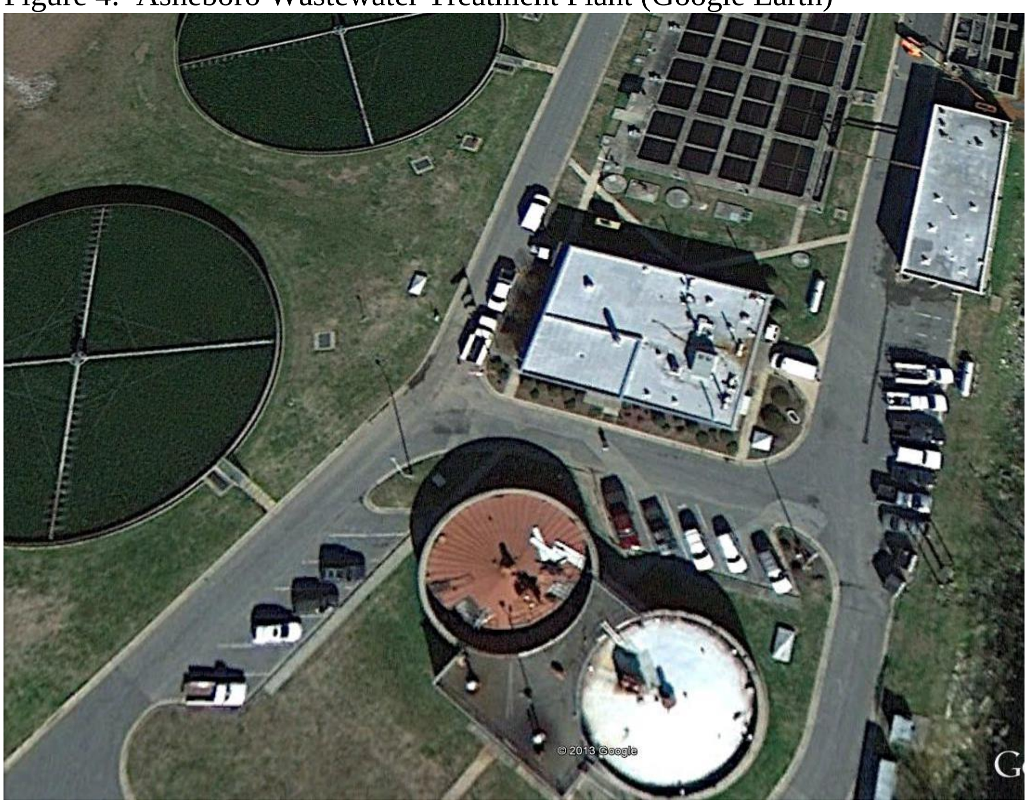
Figure 2: Exhaust from Atomic Absorption Spectrophotometer (AAS) Hood

Note: Photograph was after modifications were completed.

Figure 3: Exhaust from Total Kjeldahl Nitrogen (TKN) Exhaust Stack

Note: Photograph was after modifications were completed

Figure 4: Asheboro Wastewater Treatment Plant (Google Earth)



Attachment B: Common Aluminum Sources

Food

- Tea
- Flour
- Baking powder
- Coloring agents
- Non-dairy creamers
- Anti-caking compounds
- Microwave popcorn

Products

- Cosmetics
- Antacids
- Antidiarrheal medications
- Anti-ulcer medication
- Buffered aspirin
- First aid antibiotic/antiseptic products
- Sunscreens
- Creams (moisturizers, foundation, eye liner, synthetic tan)
- Paints
- Hair spray
- Cleaners (soft scrub cleanser, etc.)
- Cigarettes

Other sources

- Aluminum pots and pans
- Abrasives

Enhance Aluminum Absorption

- Citric acid
- Vitamin D
- Calcium citrate (calcium supplement)