Ambient Air Quality Monitoring

R. L. Pope – Tennessee Valley Authority, Kingston Ash Recovery Project, Kingston, TN
B. Smith, P.G. – Environmental Standards, Inc., Kingston, TN

Abstract

Immediately following the fly ash release, TVA personnel and contractors began assessing potential impacts of the spill and the response efforts on local ambient air quality. TVA's air monitoring contractor began monitoring on December 28, 2008, using hand-held instruments that instantly measured the concentrations of inhalable (≤ 10-micron) particulate matter (PM10) in the ambient air. The contractor also began sampling at four fixed-base locations using sampling methods that collect PM10 on filter cassettes. The filters were analyzed for 21 metals, identified as Constituents of Potential Concern (COPCs) based on available analyses of bulk ash samples. The filters were also examined for silica quartz. Based on toxicity of the different COPCs, only eight metals were selected for reporting. Within a few days, the sampling network was refined to five fixed-base locations around the perimeter of the site

In summer, 2010, TVA transitioned to continuous ambient air monitoring instrumentation to replace low volume Federal Reference Method PM2.5 samplers that had been operated on a one-in-three or one-in-six day schedules. An existing Tapered Element Oscillating Microbalance (TEOM) was reconfigured to measure PM10. The continuous monitoring instruments more directly address data quality objectives of providing real-time feedback to dust control activities and eliminating process failure opportunities related to sample shipping and laboratory handling and analyses. Graphical presentation of raw data from the continuous PM2.5 and PM10 instrumentation is immediately available as feedback for dust-control measures during the remediation.

Air monitoring associated with the KIF ash release continues to confirm that the national ambient air quality standards for PM_{10} and $PM_{2.5}$ are being met and the action levels identified in the AAMP are not being exceeded.

Introduction

On December 22, 2008, the retaining wall broke on a fly ash retention pond at the Tennessee Valley Authority (TVA) Kingston Fossil Plant (KIF) in Kingston, Tennessee. TVA took immediate steps to collect air samples to monitor and assess ambient air quality in the immediate area. The concern was that as a result of the spill and during the remediation, fly ash would become airborne and transported off-site. The potential for re-suspension of inhalable and respirable fly ash particles by strong winds was (and continues to be) the greatest concern. A *Site Dust Control and Air Monitoring Plan* was developed and implemented under the EPA Consent Order. The primary objective of the monitoring outlined in the Ambient Air Monitoring Plan (AAMP) is to provide operational information for site dust-control measures during the remediation efforts by measuring airborne particulates at the site perimeter.

EPA has established National Ambient Air Quality Standards (NAAQS) that define levels of air quality to protect the public health. The NAAQS, Federal Reference Methods (FRM), and Federal Equivalent Methods (FEM) were used in the development of the AAMP in the sense that they are Applicable, Relevant, and Appropriate Requirements (ARAR) for the project. The monitoring at the site perimeter is conducted such that the results are relevant to the NAAQS. Action levels for Constituents of Potential Concern (COPCs) were developed using the NAAQS, TDEC permitting criteria or information reported by the Agency for Toxic Substances and Disease Registry (ATSDR, 2007).

TVA's air monitoring program at KIF has undergone several changes as the needs of the program have changed and the effectiveness of the KIF dust suppression program has been demonstrated.

Routine third-party oversight and periodic audits by regulatory agencies ensure the validity of the data collected.

Methods and Materials

- Metals in air
  - Total Suspended Particulates--conforms to 40CFR50, Appendix B requirements
  - PM10--conforms to 40CFR50, Appendix J
  - Quartz fiber filters analysis-- by Compendium Method IO-3.5 (ICP/MS)
- FRM particulate matter
  - PM2.5--conforms to 40CFR50, Appendix L
  - PM10--conforms to 40CFR50, Appendix K
- FEM particulate matter
  - PM-10--determined by Thermo, Inc., Tapered Element Oscillating Microbalance (EQPM-1090-079)
  - PM-2.5--determined by MetOne Instruments BAM 1020 (EQPM-0308-170)
  - Crystalline Silica Quartz--determined according to NIOSH 7500

Sampling Locations and Equipment

Five sampling locations follow EPA siting criteria for ambient particulate monitors to the extent possible. US EPA and Tennessee Department of Environment and Conservation (TDEC) evaluations have determined that the monitors are appropriately positioned.

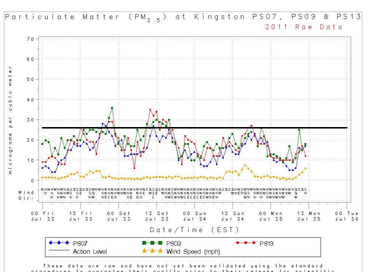
Considerations:

- Proximity to roads, proximity to tree obstructions, and vertical distance from nearby horizontal structures
- Proximal to the released fly ash, and at locations between the release and the community
- Prevailing wind direction: strongly influenced by ridge and valley topography oriented along the southwest to northeast axis of the Tennessee River Valley.

Three monitoring locations (PS07, PS09, PS13) are located roughly along the southwest to northeast axis so that "upwind" and "downwind" air sampling exist for most days. Two sampling sites (PS05 and PS08) are located on a line roughly perpendicular to the prevailing wind direction.

The locations provide for the assessment of before/after air quality as wind moves across the site. Graphical presentation of raw data from the continuous PM2.5 and PM10 instrumentation is immediately available as feedback for dust-control measures during the remediation efforts.

Particulate Monitoring Station



Dust Management

Air Monitoring Instrument Summary

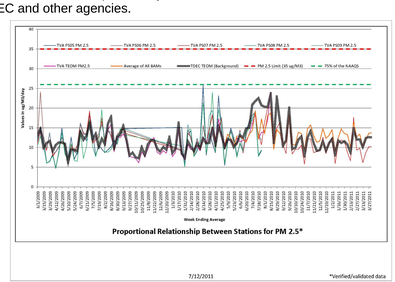
Site	Instrument	Measurement	Schedule
PS05	Met One BAM 1020	PM2.5	Continuous
PS07	Met One BAM 1020 Thermo TEOM (TDEC) Tisch HiVol Tisch HiVol Tisch HiVol Tisch HiVol SKC 224-PCXR8 BGI PQ200 Meteorological Instruments	PM2.5 PM10 PM10 Metals PM10 (Audit) Metals TSP Metals TSP(Audit) Metals Silica Quartz PM2.5 Weather data	Continuous Continuous One in Three Day One in Three Day One in Three Day One in Three Day One in Three Day One in Three Day Continuous
PS08	Met One BAM 1020	PM2.5	Continuous
PS09	Met One BAM 1020	PM2.5	Continuous
PS10	Thermo TEOM (TDEC) Meteorological Instruments	PM2.5 Weather Data	Continuous Continuous
PS13	Met One BAM 1020	PM2.5	Continuous

TDEC operates a fixed-monitoring site (former site PS10) in Harriman, Tennessee, approximately 2.5 miles (4.5 km) northwest from KIF. The site is on the opposite side of the northern ridge bounding the KIF plant site. As such, it is an appropriate location for background monitoring. PS10 represents typical upwind air quality conditions nearby, but not impacted by the ash release.

Results

Particulate Matter

As TVA transitioned to the use of continuous PM2.5 monitoring instruments in 2010, TVA conducted a correlation study between the continuous FEM and the existing FRM. The study showed that the BAM1020 is consistently biased approximately 2 $\mu g/m^3$ higher than the FRM at the conditions found at PS07. Recognizing this bias, measurements of PM2.5 and PM10 at the site perimeter have mirrored the background site at Harriman operated by TDEC and have been consistent with other regional sites operated by TDEC and other agencies.



Particulate Matter Plot

Metals

The original Ambient Air Monitoring Plan (AAMP) presented technical justifications to limit analysis of filter-based samples to arsenic, thallium, and silica. As better bulk ash data became available, thallium was removed from the list. Ten other metals were later added to duplicate and substantiate TDEC's sampling and analysis of total suspended. The complete list of analytes is as follows:

Aluminum	Crystalline Silica
Arsenic	Lead
Barium	Manganese
Beryllium	Selenium
Cadmium	Thallium
Chromium	Vanadium

Summary Statistics for TVA Air Data

Analyte	Unit	Minimum Detected Result	Maximum Detected Result	Average Detected Result	Frequency of Detect
Aluminum	ug/m3	0.0229	0.67	0.133684076	157/243
Arsenic	ug/m3	0.000032	0.0079	0.001110450	369/935
Barium	ug/m3	0.0022	0.0422	0.007225083	120/243
Beryllium	ug/m3	0.0000043	0.00028	0.000050619	37/243
Cadmium	ug/m3	0.000018	0.00062	0.000112703	176/243
Chromium	ug/m3	0.00105	0.00297	0.002224286	7/243
Lead	ug/m3	0.000709	0.00768	0.002808911	235/243
Manganese	ug/m3	0.0014	0.019	0.005263287	216/243
Selenium	ug/m3	0.00029	0.00397	0.001154415	118/243
Thallium	ug/m3	0.000005	0.00019	0.000077285	34/420
Vanadium	ug/m3	0.0000088	0.0052	0.001487589	37/235

- Four constituents detected in TVA ash samples had maximum concentrations that exceeded the range of concentrations reported for soils in the region or in Tennessee (TDEC 2001):

  · Barium
  · Beryllium
  · Thallium
  · Vanadium

  The maximum detected concentrations of these constituents were compared to the most recent version of the US EPA regional residential RBSL for residential soil (US EPA 2010). A target cancer risk level of 1.0E-06 was used as a screening level for carcinogens; a target Hazard Index of 1 was used as a screening level for non-carcinogens. None of these concentrations exceed the RBSL.

- Concentrations of arsenic reported in TVA ash samples are within the range of concentrations reported for regional soil (TDEC 2001); however, maximum detected concentrations of arsenic exceed the RBSL for residential soil. The average arsenic concentration reported for regional soil is 19.3 mg/kg, which also exceeds this RBSL.
- Chromium concentrations reported in TVA ash samples are also within the range of concentrations reported for regional soil (TDEC 2001). The maximum detected concentration of total chromium was 66 mg/kg, which is well below the residential soil RBSL of 120,000 mg/kg for Cr(III). Chromium speciation studies of fly ash indicate that the predominant form is trivalent chromium and that whatever trace amounts of Cr(VI) that be found in coal combustion products are sparingly soluble forms (*e.g.,* $PbCrO_4$ or $BaCrO_4$) and biologically unavailable, as it is fused in aluminosilicate glass (Stam 2011).
- TVA did not analyze for crystalline silica in coal ash; accordingly, the comparison to soil concentrations cannot be made. There is no residential soil RBSL for silica.

Comparison of TVA Air Data to Air Screening Levels

Arsenic was detected in approximately 42 percent of air samples, total chromium was detected in approximately 2 percent of samples, and silica was only detected in 1 out of 291 samples.

The US EPA Mid-Atlantic Risk Assessment web-site (http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search) was used to calculate RBSLs for metals in air assuming a 5-year exposure duration (5 years is the estimated duration of the KIF Ash Recovery Project).

Analyte	Screening Level[1]	Maximum	Results	Number of
Arsenic, Inorganic	3.40E-03 ca**	7.90E-03	8	447
Chromium(III),Insoluble Salts	NA	2.79E-03	NA	116
Chromium(VI)	1.67E-05 ca	2.79E-03	2	116
Silica (crystalline, respirable)	3.13E+00 nc	2.00E+00	0	291

1 = Screening levels are based on a 5-year exposure duration.
NA = Not Applicable. Toxicity values for the inhalation pathway are not available for the constituent.
nc = Screening level is based on a non-cancer effect
ca = Screening level is based on 10^{-6} target cancer risk.
** Screening level based on non-cancer effect is less than 10-times the cancer-based screening level.

Conclusions

- Air monitoring associated with the KIF ash release continues to confirm that the national ambient air quality standards for PM_{10} and $PM_{2.5}$ are being met and the action levels identified in the AAMP are not being exceeded.
- Action levels for arsenic and silica specified in the AAMP have never been exceeded.
- Eight of the 12 metals [including arsenic and Cr(VI)] had concentrations in coal ash within the ranges found in naturally occurring local soils, and therefore, cannot be distinguished from background.
- The concentrations in ash of the four other metals above the ranges found in local soils are all below their respective soil RBSLs.
- Monitored concentrations in air for 10 of the 12 metals and silica are either below their respective air RBSLs at the 10^{-6} cancer risk level, or there was no respective air RBSL.
- Arsenic and projected Cr(VI) concentrations as compared to their RBSLs for air only exceeded their respective RBSLs infrequently and do not pose a risk to human health; those detected concentrations cannot be distinguished from background. Cr(VI) is not biologically available in coal combustion products.

Acknowledgements

The authors recognize the support of their colleagues in the following organizations whose efforts are summarized in this poster. Special thanks go to:

- TVA Environment and Technology
- Environmental Standards, Inc.
- Jacobs Engineering, Inc.

References

- Hazardous Trace Elements in Tennessee Soils and Other Regolith, Tennessee Department of Environment and Conservation Division of Geology Report of Investigations No. 49 2001.
- United States Environmental Protection Agency Regions 3, 6, and 9. 2010. Regional Screening Levels for Chemical Contaminants at Superfund Sites. (www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm)
- Chromium Speciation in Coal and Biomass Co-Combustion Products. Arthur F. Stam, Ruud Meij, Henk te Winkel, Ronald J. van Eijk, Frank E. Huggins, Gerrit Brem. *Environmental Science & Technology,* 2011, *45* (6), 2450-2456.