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FGD Wastewater Treatment Evaluation

Paul Chu

EPRI

650 855 2362

pchu@epri.com

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Proposed EPA Numeric Limits (April 2013)

FGD ELG Limits by Technology Option		Daily Maximum	Monthly Average
Chemical Precipitation + Biological			
Arsenic	µg/L	8	6
Mercury	ng/L	242	119 *
Selenium	µg/L	16	10
Nitrate/Nitrite	mg/L	0.17	0.13

ORSANCO, others considering a 12 ppt discharge limit

Effluent Guidelines is an internal limit of 119 ppt

Treatment Strategy: Putting the Puzzle Together

- Selenium, nitrate drive “core” selection
  1. Biological
  2. Zero valent iron (ZVI), others phys/chem approaches?
  3. ZLD: thermal, flue gas based
- Mercury, arsenic
  - Possibly achieve with “core” technology
  - Add polishing technology, if necessary

R&D Needs, i.e. Technology Gaps
Cost-Effective, Reliable Technologies

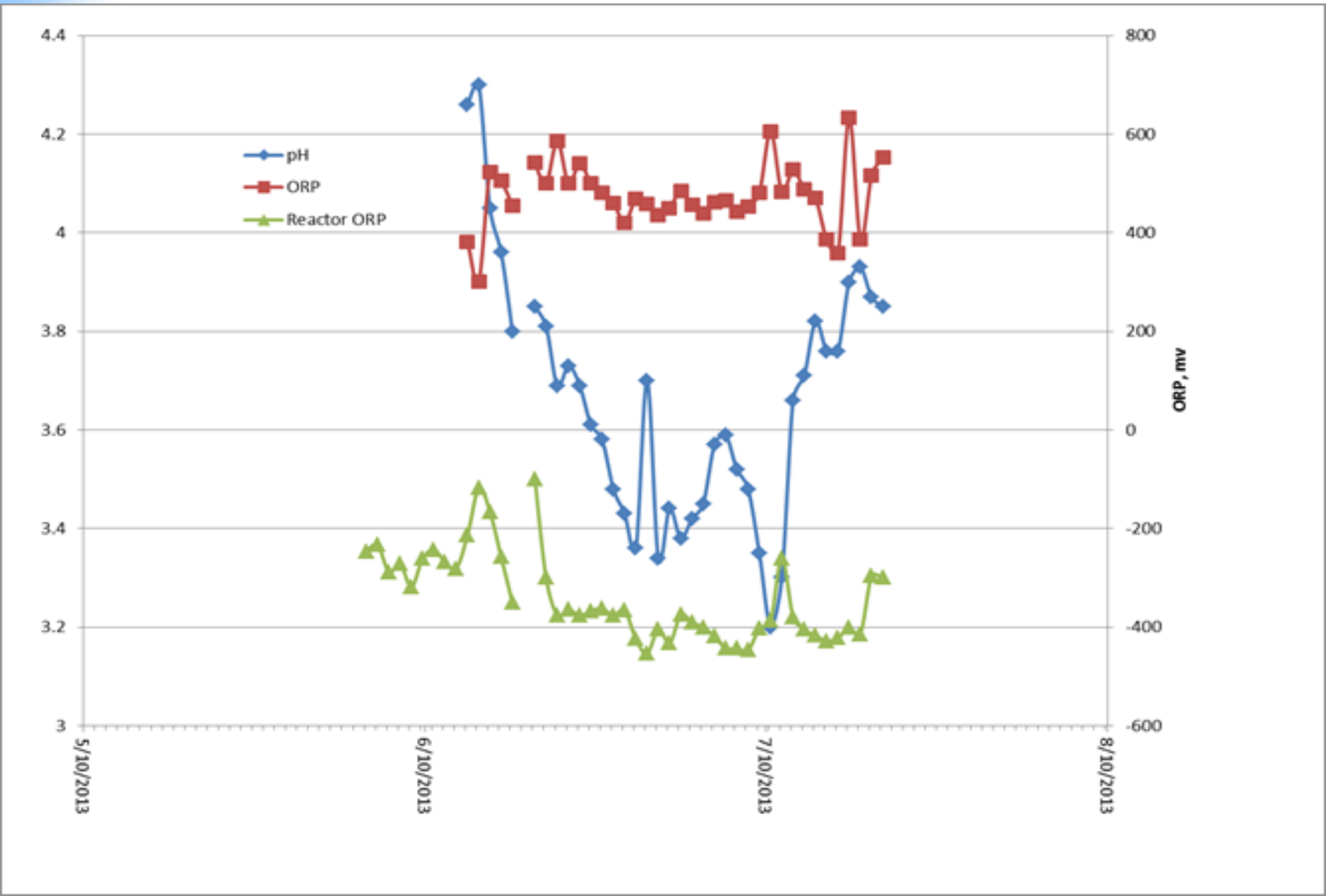
- Selenium
  - Treatment of selenate and “other” Se compounds
- Nitrate/nitrite
  - Will current biological systems, ZVI meet limits?
- Mercury
  - Evaluate various polishing adsorption media
- Arsenic
  - Optimize current phys/chem systems
  - Evaluate adsorption media developed in drinking water applications on FGD water

Independent Evaluation of Treatment Technologies

Selenium, Nitrate/Nitrite Biological Treatment

- Several commercial biological treatment systems
  - Much of the Duke data less than 10 ppb
- EPRI R&D: Evaluate alternative bioreactors, applied in non-power applications
- Ongoing pilots at eastern bituminous power plant
  - Membrane bioreactor (MBR)
  - Fluidized bed reactor (FBR)
- Manage untreated FGD water chemistry i.e. ORP, pH
  - Concerns with coal switching, load swings
- Vertical flow wetlands
  - Several pilot completed; 2 full-scale evaluations

FGD Water Variability Requires “Management”



"Other" Selenium Compounds
Treatability Concern; Vertical Flow Wetland Study

	Se^{+4}	Se^{+6}	Other Measured Se	Total Dissolved Se	Sum of Se Species	Unaccounted Se
Influent	1730	154	39	1990	1923	67
Effluent	9	ND	10	94	19	75

- What are these compounds, possibly:
  - Se-S
  - Se-organic
  - Se-N
  - Se-halide
- Planned lab studies to evaluate converting these Se compounds to more treatable forms

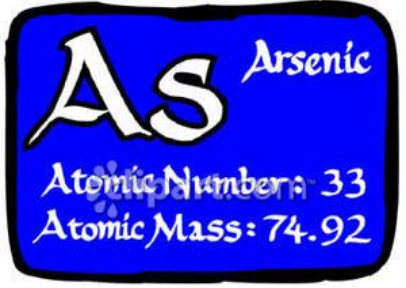
Selenium, Nitrate/Nitrite
Zero Valent Iron (ZVI)

- Two 1-gpm pilots completed
  - Generally met selenium, mercury, arsenic, nitrate targets
  - “Other” selenium compounds: potential concern at 1 site
- Promising results warrant more studies on more FGD waters; every FGD water may be different
  - Planned 1-gpm pilot at eastern bituminous site, parallel with pilot bioreactors
  - Planned 50-gpm demo at Water Research Center (WRC)

Mercury Summary

- Reminder: Effluent Guidelines set internal limits; some regions/states considering more stringent discharge limits
- Strategy: Evaluate polishing treatment i.e. adsorption media
- EPRI working with technology vendors to conduct lab screening studies for mercury (and other trace elements)
  - Various adsorption media, “designer” compounds show promise for further evaluation
- Planned pilot studies beginning this Fall

Arsenic Summary



- Will conventional phys/chem (lime desaturation plus ferric coprecipitation) achieve 6 and 8 ppb limits?
  - Field studies to characterize speciation, total vs dissolved
  - Planned lab studies to evaluate ideal pH
- Arsenic speciation: +3 vs +5, both may be present
  - Most technologies (e.g. ferric) preferentially treat +5
  - +3 can easily be oxidized to +5, i.e., with Cl
- Will traditional arsenic media from groundwater/drinking applications extrapolate to FGD water?
  - GFO (granular ferric oxide)
  - GFH (granular ferric hydroxide)

Additional Planned Pilot Field Studies
Encourage interested companies to participate

- Conduct additional pilot studies of promising approaches for these target pollutants
  - Evaluate mercury, selenium, possibly arsenic
- AEP Amos: ~ 6 months of pilot tests
  - 2 phases: upfront screening followed by longer-term testing
  - Target start date ~October ’13
- 2nd FGD site (TBD)
  - Target start data ~March ’14

FGD Water Chemistry Will Likely Vary
More Studies on More FGD Waters

Summary:
Our Current Path Forward

- More stringent limits are almost here
- Treatment performance could be very site-specific
  - Need more studies on more FGD waters
- Selenium/Nitrate
  - Biological: pilot studies of promising technologies
  - ZVI: 2 pilots completed; 2 more studies planned
- Mercury: planning pilot studies in Fall
- Arsenic: conducting lab evaluations with FGD

Collaborative Effort with Interested Companies

Together…Shaping the Future of Electricity