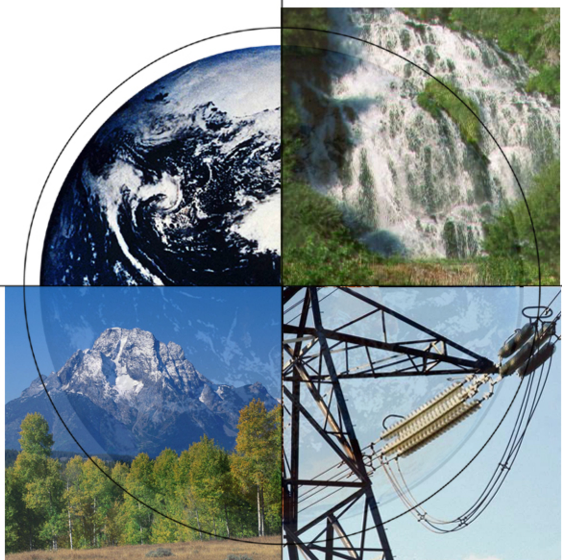
NETL In-House Characterization of Mercury in Coal Combustion By-Products



Karl Schroeder

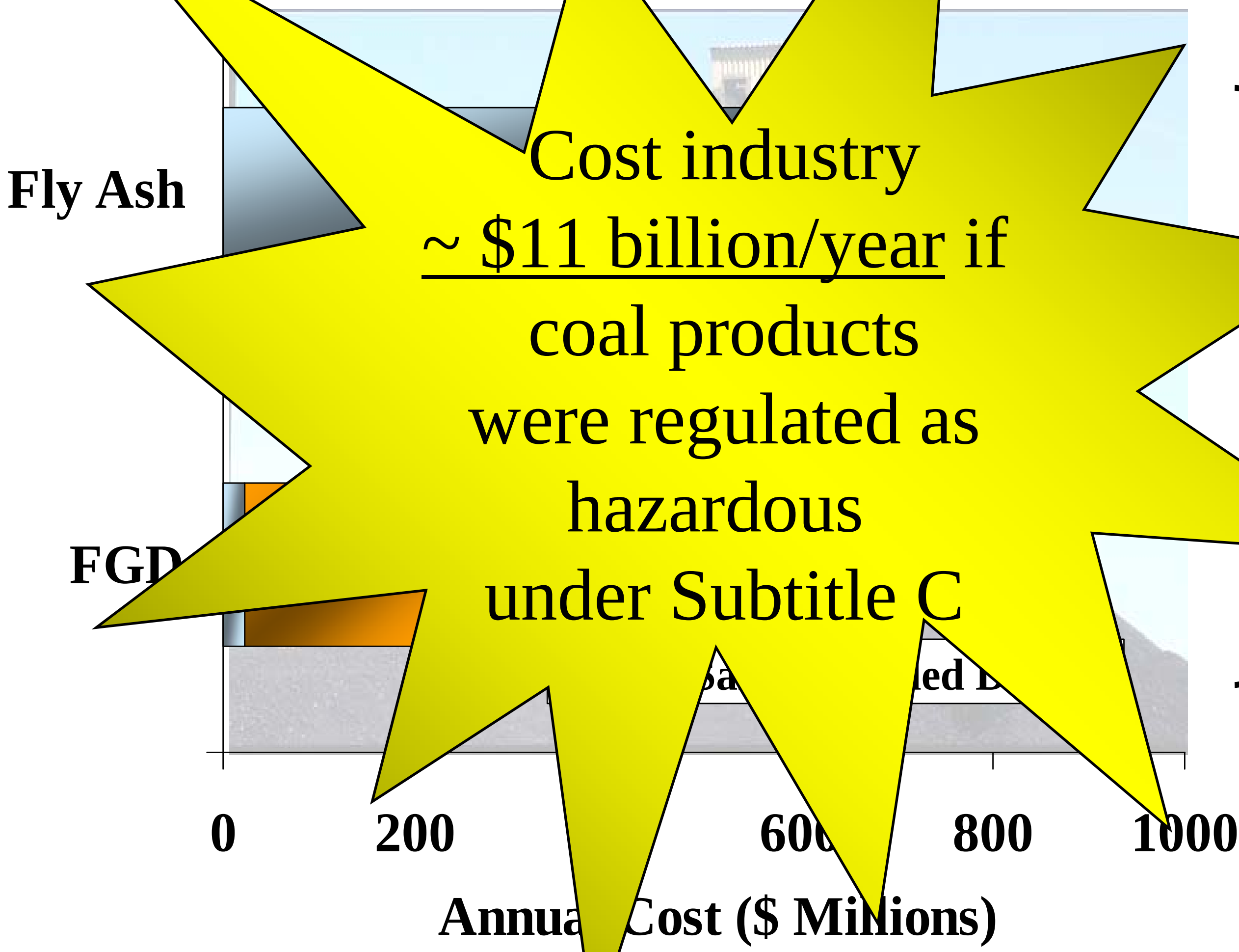
Carol Cardone
Peter Hesbach
Candace Kairies
George Kazonich
Ann Kim

Session: Byproduct Characterization/ Management

Mercury Control Technology R&D Program Review

July 14, 2005

Potential Impact of Regulations on Coal Product



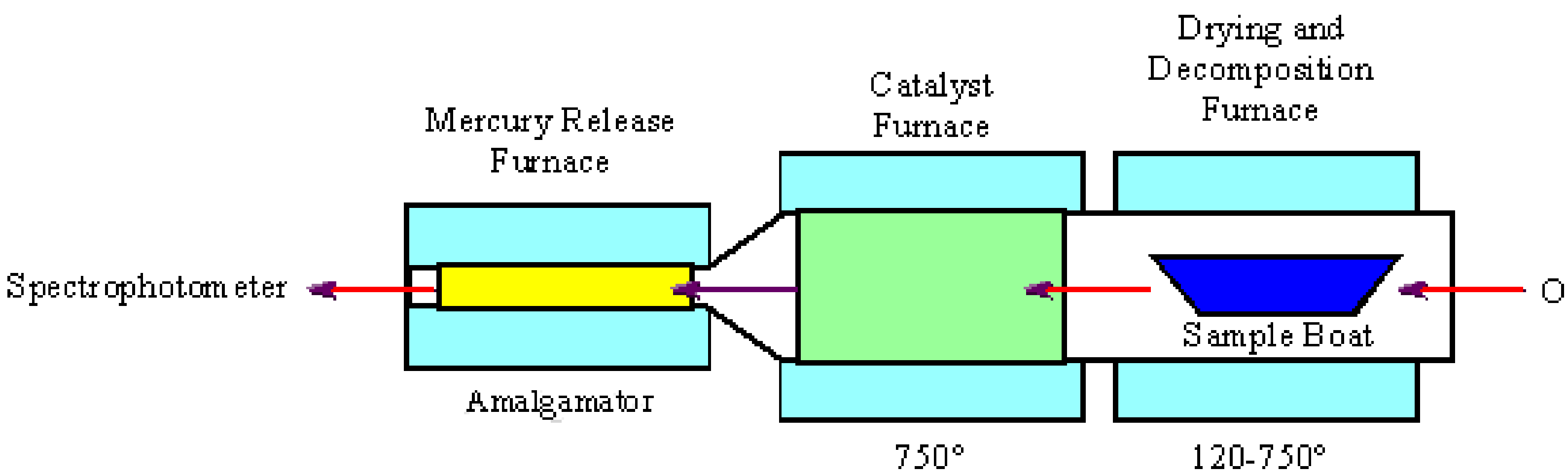
Cost industry
<u>~ $11 billion/year</u> if
coal products
were regulated as
hazardous
under Subtitle C

Total cost impact of lost sales and added disposal requirements

Hg Analysis

Techniques

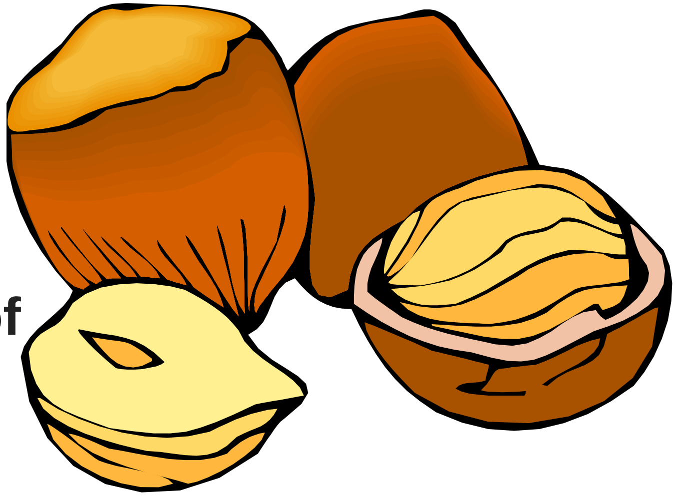
- Solids via Milestone DMA-80
- Leachate via CVAA (DL = 1 ng/L = 1 ppt)



DMA-80 Mercury Analyzer

In a Nut Shell

1. **FLY ASH - Comparison of leaching methods for a single bituminous ash**
   - complex leaching chemistry
   - 5 batch leaching methods + long term column leaching



2. **FGD GYPSUM - Continuous leaching of FGD-derived gypsum and wallboard**
   - no mercury in leachate
   - retention due to unidentified iron-containing phase

1

Comparison of leaching methods for a single ash

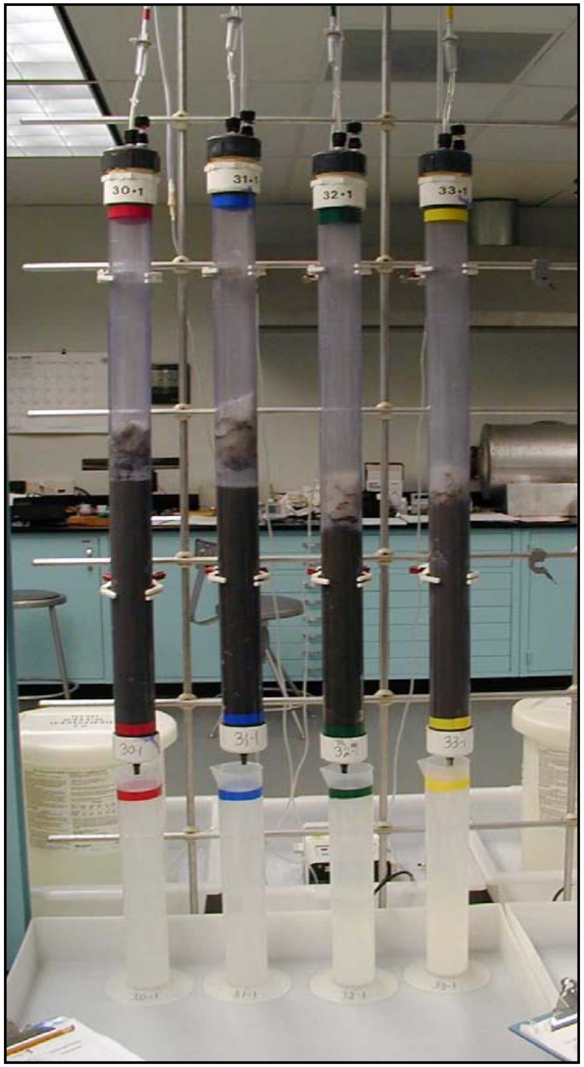
bituminous coal fly ash

a. Leaching chemistry

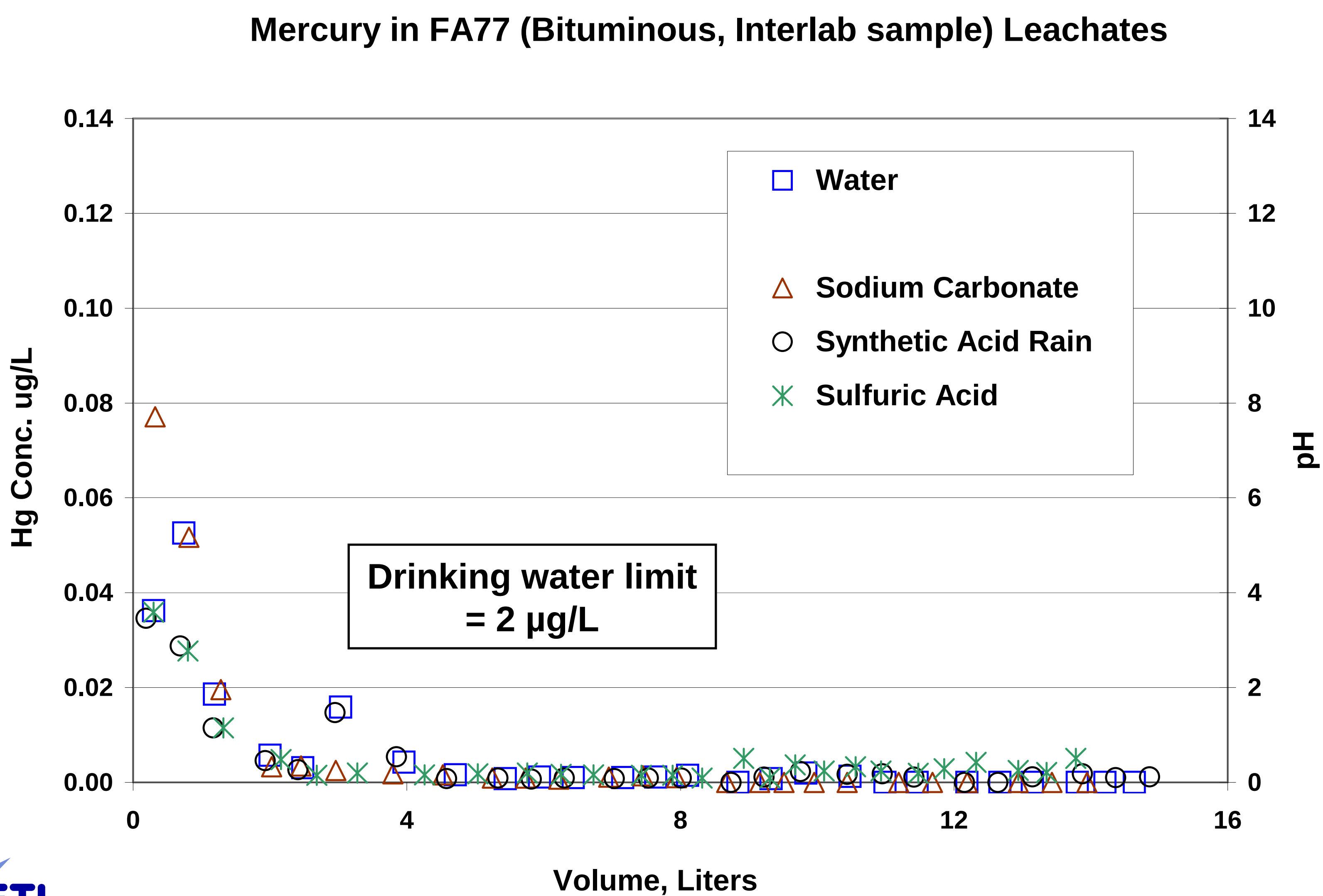
b. Multi-method comparison

Long-Term Column Leaching

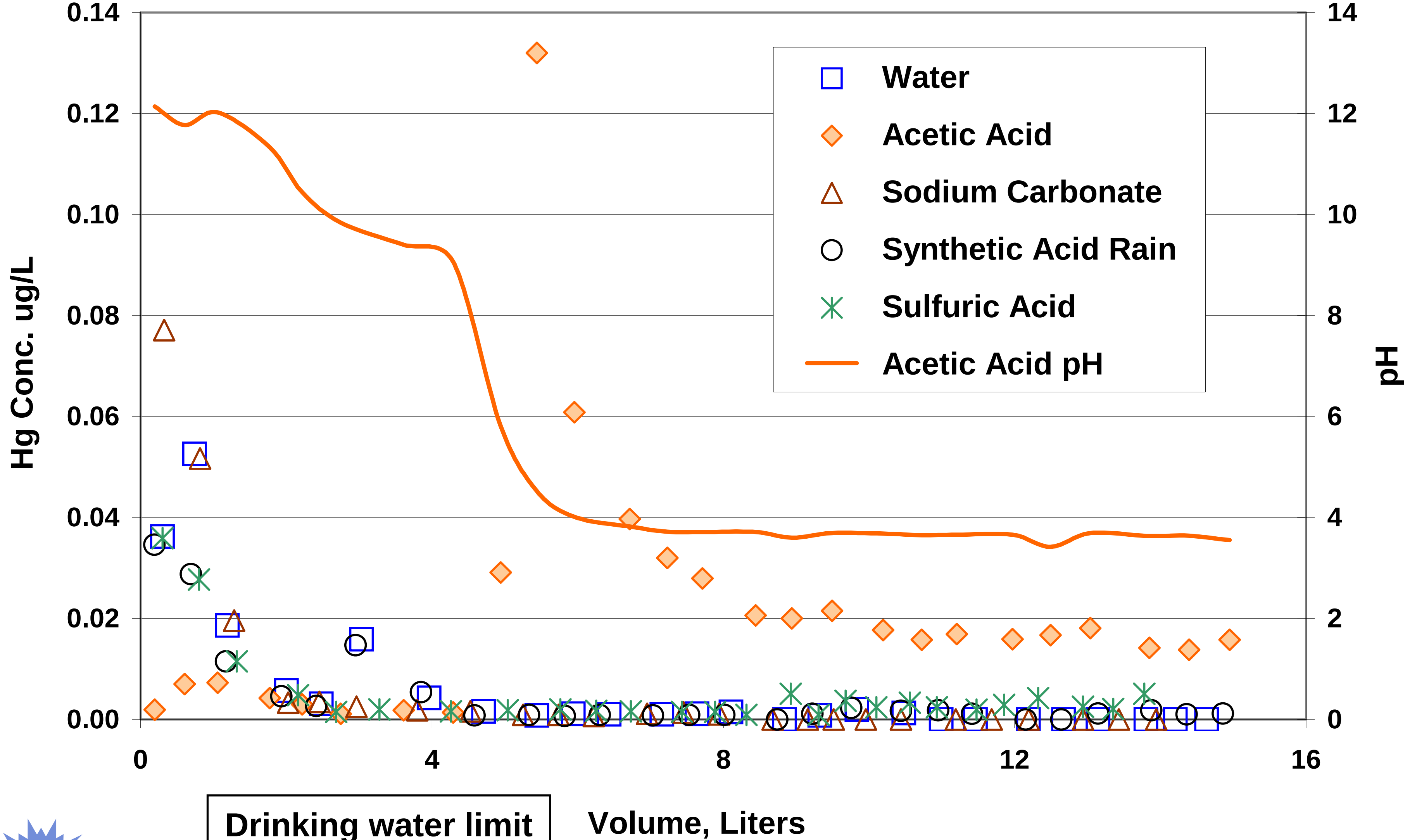
Leachant	ID	Type	pH
Sulfuric Acid	H_2SO_4	acid mine drainage	1.2
Acetic Acid	HAc	MSW landfill	2.9
Synthetic Precipitation	SP	acid rain	4.2
Water	H_2O	neutral	6.0
Sodium Carbonate	Na_2CO_3	high pH	11.1



Leaching Chemistry

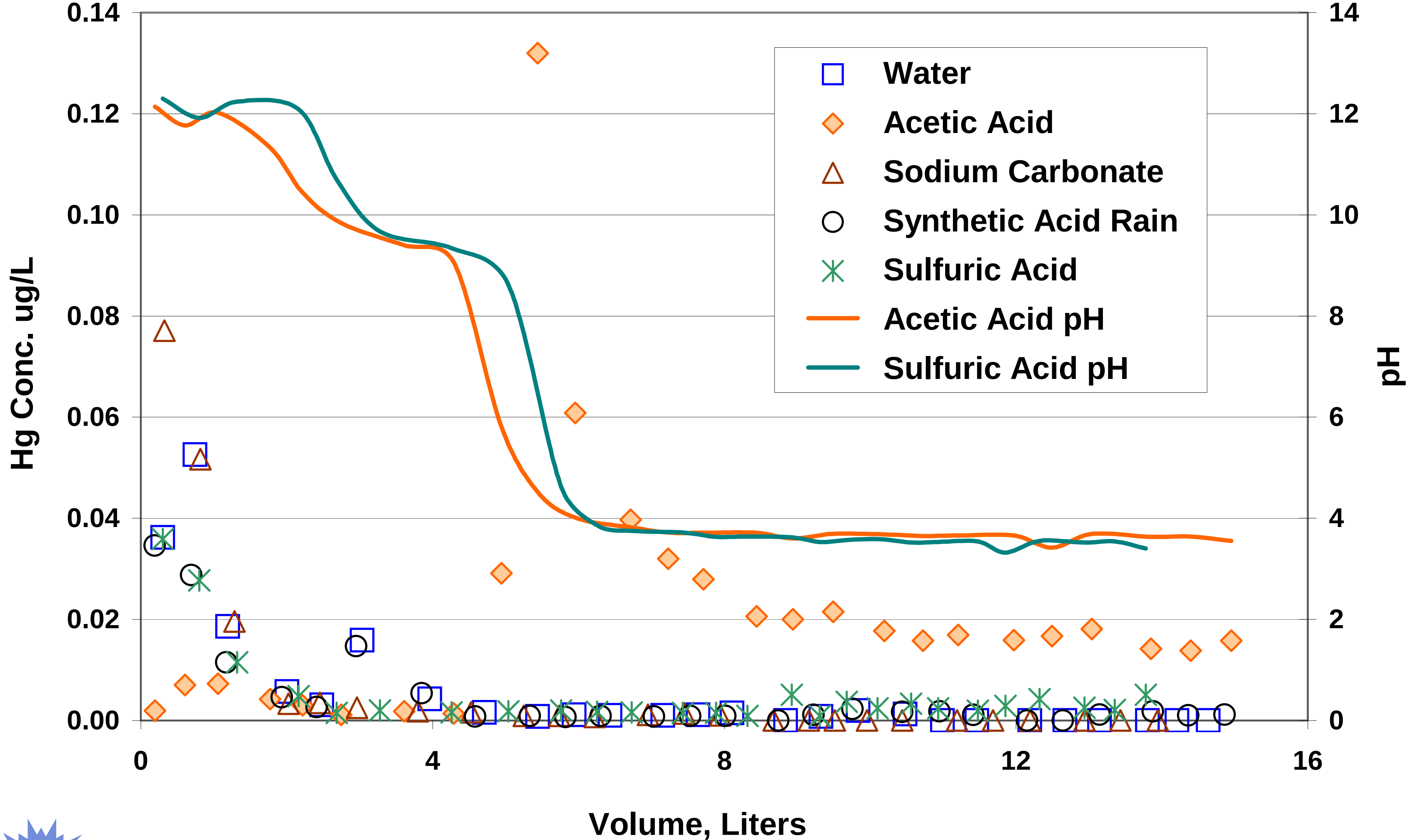


Mercury in FA77 (Bituminous, Interlab sample) Leachates



Drinking water limit = 2 µg/L

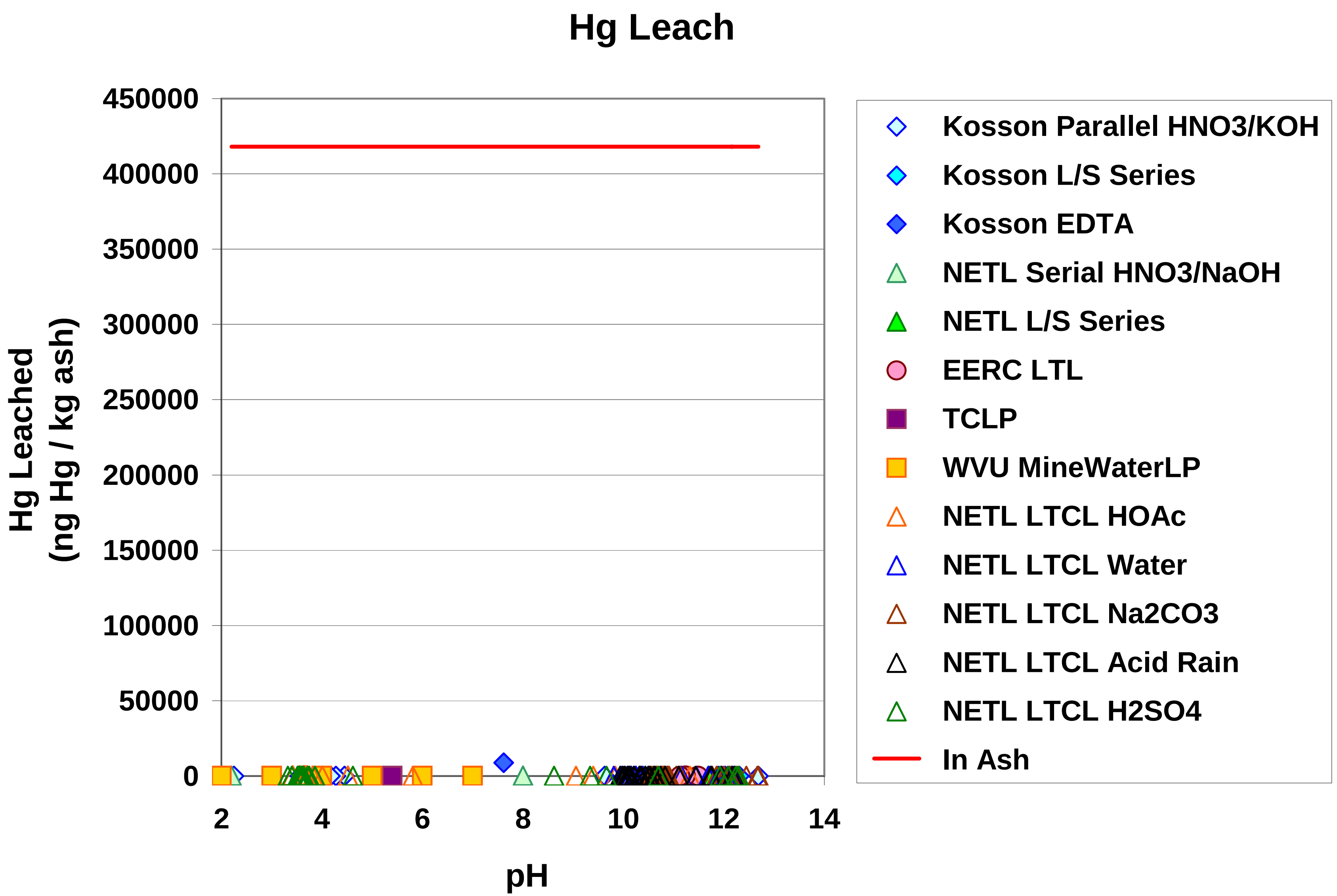
Mercury in FA77 (Bituminous, Interlab sample) Leachates



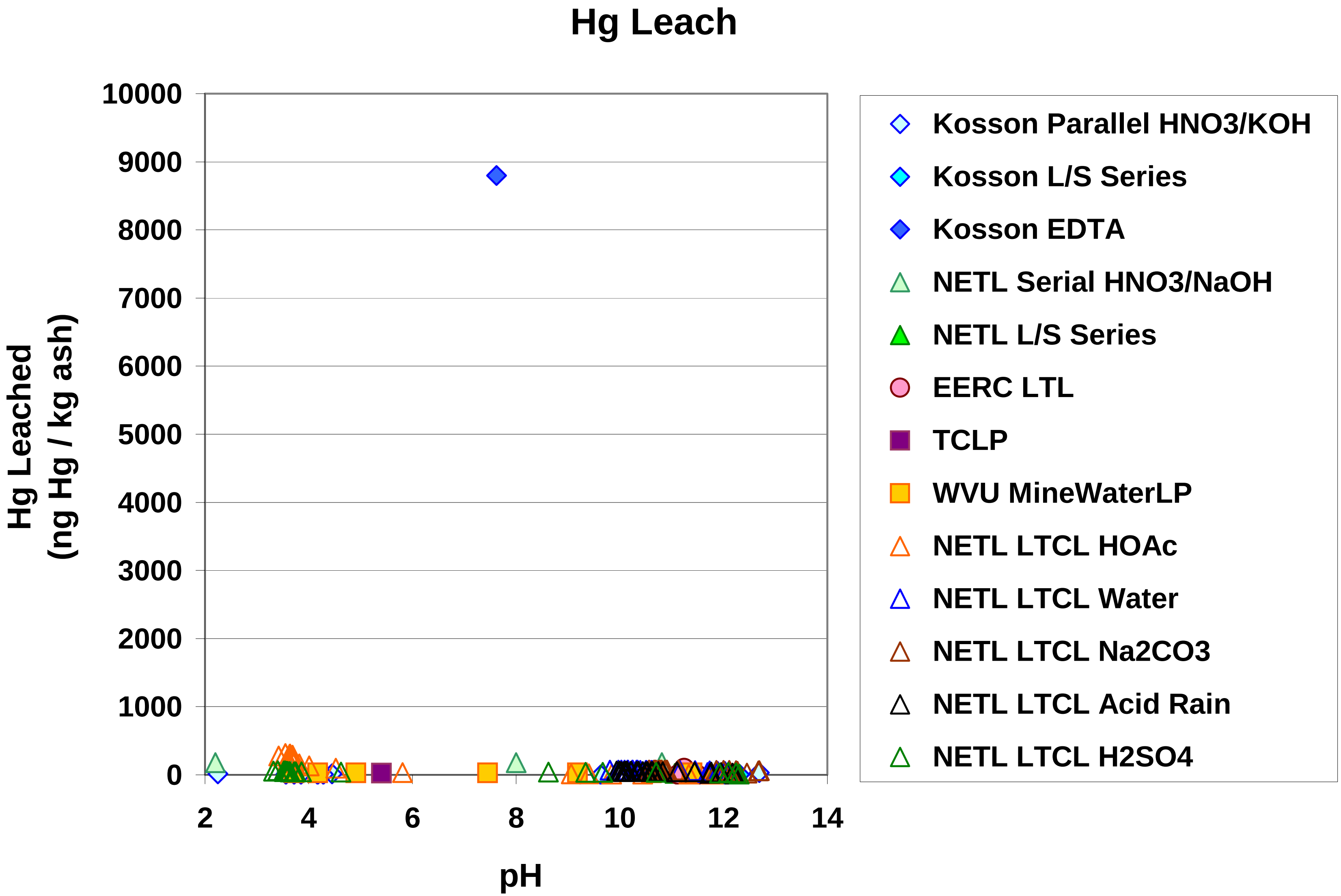
Batch Leaching Procedures

Method Comparison Summary

Method (Source)	Leaching Type	Total Steps	Minimum Time	Sample Per Rep	Leachants
SBLP (NETL)	Serial batch	8	2 d	50 g	H_2O HNO_3
SGLP (EERC)	Batch	3	60 d	300 g	H_2O
MWLP (NMLRC)	Serial batch	Varies	Varies 1 d / cyc.	100 g	H_2O H_2SO_4
3-Tier (Kosson)	Titrations + Batch	2 19	2 d / run 14 ?	900 g	H_2O EDTA HNO_3 KOH



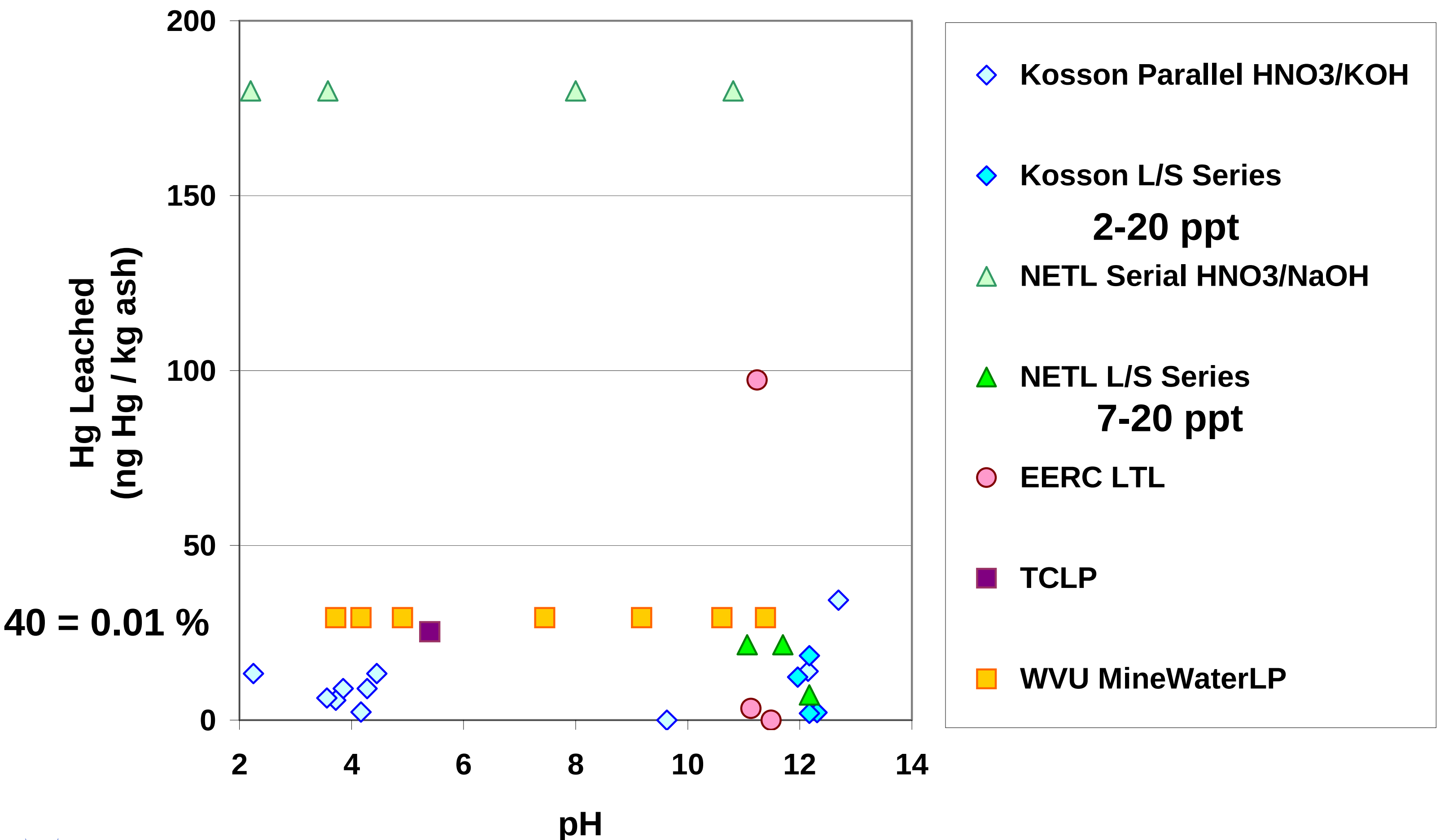
Very little Hg is leached (Maximum = 2.1%)



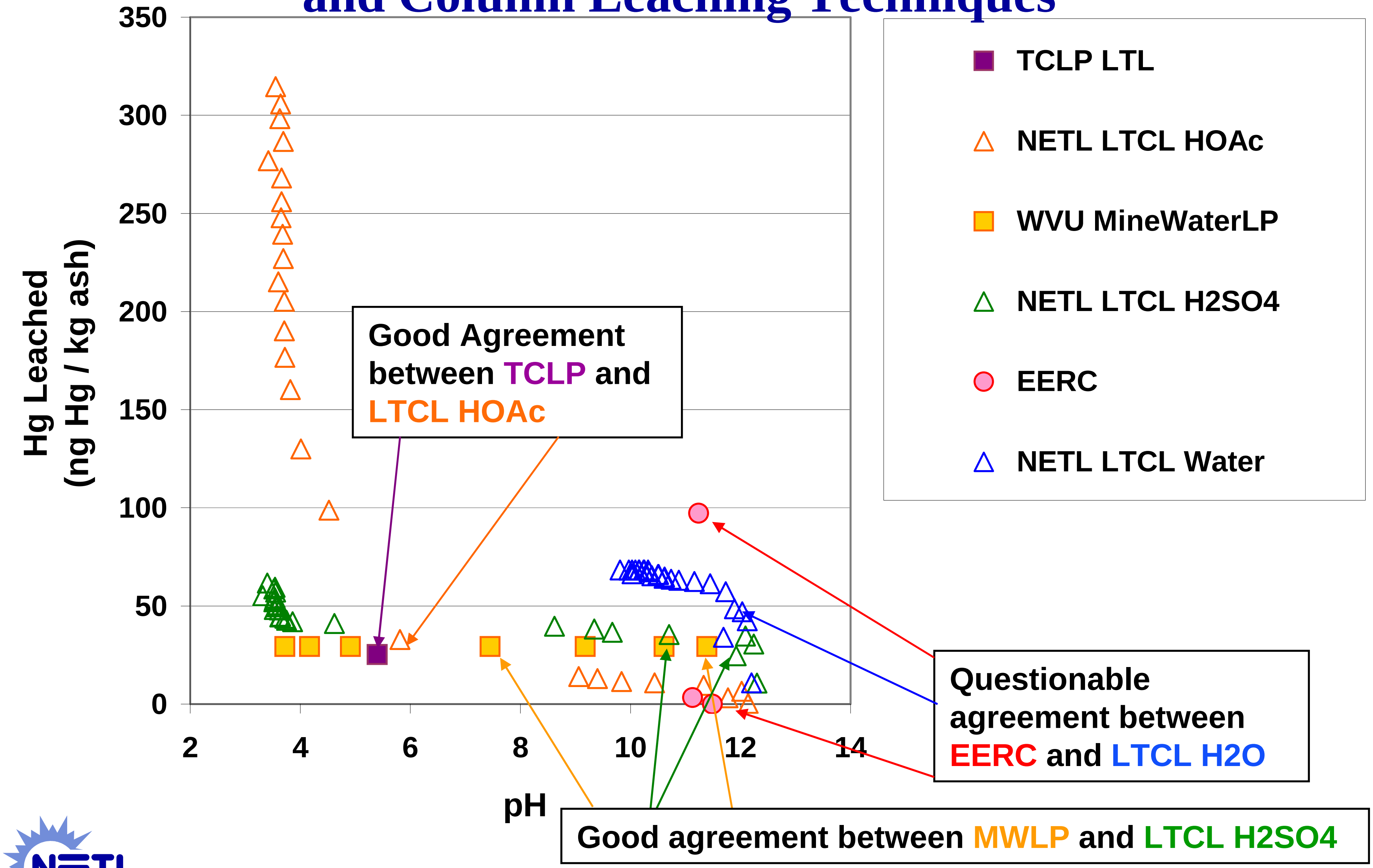
Very little Hg is leached

EDTA = 2.1%, HOAc 0.08%

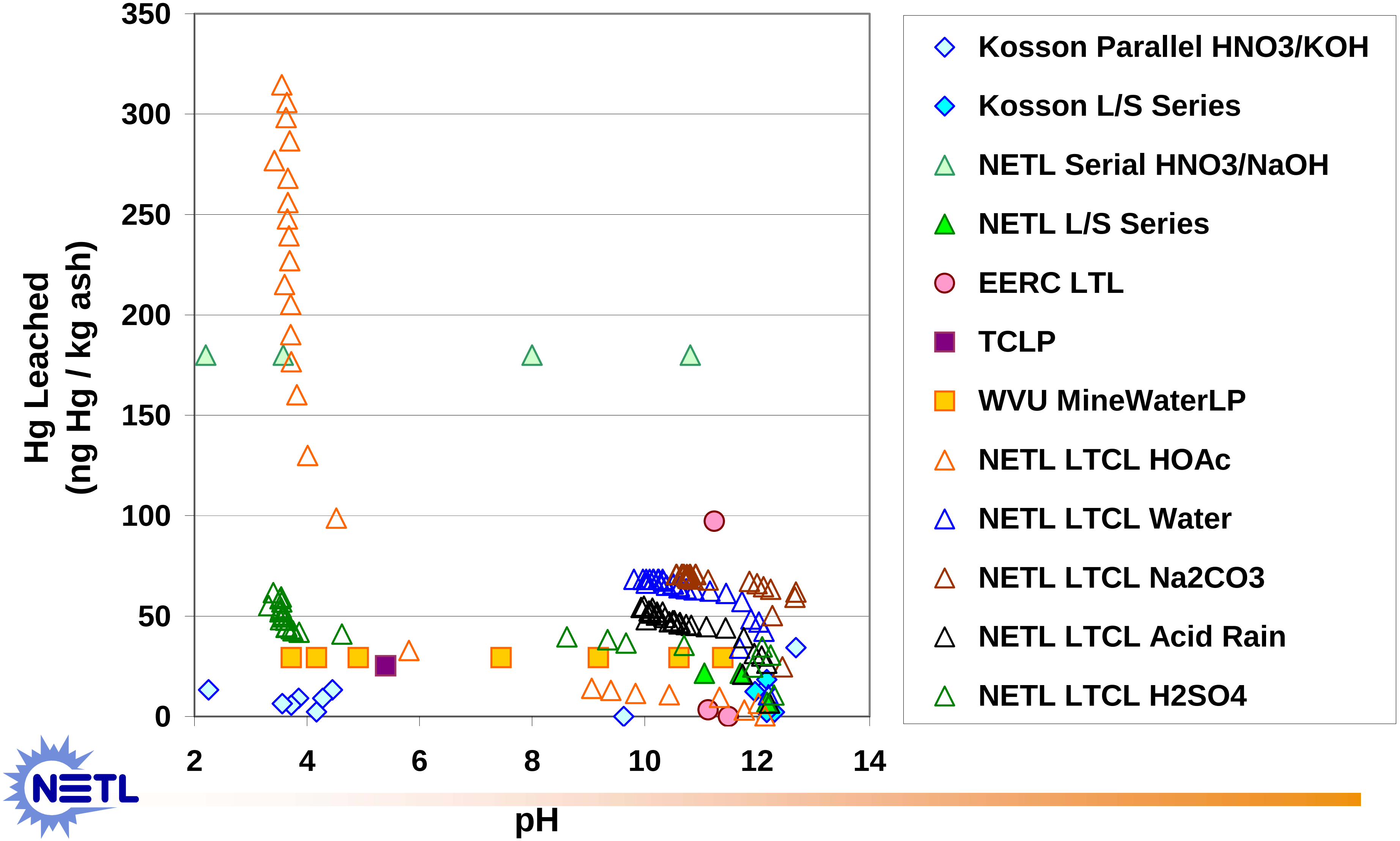
Batch Leaching Techniques



Comparison of Selected Batch and Column Leaching Techniques



Comparison of Batch and Column Leaching Results for a Single Flyash



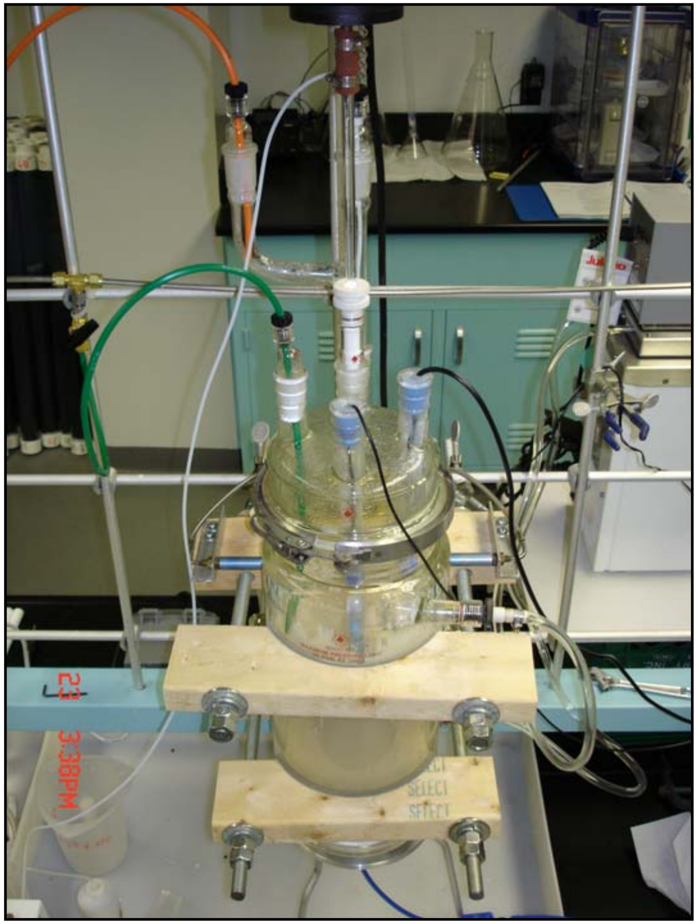
2

Continuous leaching of FGD-derived gypsum and wallboard

Hg Capture and Release in FGD Solids

- How mobile is the Hg in FGD gypsum and wallboard?
- What are the mechanisms of Hg retention in FGD products?

Leaching of FGD-gypsum



- **Gypsum leaching**
  - Gypsum totally dissolved
  - Leachate: No mercury
  - Residue
    - < 1% of original material
    - Fe, Al
    - Contains most of / all Hg
- **Wallboard post-leaching residue**
  - Gypsum totally dissolved
  - Leachate: About 1% of Hg leached
  - Residue
    - about 2% of original material
    - Fe, Al
    - Contains most of / all Hg
- **Conclusion: Phase responsible for strong Hg retention is not gypsum**
    - Fe or mixed Fe-Al phase
    - Mineralogy not determined

NETL

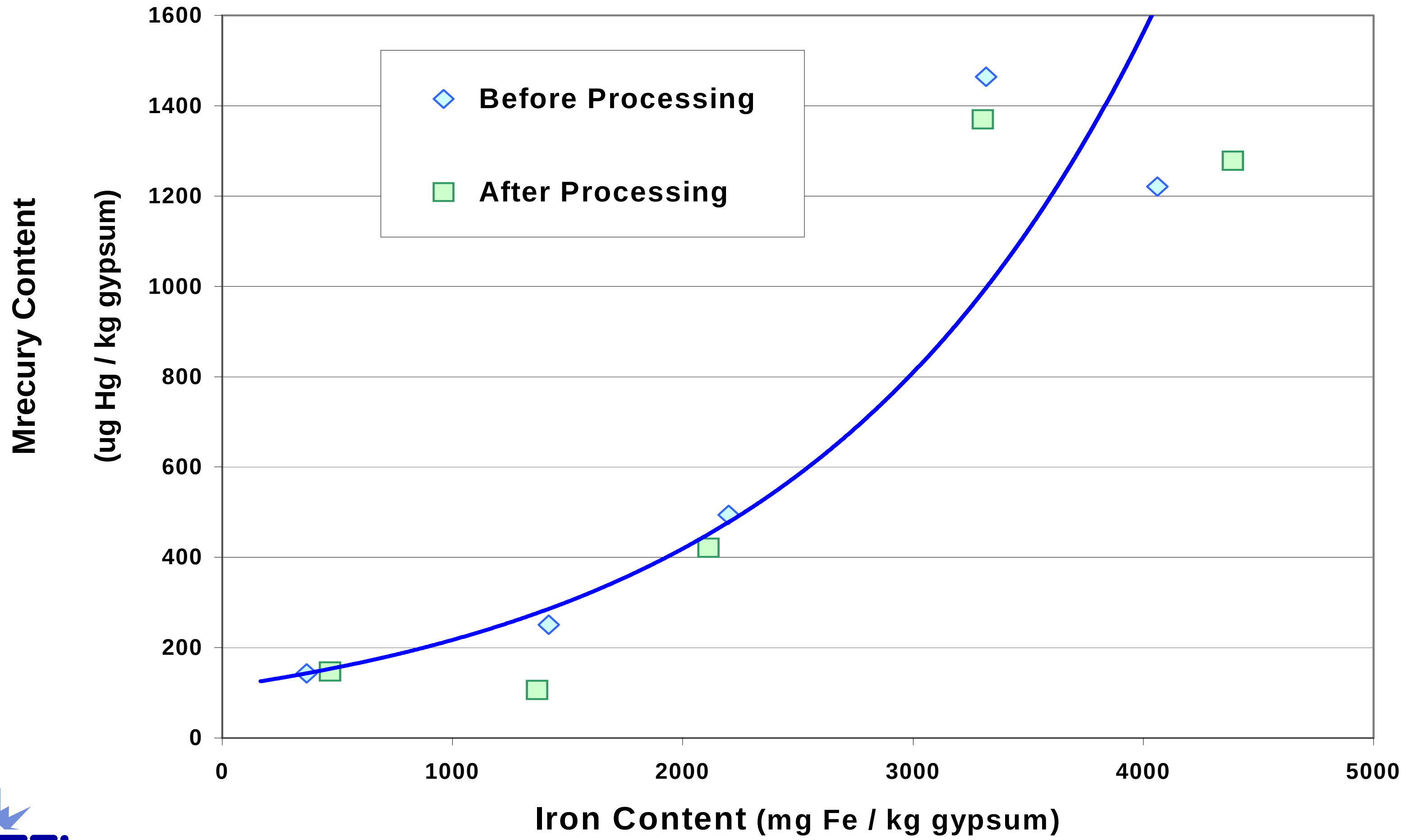
Partitioning of Hg during laboratory FGD-slurry settling studies

Mercury in FGD settled-slurry layers (μg/kg = ppb)	Top Layer	Bottom Layer	Ratio of Hg in Top to Hg in Bottom Layer
Slurry 1, Aliquot 1	3,560 ± 170	72 ± 6	49 ± 6
Slurry 1, Aliquot 2	2,900 ± 80	108 ± 10	26 ± 3
Slurry 2	13,000 ± 800	700 ± 27	19 ± 2

- Mercury in FGD slurry reports preferentially to less-easily settled material
- Top layers enriched in Fe by an order of magnitude

NETL

Mercury Content of Gypsum Tends to Correlate with Iron Content



Current Hypothesis – An iron-containing phase, probably introduced with limestone, is responsible for sorption of mercury.

- All Hg remains in iron-rich residues after leaching experiments
- Both Hg and Fe preferentially report to top layers during settling experiments
- Hg content of FGD gypsum appears to correlate with Fe content

Summary

1. **Comparison of leaching methods for a single ash**
   - Complex leaching chemistry
   - General agreement on the magnitude of leaching
   - Much difference in the details

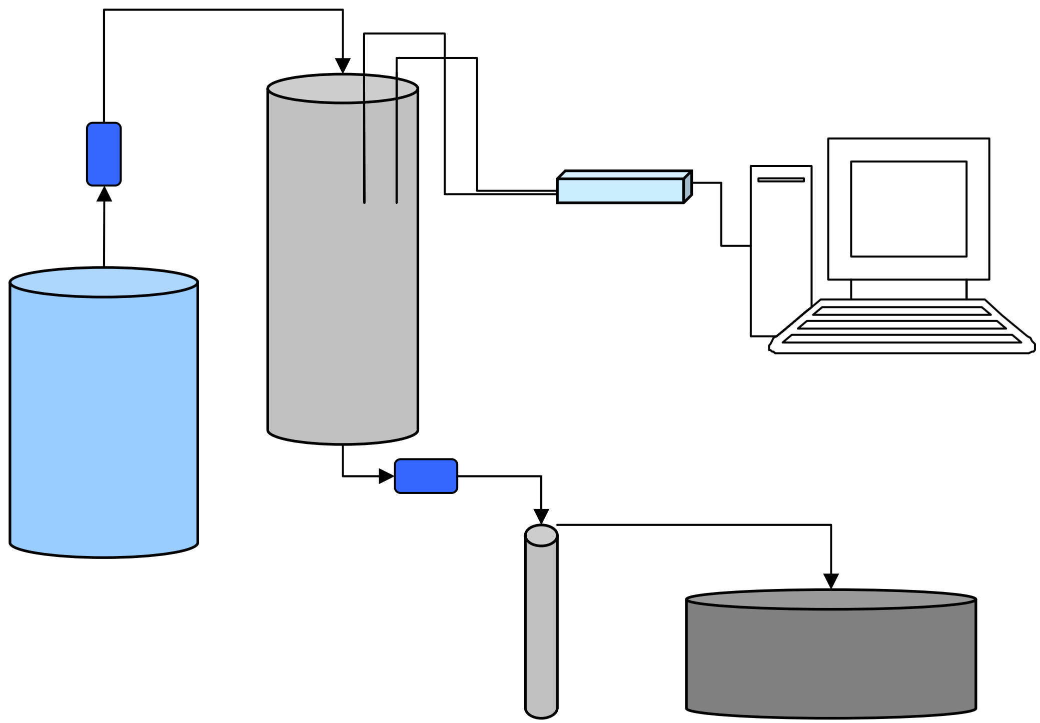
2. **Leaching of FGD-derived gypsum and wallboard**
   - No mercury in leachate
   - Retention due to unidentified iron-containing phase

NETL In-House Research
Hg Release from CUB

- Evaluate potential environmental impacts of CUB disposal or utilization
- Determine the stability of Hg and other metals in CUB under simulated end-use environments
- Explain the chemistry underlying metal stability

Leaching of FGD products using a CSTX

- **Measure Hg and metals release**
- **Leachant**
  - Ultra pure water
  - Dilute HCl



Mercury retention during wallboard production from FGD-gypsum

Mercury in FGD Products (µg/kg = ppb)					
	Plant A	Plant B	Plant C	Plant D	Plant E
Feed FGD-Derived Gypsum	143 ± 4	251 ± 7	1221 ± 51	1464 ± 50	494 ± 16
Product FGD-Derived Wallboard	147 ± 2	106 ± 5	1278 ± 63	1370 ± 59	421 ± 3
% Hg Retained During Processing	103 ± 3%	42 ± 2%	104 ± 7%	94 ± 5%	88 ± 3%

NETL

Current Work

Iron retention during FGD-gypsum to wallboard production

Fe in FGD Products (mg/kg)					
	Plant A	Plant B	Plant C	Plant D	Plant E
Feed FGD-Derived Gypsum	367	1418	4061	3317	2199
Product FGD-Derived Wallboard	468	1368	4389	3303	2112
% Fe Retained During Processing	128%	97%	108%	100%	96%

NETL