The feasibility of removing inorganic arsenic from landfill leachate via sorption to mineral oxide surfaces.

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5/1/06

Presentation made to
Technical Advisory Group
USF, Tampa, FL

USF UNIVERSITY OF SOUTH FLORIDA

Outline

- Introductions
  - TAG members
- Project Background
  - The scope of the Florida Center Proposal
- Research Progress
- The next 6 months of research

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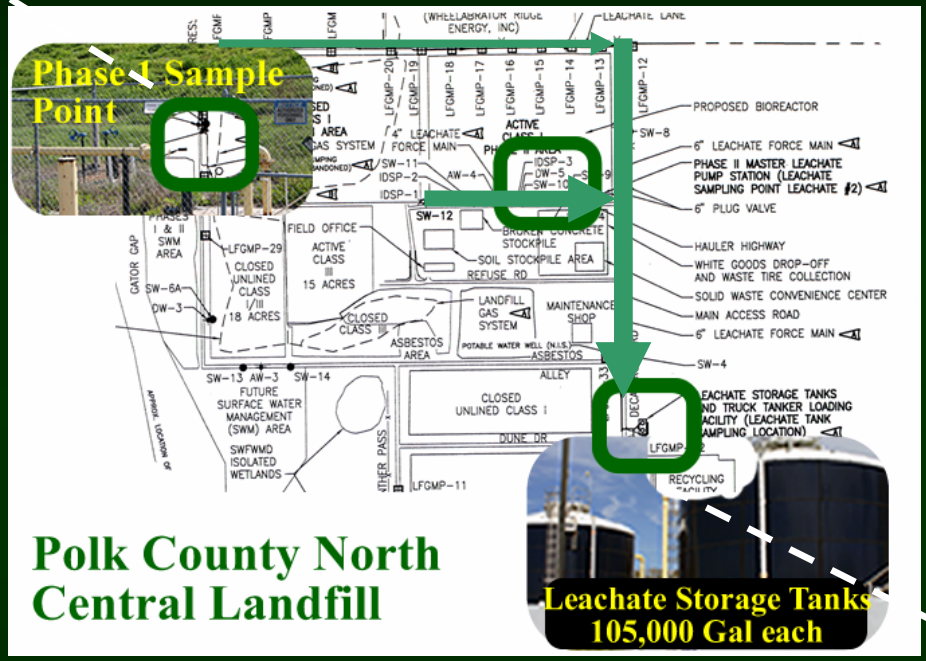
Leachate Collection System

Total As: 157 μg/L (4/12/05)

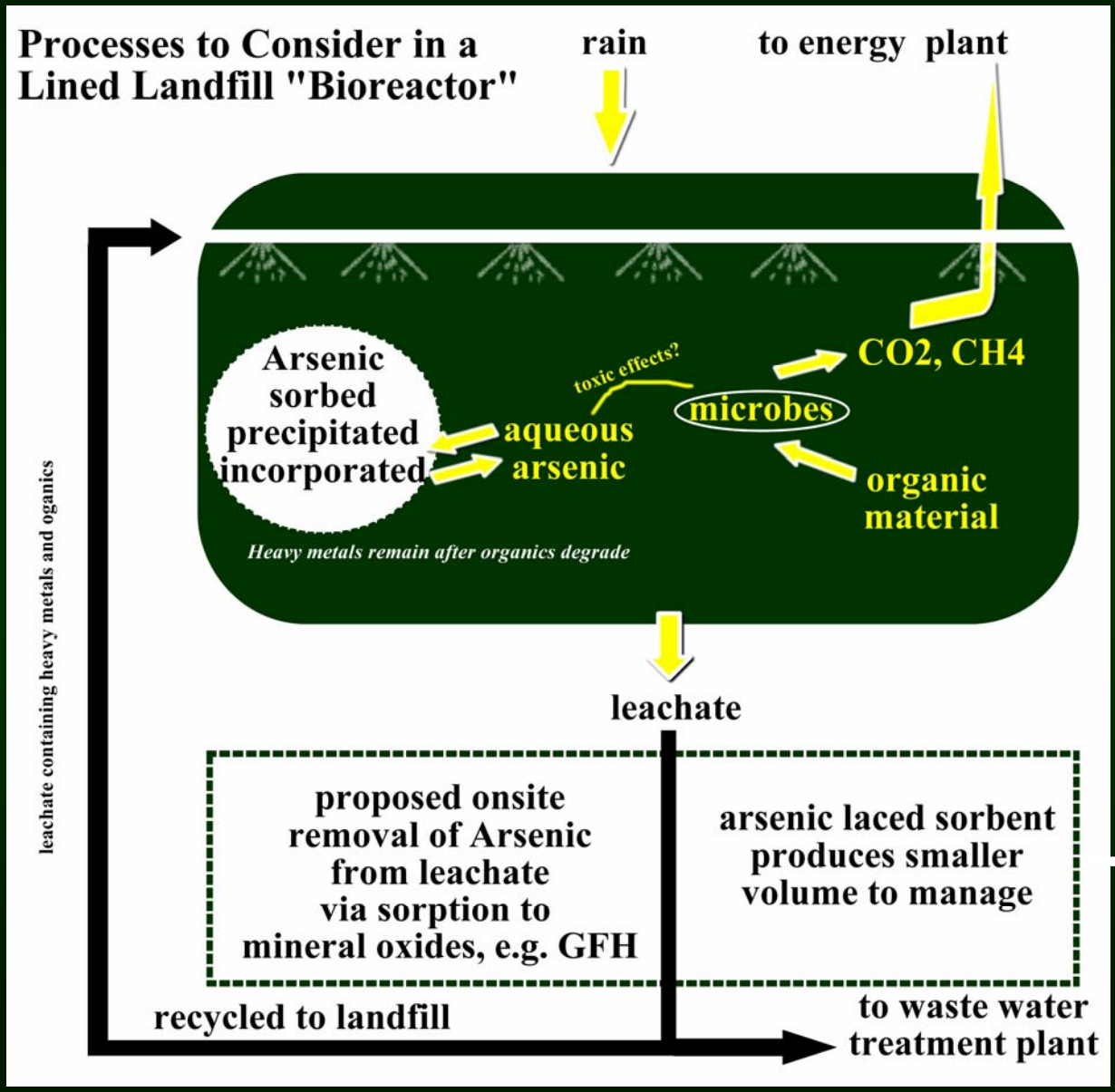


2004 Leachate Quantity (gallons)	
Phase I	1,730,400
Phase 2	6,418,206
Tank then hauled to Treatment	7,986,529

Total As: 89 μg/L (4/12/05)
Filtrate: 66 ug/L

Let, average **As in tank = 100 μg/L**
Leachate produced: 7,986,529 gals/yr x 3.785 L/gal * 100E-6 g As/L = **3023 g As/yr**

Rationale for on site removal of As from leachate



Approximate surface area of Phase I and Phase II at Polk County North Central Landfill is 4×10^6 ft^2.

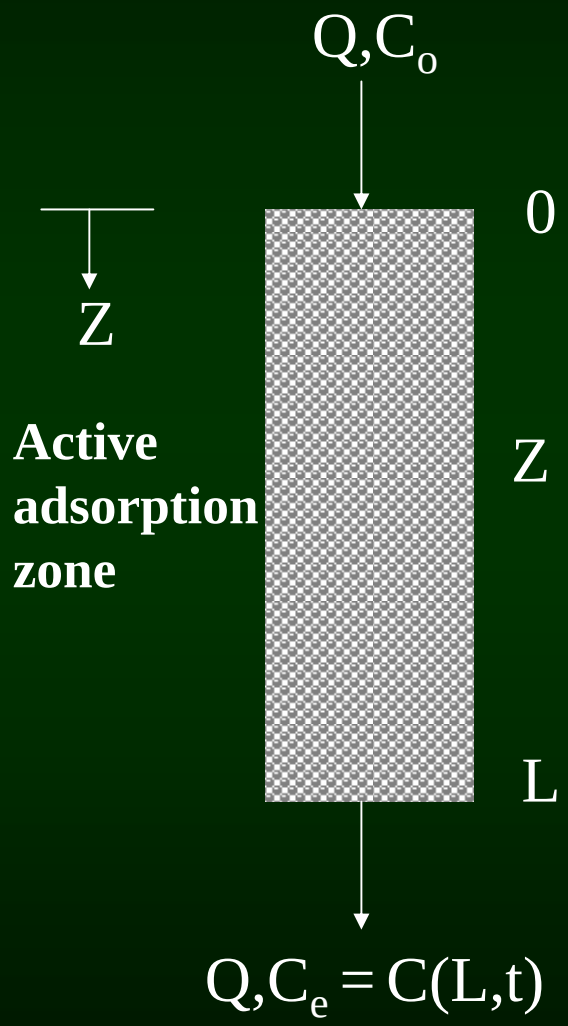
In 2004, 7.9×10^6 gals leachate produced. Assume average As conc. in leachate was 100 μg/L, produced ~ 3023 g As/yr

Assume sorbent Capacity:
= 40 mg As/g sorbent

$$\frac{3023 \text{ g As/yr} \times 1000 \text{ mg/g}}{40 \text{ mg As/g sorbent}}$$

= 76,000 g sorbent/yr

Sorption Processes

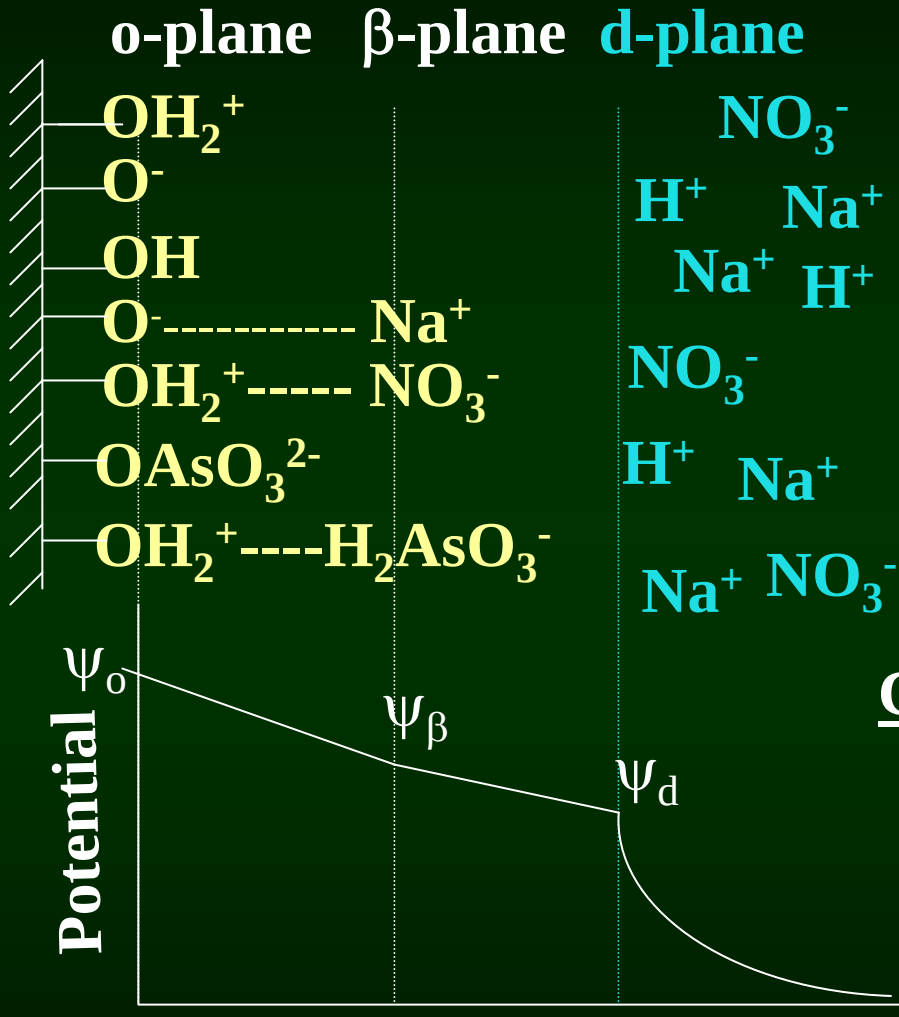


Activated Alumina

Sorbent	Capacity	Study
ALCOA DD660	32 mg/g	Trotz, 2004
Mesoporous Alumina	121 mg/g	Kim et al., 2004
NZVI	3.5 mg/g	Kanel et al., 2005

GFH

Schematic of the Triple Layer Model



$$K_{a1} = \frac{\left[SOH_2^+\right]}{\left[SOH\right]\left[H^+\right]\gamma_{H+}} \exp\left(\frac{F\psi_o}{RT}\right)$$

Charge-potential relationships

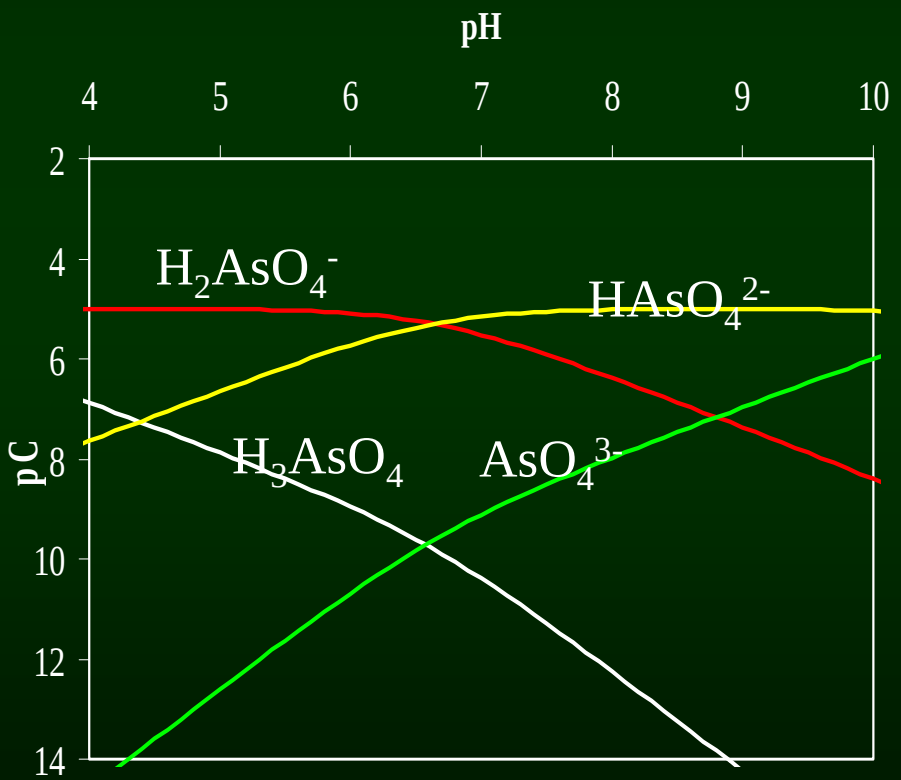
$$\sigma_o + \sigma_\beta + \sigma_d = 0$$

$$\psi_o - \psi_\beta = \sigma_o / C_1$$

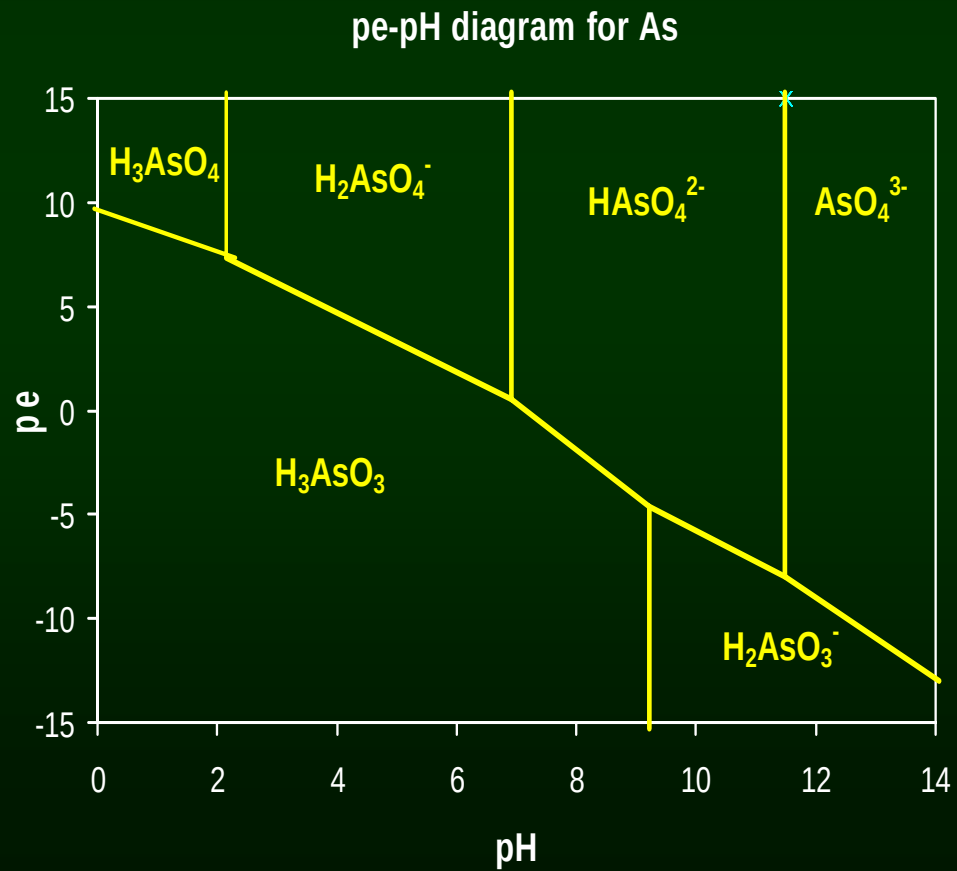
$$\psi_\beta - \psi_d = \sigma_d / C_2$$

Arsenic Chemistry

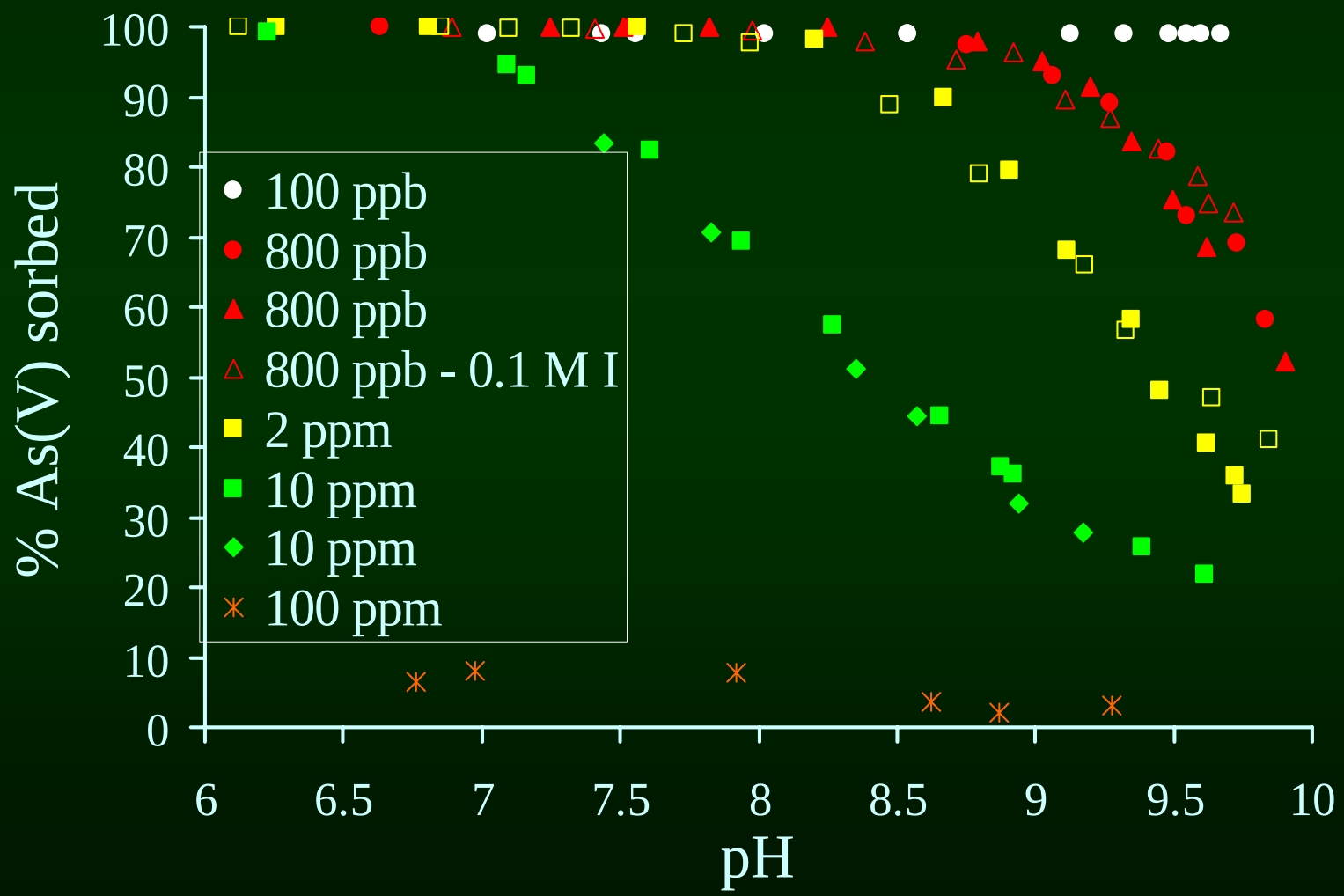
- inorganic forms in the +3 and +5 oxidation states
- pK_as for H_3AsO_4 (As (V)) : 2.19, 6.94, 11.5
- pK_as for H_3AsO_3 (As (III)) : 9.23, 12.13, 13.4



Arsenate Speciation



As(V) Sorption: 0.5 g/L DD660 0.01 M $NaNO_3$, no CO_2

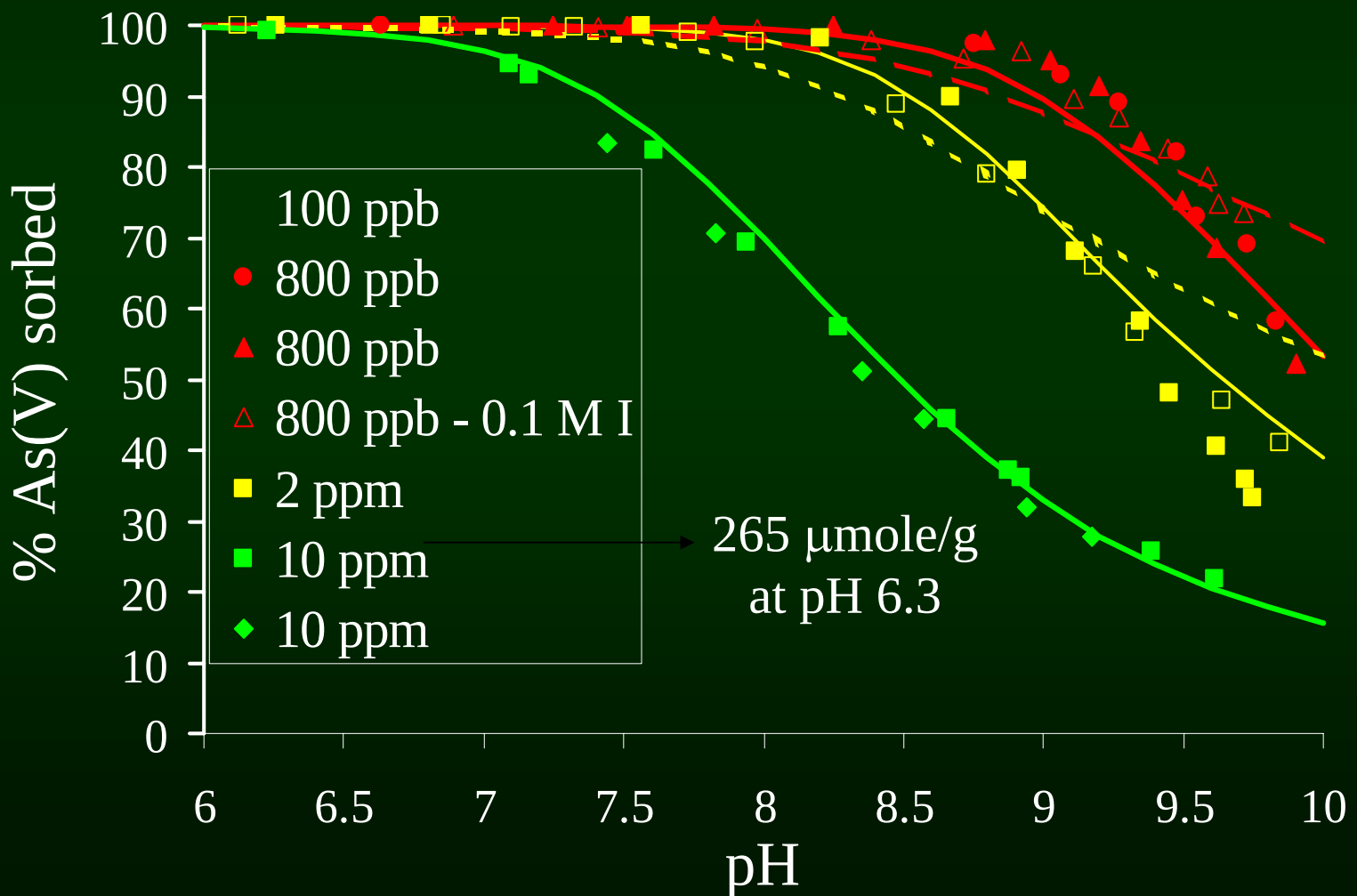


As(V) Sorption: lines are TLM fits

0.5% YOH: $SOAsO_3H^-$ & $SOH_2^+ \ldots HAsO_4^{2-}$

$\log K_{XOH} = 25.0 ; 25.1$

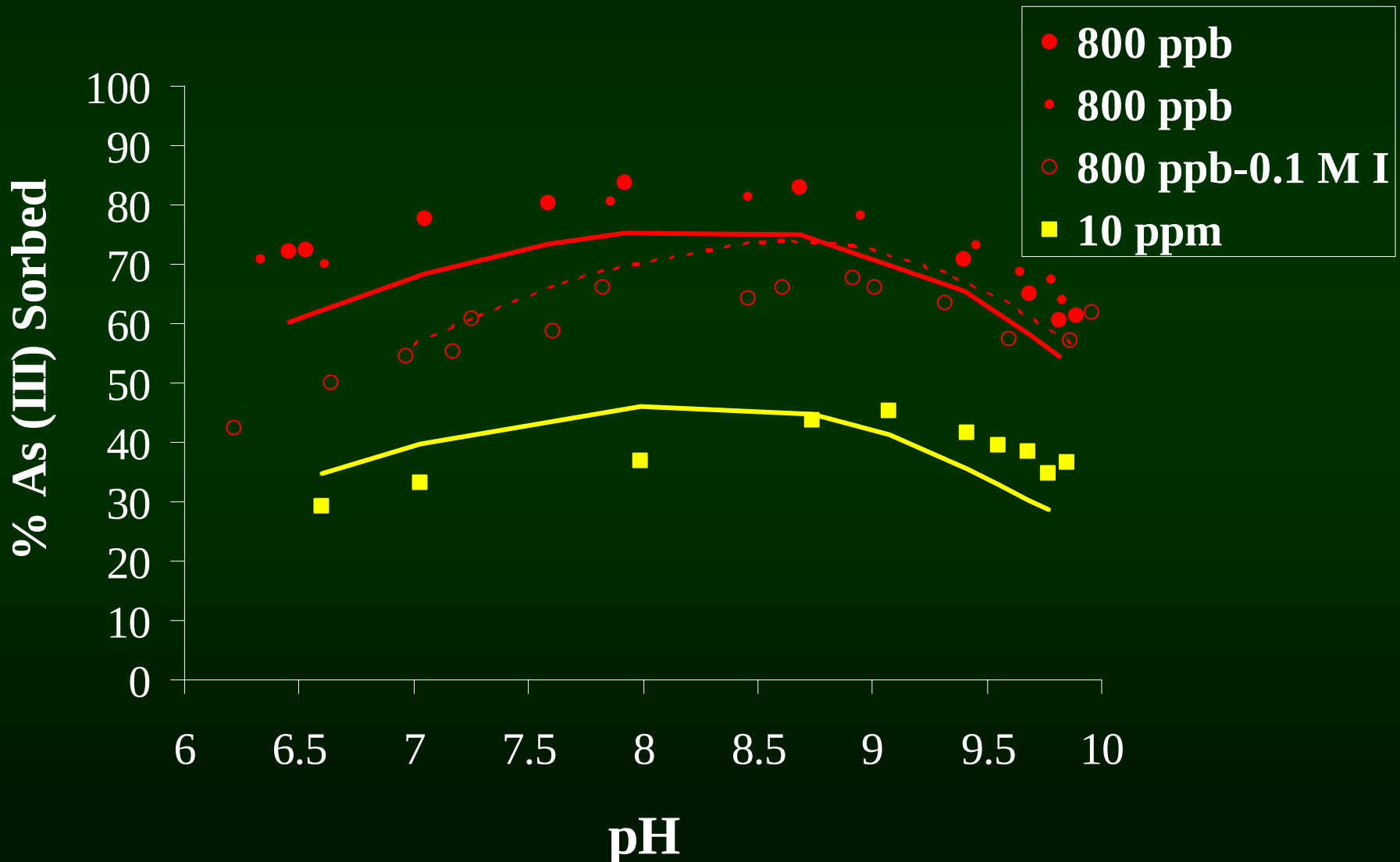
$\log K_{YOH} = 25.5; 25.3$



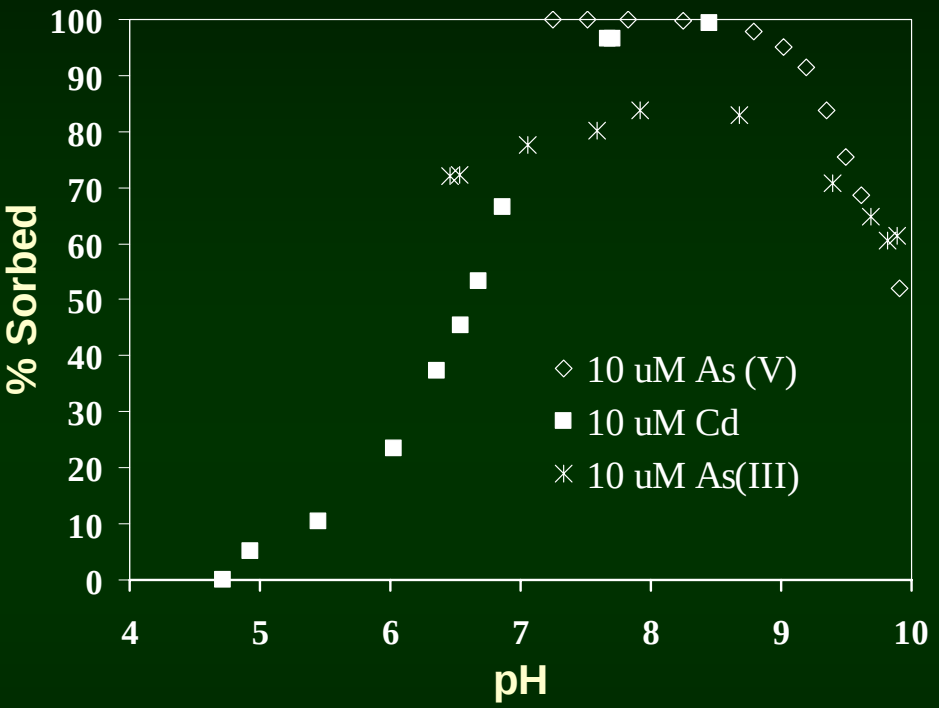
As(III) Sorption: lines are TLM fits

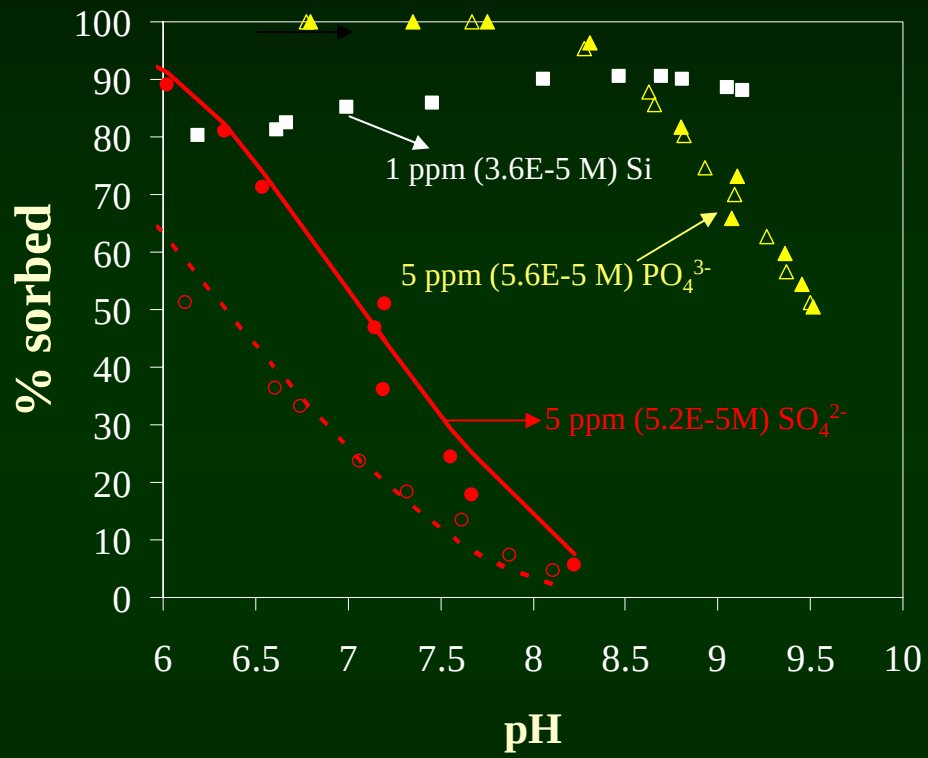
0.5% YOH: $SOH_2^{+0.5}$…$H_2AsO_3^{-0.5}$

$\log K_{XOH} = 37.5$; $\log K_{YOH} = 40.5$



Sorption of ions to DD660 Alumina





0.5 g/L, 0.01 or 0.1 N $NaNO_3$ background electrolyte. No CO_2. Binary systems.

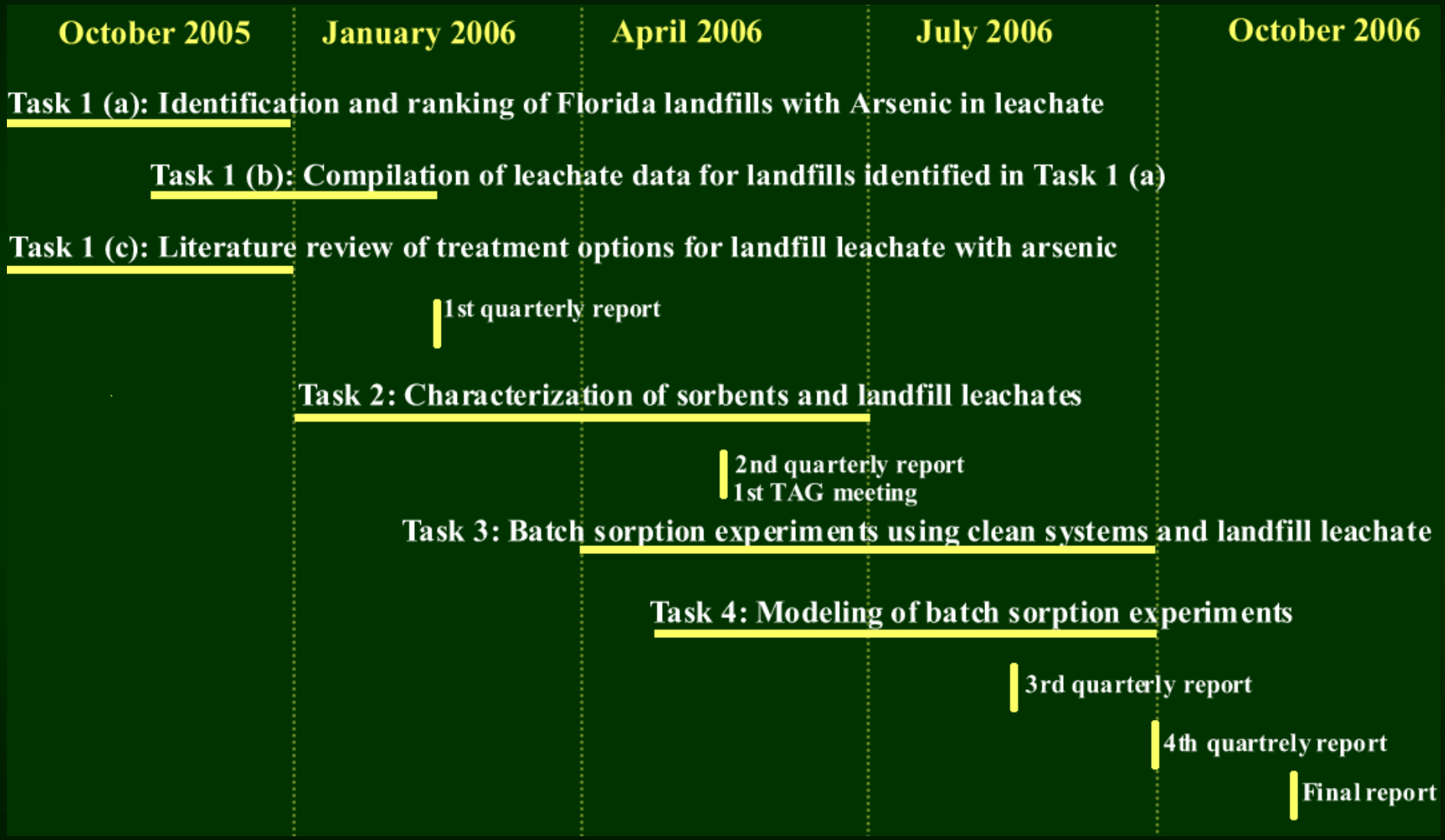
Project Objectives

Objective 1: To identify Class 1 landfills in Florida with potential leachate disposal problems due to arsenic and select experimental conditions based on leachate characterization information.

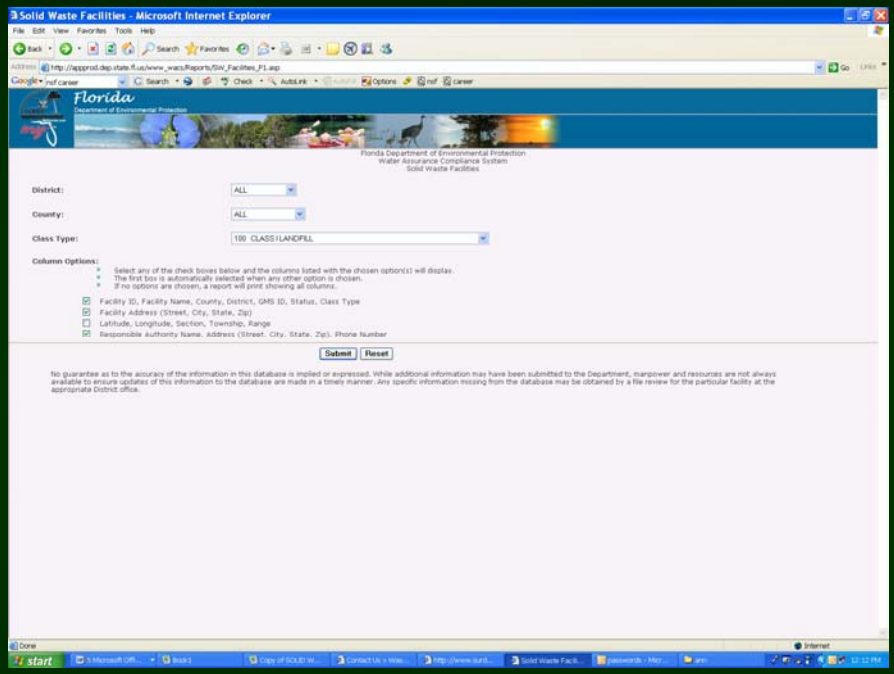
Objective 2: To determine the influence of geochemical conditions (pH, temperature, ionic strength, competing ions) on the removal of arsenic from landfill leachate solutions using mineral oxide surfaces

Objective 3: To establish an equilibrium modeling dataset that can be used to predict the feasibility of arsenic removal under a range of geochemical conditions.

Objectives/Tasks/Timeline



Identification and Ranking of Florida Landfills

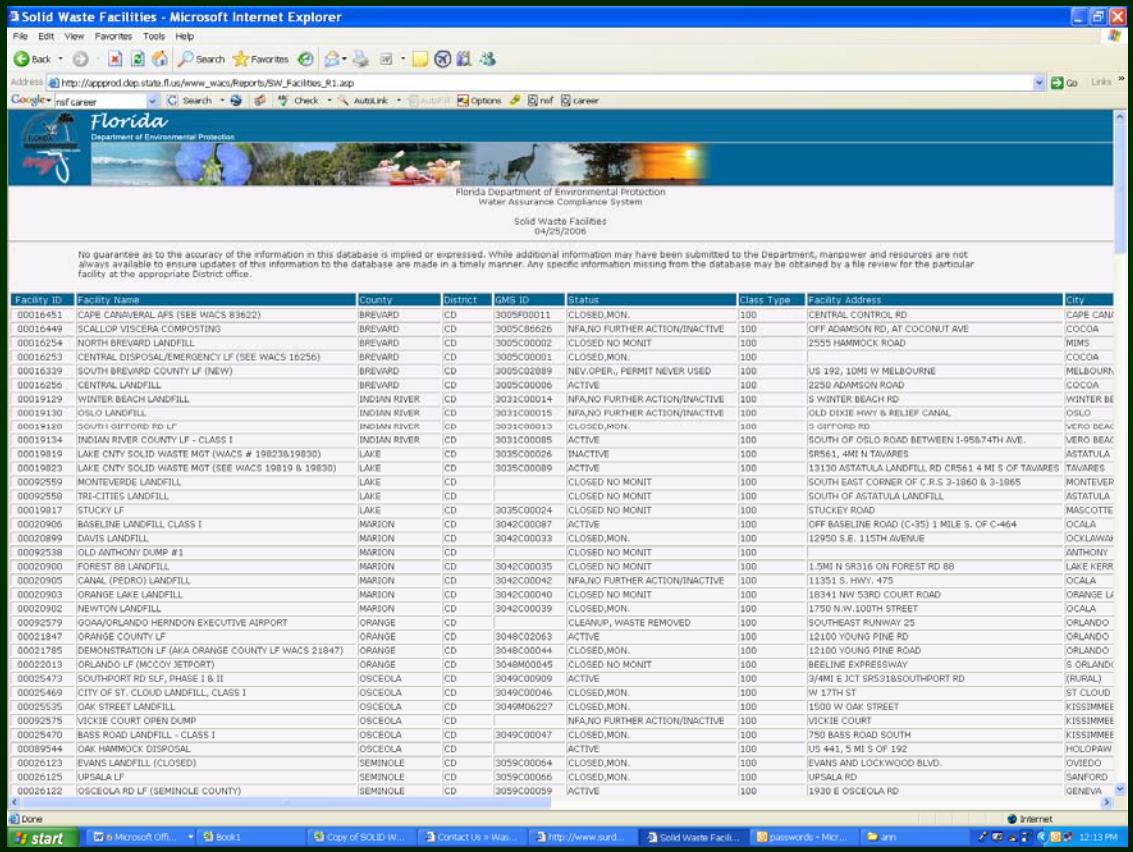


An excel spreadsheet of solid waste facilities was also provided by Lee Martin of the FDEP. This list also included non Class 1 landfills. We attempted to contact all 68 people on that list:

1. email
2. phone

http://appprod.dep.state.fl.us/www_wacs/Reports/SW_Facilities_P1.asp

Identification and Ranking of Florida Landfills



Facility ID	Facility Name	County	District	GMS ID	Status	Class Type	Facility Address	City
00016451	CAPE CANAVERAL AFS (SEE WACS 83622)	BREVARD	CD	3005F00011	CLOSED,MON.	100	CENTRAL CONTROL RD	CAPE CANA
00016449	SCALLOP VISCERA COMPOSTING	BREVARD	CD	3005C86626	NFA,NO FURTHER ACTION/INACTIVE	100	OFF ADAMSON RD, AT COCONUT AVE	COCOA
00016254	NORTH BREVARD LANDFILL	BREVARD	CD	3005C00002	CLOSED NO MONIT	100	2555 HAMMOCK ROAD	MIMS
00016253	CENTRAL DISPOSAL/EMERGENCY LF (SEE WACS 16256)	BREVARD	CD	3005C00001	CLOSED,MON.	100		COCOA
00016339	SOUTH BREVARD COUNTY LF (NEW)	BREVARD	CD	3005C02089	NEV.OPER., PERMIT NEVER USED	100	US 192, 10MI W MELBOURNE	MELBOURN
00016256	CENTRAL LANDFILL	BREVARD	CD	3005C00006	ACTIVE	100	2250 ADAMSON ROAD	COCOA
00019129	WINTER BEACH LANDFILL	INDIAN RIVER	CD	3031C00014	NFA,NO FURTHER ACTION/INACTIVE	100	S WINTER BEACH RD	WINTER BE
00019130	OSLO LANDFILL	INDIAN RIVER	CD	3031C00015	NFA,NO FURTHER ACTION/INACTIVE	100	OLD DIXIE HWY & RELIEF CANAL	OSLO
00019120	SOUTH GIFFORD RD LF	INDIAN RIVER	CD	3031C00013	CLOSED,MON.	100	S GIFFORD RD	VERO BEAC
00019134	INDIAN RIVER COUNTY LF - CLASS I	INDIAN RIVER	CD	3031C00085	ACTIVE	100	SOUTH OF OSLO ROAD BETWEEN I-95&74TH AVE.	VERO BEAC
00019819	LAKE CNTY SOLID WASTE MGT (WACS # 19823&19830)	LAKE	CD	3035C00026	INACTIVE	100	SR561, 4MI N TAVARES	ASTATULA
00019823	LAKE CNTY SOLID WASTE MGT (SEE WACS 19819 & 19830)	LAKE	CD	3035C00089	ACTIVE	100	13130 ASTATULA LANDFILL RD CR561 4 MI S OF TAVARES	TAVARES
00092559	MONTEVERDE LANDFILL	LAKE	CD		CLOSED NO MONIT	100	SOUTH EAST CORNER OF C.R.S 3-1960 & 3-1965	MONTEVER
00092558	TRI-CITIES LANDFILL	LAKE	CD		CLOSED NO MONIT	100	SOUTH OF ASTATULA LANDFILL	ASTATULA
00019817	STUCKY LF	LAKE	CD	3035C00024	CLOSED NO MONIT	100	STUCKEY ROAD	MASCOTTE
00020906	BASELINE LANDFILL CLASS I	MARION	CD	3042C00087	ACTIVE	100	OFF BASELINE ROAD (C-35) 1 MILE S. OF C-464	OCALA
00020899	DAVIS LANDFILL	MARION	CD	3042C00033	CLOSED,MON.	100	12950 S.E. 115TH AVENUE	OCKLAWA
00092538	OLD ANTHONY DUMP #1	MARION	CD		CLOSED NO MONIT	100		ANTHONY
00020900	FOREST 88 LANDFILL	MARION	CD	3042C00035	CLOSED NO MONIT	100	1.5MI N SR316 ON FOREST RD 88	LAKE KERR
00020905	CANAL (PEDRO) LANDFILL	MARION	CD	3042C00042	NFA,NO FURTHER ACTION/INACTIVE	100	11351 S. HWY. 475	OCALA
00020903	ORANGE LAKE LANDFILL	MARION	CD	3042C00040	CLOSED NO MONIT	100	18341 NW 53RD COURT ROAD	ORANGE LA
00020902	NEWTON LANDFILL	MARION	CD	3042C00039	CLOSED,MON.	100	1750 N.W.100TH STREET	OCALA
00092579	GOAA/ORLANDO HERNDON EXECUTIVE AIRPORT	ORANGE	CD		CLEANUP, WASTE REMOVED	100	SOUTHEAST RUNWAY 25	ORLANDO
00021847	ORANGE COUNTY LF	ORANGE	CD	3048C02063	ACTIVE	100	12100 YOUNG PINE RD	ORLANDO
00021785	DEMONSTRATION LF (AKA ORANGE COUNTY LF WACS 21847)	ORANGE	CD	3048C00044	CLOSED,MON.	100	12100 YOUNG PINE ROAD	ORLANDO
00022013	ORLANDO LF (MCCOY JETPORT)	ORANGE	CD	3048M00045	CLOSED NO MONIT	100	BEELINE EXPRESSWAY	S ORLAND
00025473	SOUTHPORT RD SLF, PHASE I & II	OSCEOLA	CD	3049C00909	ACTIVE	100	3/4MI E JCT SR531&SOUTHPORT RD	(RURAL)
00025469	CITY OF ST. CLOUD LANDFILL, CLASS I	OSCEOLA	CD	3049C00046	CLOSED,MON.	100	W 17TH ST	ST CLOUD
00025535	OAK STREET LANDFILL	OSCEOLA	CD	3049M06227	CLOSED,MON.	100	1500 W OAK STREET	KISSIMMEE
00092575	VICKIE COURT OPEN DUMP	OSCEOLA	CD		NFA,NO FURTHER ACTION/INACTIVE	100	VICKIE COURT	KISSIMMEE
00025470	BASS ROAD LANDFILL - CLASS I	OSCEOLA	CD	3049C00047	CLOSED,MON.	100	750 BASS ROAD SOUTH	KISSIMMEE
00089544	OAK HAMMOCK DISPOSAL	OSCEOLA	CD		ACTIVE	100	US 441, 5 MI S OF 192	HOLOPAW
00026123	EVANS LANDFILL (CLOSED)	SEMINOLE	CD	3059C00064	CLOSED,MON.	100	EVANS AND LOCKWOOD BLVD.	OVIEDO
00026125	UPSALA LF	SEMINOLE	CD	3059C00066	CLOSED,MON.	100	UPSALA RD	SANFORD
00026122	OSCEOLA RD LF (SEMINOLE COUNTY)	SEMINOLE	CD	3059C00059	ACTIVE	100	1930 E OSCEOLA RD	GENEVA

230 Class 1 Landfills
52 are ACTIVE
1 ACT NOT PERMITED
1 CLEANUP, WASTE REMOVED
19 CLOSED NO MONIT
127 CLOSED, MONITORING
21 INACTIVE
4 NEV.OPER., PERMIT NEVER USED
5 NFA,NO FURTHER ACTION/INACTIVE

Landfills in Florida with arsenic leachate concerns

- Alachua County Public Works. phone: (352) 374-5213, contact: David Wood; Average Arsenic concentration 130 ppb, cost of transporting to facility $70-73/1000 gallons.

- Lake County, Solid Waste Mgmt Services. phone:(352) 343-6030, contact Gary Debo. Leachate disposal is accomplished by trucking to Jacksonville (approx. 130 miles one way) at a cost of $0.13/gallon for transportation & disposal. $130.00/1,000 gallons. Arsenic Levels 10/2/04 - 11ug/L, 10/26/04 -18ug/L, 05/10/05 - 19ug/L.

- Marion County Solid Waste Dept, Ocala, FL. phone: (352) 245-4584, contact: Mike Sims. current Arsenic concentrations 78 ppb, method of disposal is a Pipeline to the City of Ocala Waste Water Treatment Plant #2. Cost of disposal $9.00 / 1000 gallons. Arsenic surcharge in effect.

- Martin County Solid Waste Management Department. phone (772) 221-1386, Stuart, FL, contact: Patrick N. Yancey. Arsenic concentration level 280 ppb. Martin County hauls all leachate and it is deep well injected at a local Utility (a permitted disposal site). Hauling and disposal costs are $23.23/1000 gallons.

Landfills in Florida with arsenic leachate concerns cont'd

- Orange County Resource Rec Dept. phone (407) 836-7251, contact: Ryan. Arsenic concentration is 280 ppb. The leachate is disposed of through a pipe network to the nearby Orange County wastewater treatment plant. Cost of treatment is $3.17/1,000 gallons. Though they are surcharge for high concentration of heavy metals and for BOD that is over 300 mg/l and TSS that is over 300 mg/l. For July the flow was 3,584,000 gallons ($11,361.28) and the surcharge bill was $43,737.53.

- Polk County Solid Waste Division. (863) 284-4319, Interim solid waste director, Brooks Stayer. Maintain North Central Polk county, NE Landfill (Hanes City), SE Landfill (whales); also contact Allan Choate Sample date 4/14/05, 0.131 mg/l at Phase I Leachate Pumping Station; 0.072 mg/l at Phase II Leachate Pumping Station. Haul by truck to an industrial wastewater treatment facility. The County has an annual contract for the service. The contractor is Aqua Clean Environmental Co., Inc. in Lakeland. Hauling at $10.00 +Treatment/Disposal at $100.00 = $110.00/1,000 gallons.

- Santa Rosa County. (850) 626-0191, contact Julian Cooey. Central Landfill leachate has analyzed arsenic at: ,11/11/03 480.0 ppb, 06/01/04 24.0 ppb, 12/06/04 <5.0 ppb, 05/10/05 <5.0 ppb; Holley Landfill leachate has analyzed arsenic at: 11/04/03 28.0 ppb, 05/24/04 23.0 ppb 11/15/04 17.0 ppb 05/17/05 30.0 ppb; Current method of leachate disposal: Central and Holley leachate is presently trucked to a waste water facility in Milton, Florida. Disposal cost $7/1000 gallons.

Leachate Characteristics

- Marion County

	City of Ocala Limits	Marion County Leachate				
	mg/L					
		10/2/2002	3/26/2003	3/4/2004	3/8/2005	3/10/2006
Arsenic	0.06	0.04	0.033	0.066	0.1	0.1
Cadmium	0.53	0.005	<.001	0.00024	0.00013	0.00051
Chromium	14.44	0.038	0.013	0.039	0.1	0.072
Copper	2.95	0.05	0.013	0.0052	0.015	0.011
Lead	2.42	0.01	<.005	<.00189	0.097	0.0056
Mercury	0.6	0.0005	<.0001	0.000056	0.00018	0.000073
Nickel	4.38	0.11	<.0052	0.15	0.17	0.11
Selenium	0.54	0.01	<.01	<0.004	0.0021	0.0065
Silver	1.43	0.01	<.005	0.0042	0.0022	0.003
Zinc	5.51	0.1	0.022	0.05	0.19	0.066

Obtained from the Mike Sims of the Marion County Board of County Commissioners, Marion County Solid Waste Department.

Leachate Characteristics

- Polk County

	Polk County Leachate (mg/L)			
	3/6/2003-7/16/2003	9/10/2003-1/15/2004	9/10/2003-1/15/2004	3/8/2004-7/15/2004
	Leachate Tank	Leachate 1	Leachate 2	Leachate Tank
Arsenic	0.043	0.083	0.07	0.0712
Cadmium	0.011	0.0183	0.0081	0.002
Chromium	<0.001	0.0251	0.0214	0.0198
Copper	<0.005	<0.005	<0.005	0.0147
Lead	0.0335	0.0282	0.0256	0.0329
Mercury	<0.0001	0.0003	0.0001	<0.0001
Nickel	<0.0722	0.219	0.161	0.148
Selenium	<0.005	<0.005	<0.005	<0.005
Silver	0.0143	0.0063	0.0093	0.0074
Iron	27.16	3.746	21.278	6.3
Zinc	0.0129	0.0346	0.121	0.0343

	Polk County Leachate			
	3/6/2003-7/16/2003	9/10/2003-1/15/2004	9/10/2003-1/15/2004	3/8/2004-7/15/2004
	Leachate Tank	Leachate 1	Leachate 2	Leachate Tank
pH	7.21	7.12	7.12	7.51
DO (mg/L)	6.21	1.89	2.04	4.82
Bicarbonate (mg/L)	1873	2611	3424	2913
Chlorides (mg/L)	592	1266	867	1463
TDS (mg/L)	2480	3820	3820	4300
xylenes (ug/L)	44.2	88.5	34.47	51.6
benzene (ug/L)	<10	2.21	5.71	3.99

Analysis of Leachate Samples

filtered/unfiltered → pH, alkalinity, DO, TDS, etc.

↓

acid digestion

↓

heavy metal analysis

AA, ICP-MS

As speciation

Atomic Absorption Spectrometer

HG-Flame and Furnace

Leachate Treatment: Green Applications

- ***Phragmites australis,*** or common weed was used in constructed wetlands in a leacahte treatment study.
- Leachate was pumped through constructed wetland beds, where metals that could act as nutrients to the plant were adsorbed though the roots.
- Because of the natural environment of the plant, its roots are suited to grow in low oxygen environments, rich in iron and manganese.
- These conditions can lead to the development of anaerobic micro-zones and coating of Fe and Mg on the plant roots.
- The Fe and Mg plaque acts as a filter and adsorptive surface for metal content, removing amounts of copper, phosphorus, and Zn, etc.

(Peverly, 1995)

Basic Treatments

- Membrane Processes
  - Membrane processes are becoming increasingly popular in leachate treatment
  - Some examples include: nanofiltration, ultrafiltration, or reverse osmosis
- Adsorption Processes
  - Pollutants are adsorbed to different solid materials such as activated carbon
- Oxidation Processes
  - This is the only type of treatment where contaminants are chemically transformed into biodegradable substrates or harmless materials
- Coagulation-Flocculation
  - A substance (usually Ferric Chloride or Fentons reagent (Fe(III) + H_2O_2) is used to precipitate contaminants out at lower pH values

(Rivas, 2005)

Some highlighted treatments

- Wet OXONE oxidation + coagulation-flocculation + adsorption to activated carbon
  - This process achieved 90% COD removal from stabilized older leachate. The only treatment required after this would be a final biological polishing stage
- Electrochemical oxidation
  - After 240 minutes of electrolysis with a oxide coated titanium anode, 92% of COD in leachate was removed.
  - However, when compared to energy costs, it proves to be inefficient, because of the high ammonia content that had to be broken down.
  - So if nitrogen removal treatment could be applied before hand, not only would effeciency increase, but total COD removal would increase as well.

(Rivas, 2005) (Chiang, 1995)

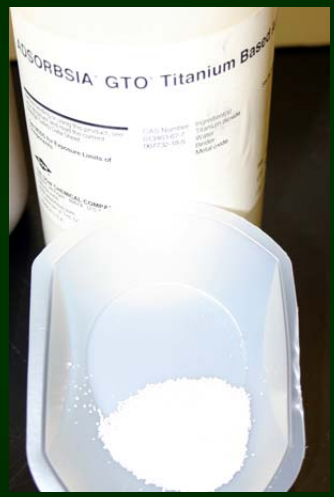
Sorbent Characterization

Materials:

The adsorbents studied are:

- Kemiron from Kemiron, U.S.A (iron oxide)
- Lanxess Bayoxide E33 from Severn Trent Services, USA (iron oxide)
- ADSORBSIA GTO (titanium dioxide) from DOW Chemical Company, USA
- ALCOA DD660 (aluminum oxide)

Sorbents cont'd



Sorbent Characterization Methods

Media grinding and sieving:
The dry media was ground in a mortar and pestle made of porcelain. The ground material was sieved in Tyler sieves (Fisher scientific, USA) to produce size range of particles.

Size fractions for analysis:
425 μm ≤size fraction ≥500 μm used for surface area analysis, porosity, Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS).
Less than 38 μm was used for X-ray diffractometry

Surface Area: BET Multi point N_2 sorption isotherm with NOVA 2200 Surface Analyzer at 77 Kelvin. The Bayoxide and Kemiron were dried and degassed at 80°C for 18 hours and 3 hours respectively prior to the surface area analysis while Adsorbsia GTO was degassed at 250°C for three hours. Analysis done by Dr. Sunol's lab group.

Porosity: Mercury Intrusion Porosimetry by Micromeritics

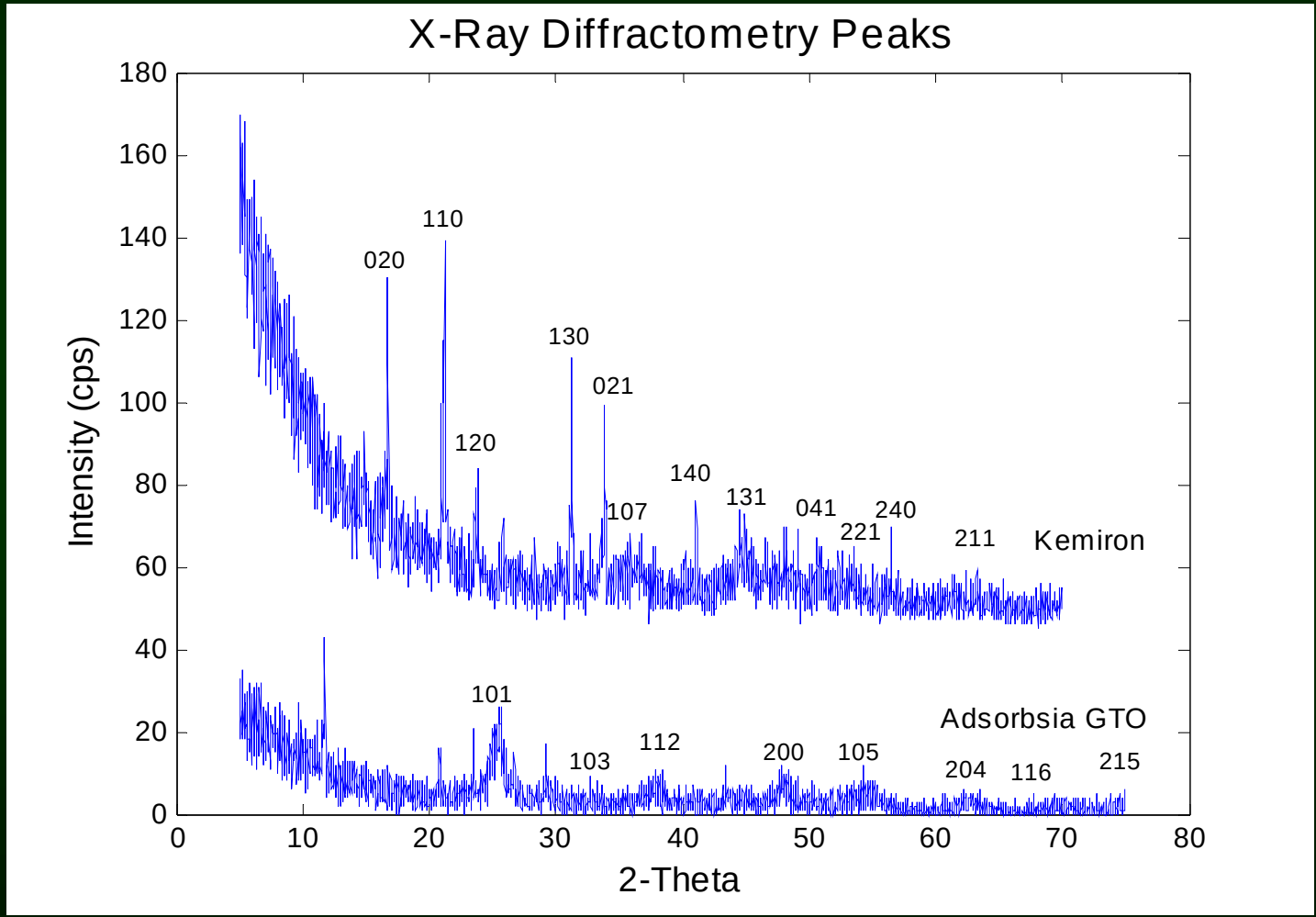
Philips MRD PW3060/20 X-Ray Diffractometer for lattice structure and d-spacing

Hitachi S-800 Scanning Electron Microscope.

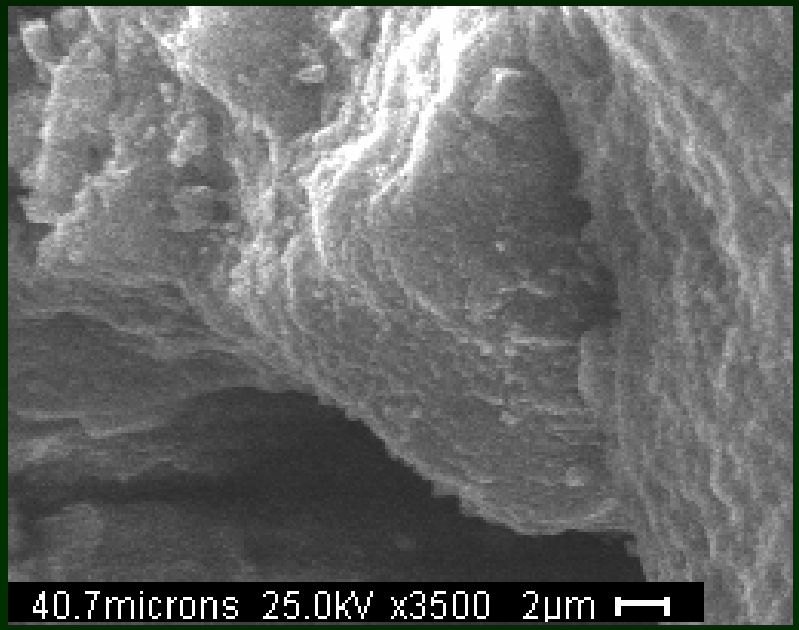
Sorbent Characterization

Property	Bayoxide E33	GTO Absorbsia	Kimiron
Total Pore Volume (ml/g)	1.5	0.90	0.25
Bulk Density @ 55 psia (g/ml)	0.571	0.74	1.32
Porosity (%)	85.36	67.35	55.19
Max Pore Diameter (μm)	328.456	327.6878	327.6878
Min Pore Diameter (μm)	0.003016	0.003016	0.003016
Median Pore Diameter (μm)	0.002	0.0057	0.0073
Mean Pore Diameter (μm)	0.0395	0.0348	0.0756
Total Surface Area (m^2/g)	94.98	207.45	89.52
XRD			goethite

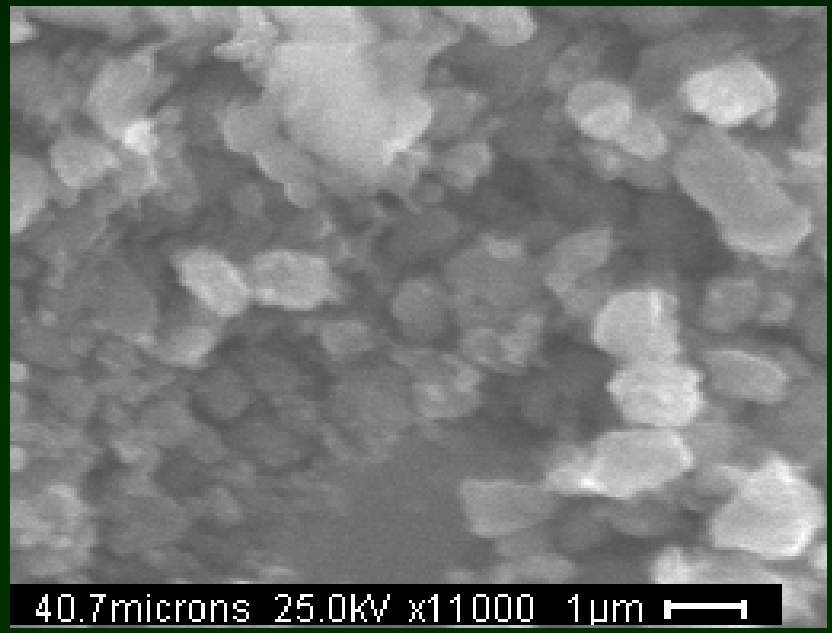
Sorbent Characterization



Sorbent Characterization: SEM

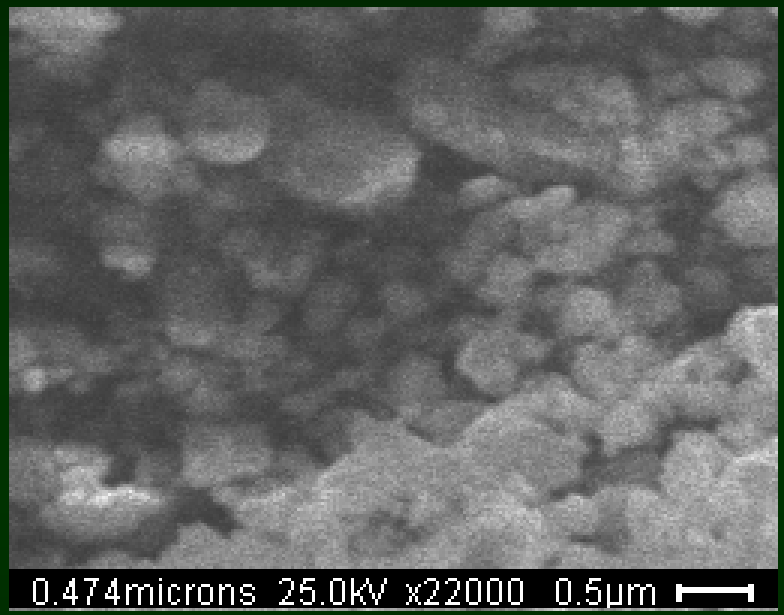


BAYOXIDE E33

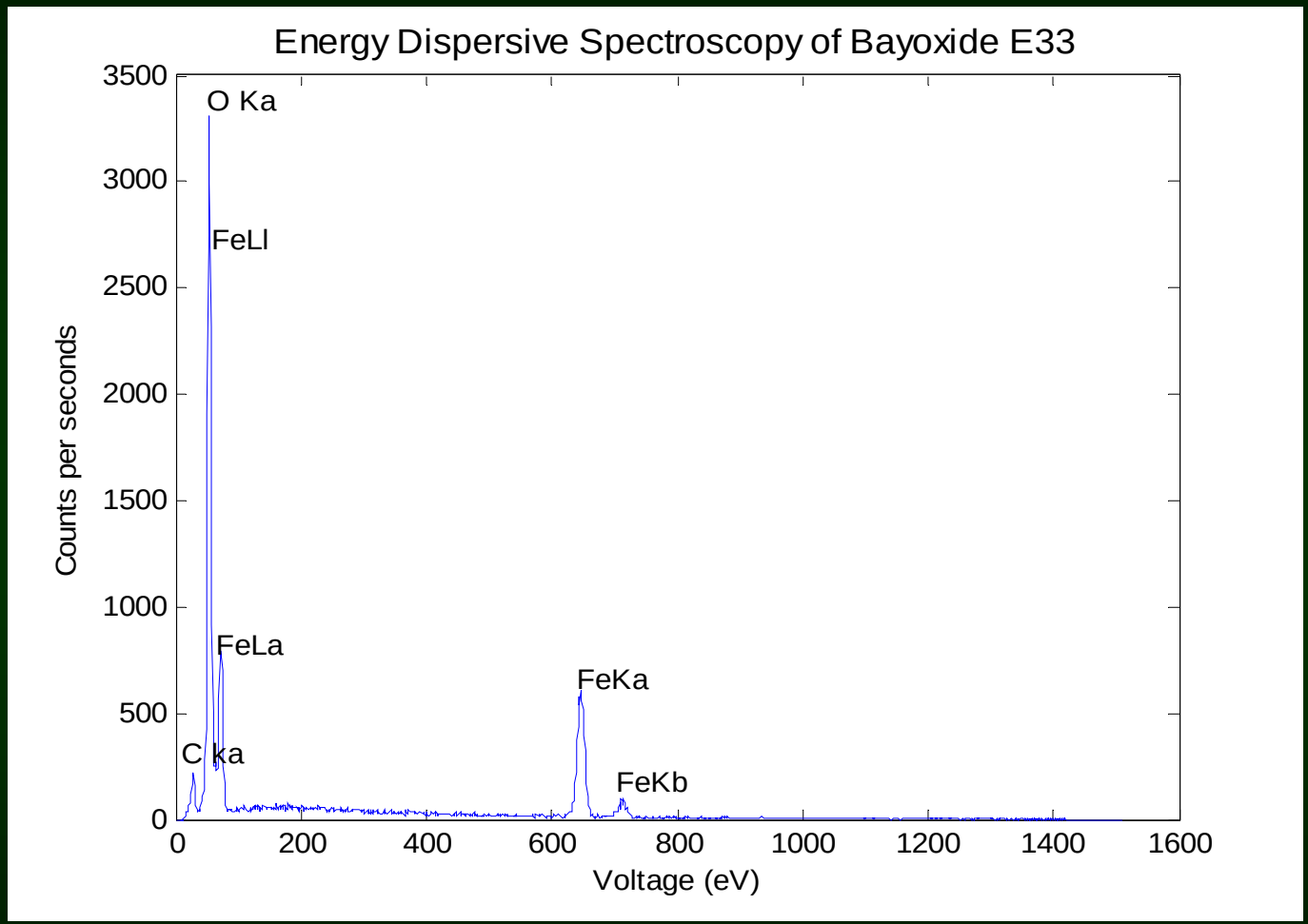


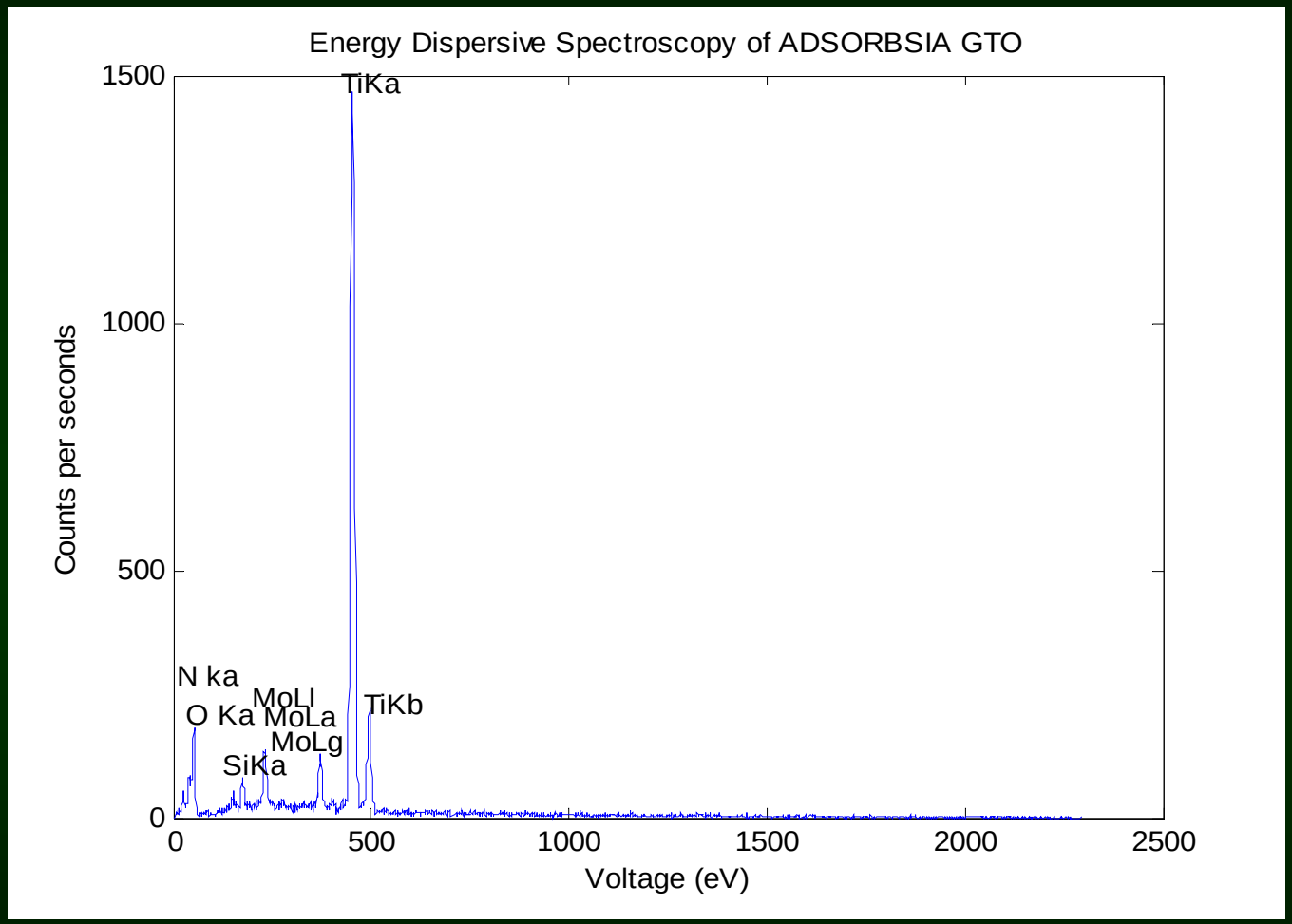
ADSORBSIA GTO

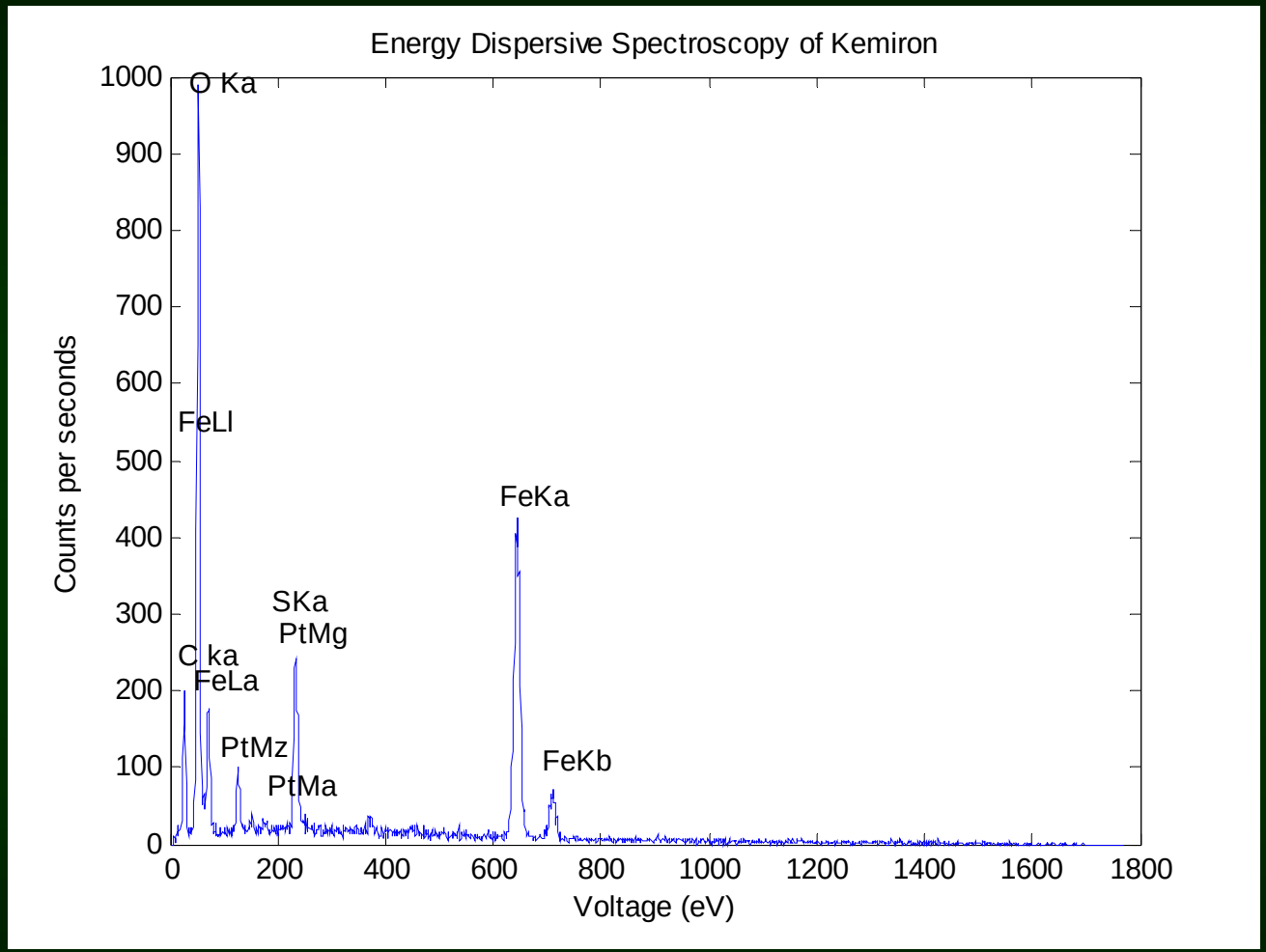
Sorbent Characterization: SEM



Kimiron


Energy Dispersive Spectroscopy of Bayoxide E33
Counts per seconds
Voltage (eV)
O Ka
FeLl
FeLa
FeKa
C ka
FeKb
0
500
1000
1500
2000
2500
3000
3500
0
200
400
600
800
1000
1200
1400
1600


Energy Dispersive Spectroscopy of ADSORBSIA GTO
Counts per seconds
Voltage (eV)
0
500
1000
1500
2000
2500
TiKa
N ka
O Ka
MoLl
MoLa
MoLg
SiKa
TiKb

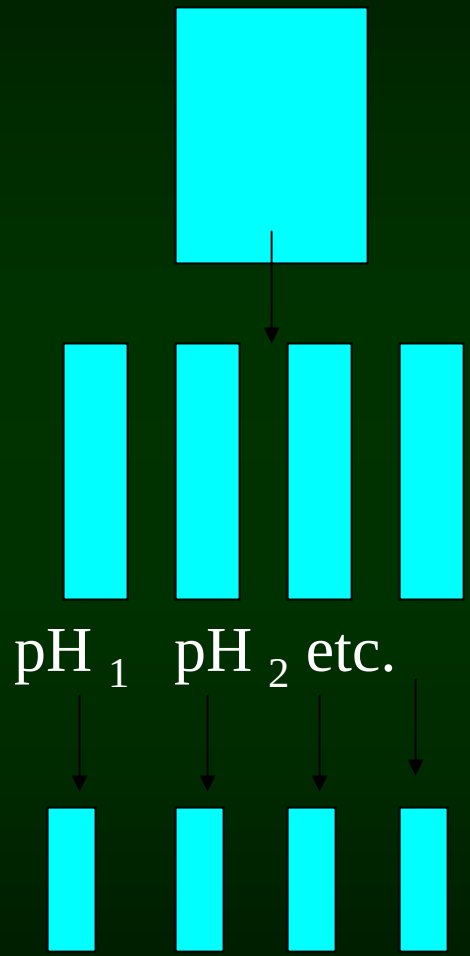

Energy Dispersive Spectroscopy of Kemiron
Counts per seconds
Voltage (eV)
O Ka
FeLl
C ka
FeLa
PtMz
PtMa
SKa
PtMg
FeKa
FeKb
0
100
200
300
400
500
600
700
800
900
1000
0
200
400
600
800
1000
1200
1400
1600
1800

Batch Experiments: Equilibrium Sorption

1. Pre-equilibrate fines (<38 μm)
Overnight. Increase pH to ~10, add As soln.

2. Drop pH & sample into 10 ml PC tubes.
Equilibrate for 24 hrs on end
over end shaker. Measure pH.

3. Pass through 0.2 μm PES filter,
acidify & analyze for As (GFAA)



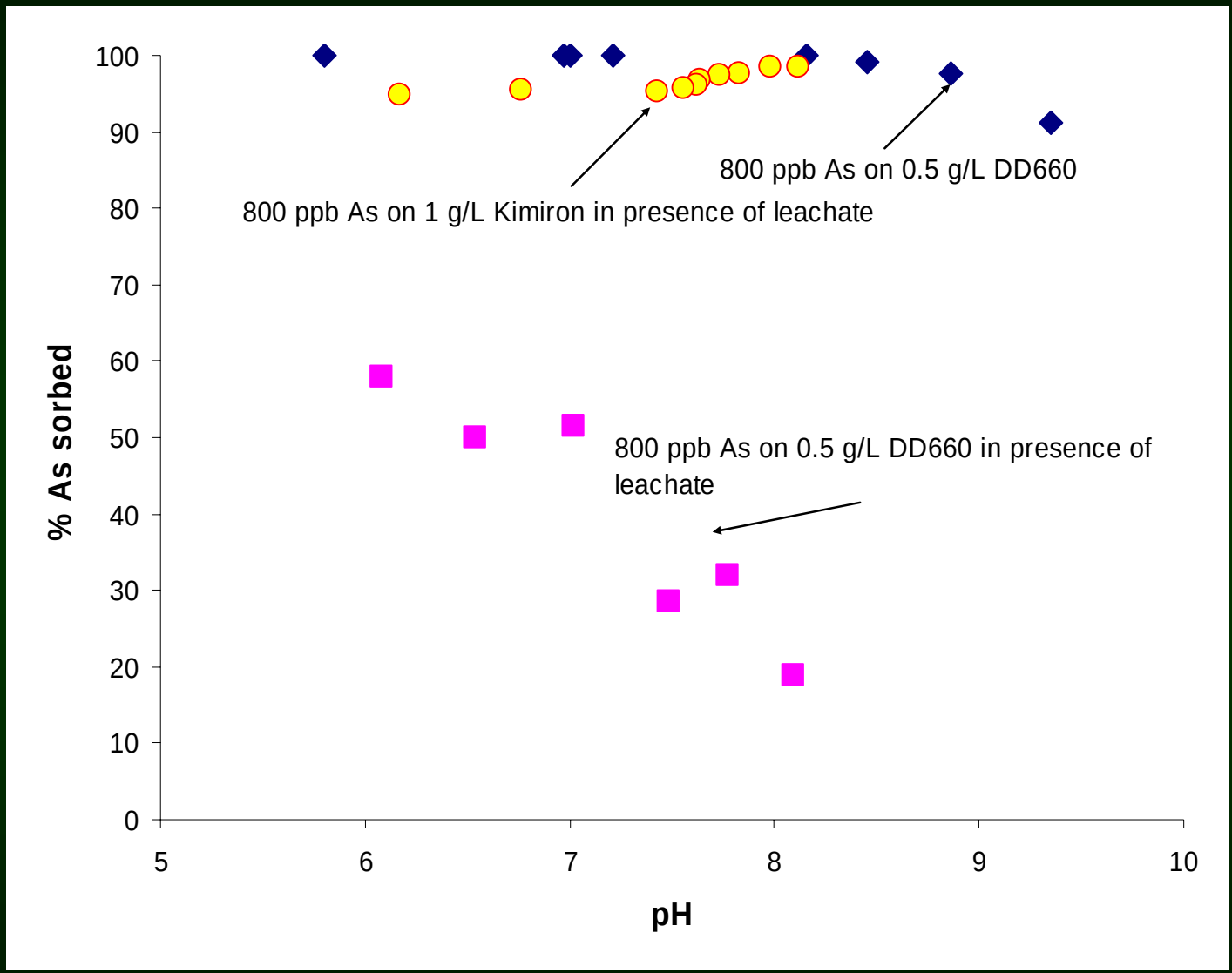
Batch Adsorption Tests

	Alumina DD660	Kimiron
Solids Conc. (mg/L)	0.5	1
m^2/L	200	180
$[As]_{tot}$ spiked	800, 800	100, 100, 800
With phase 1 leachate?	Yes, Yes	No, Yes, Yes
$[NaNO_3]$	0.1	0.1

	Total As (ug/L)		
	phase1	phase 2	phase 1&2
filtered	29.64	75.57	98.40
filtered & digested	91.28	60.94	126.42

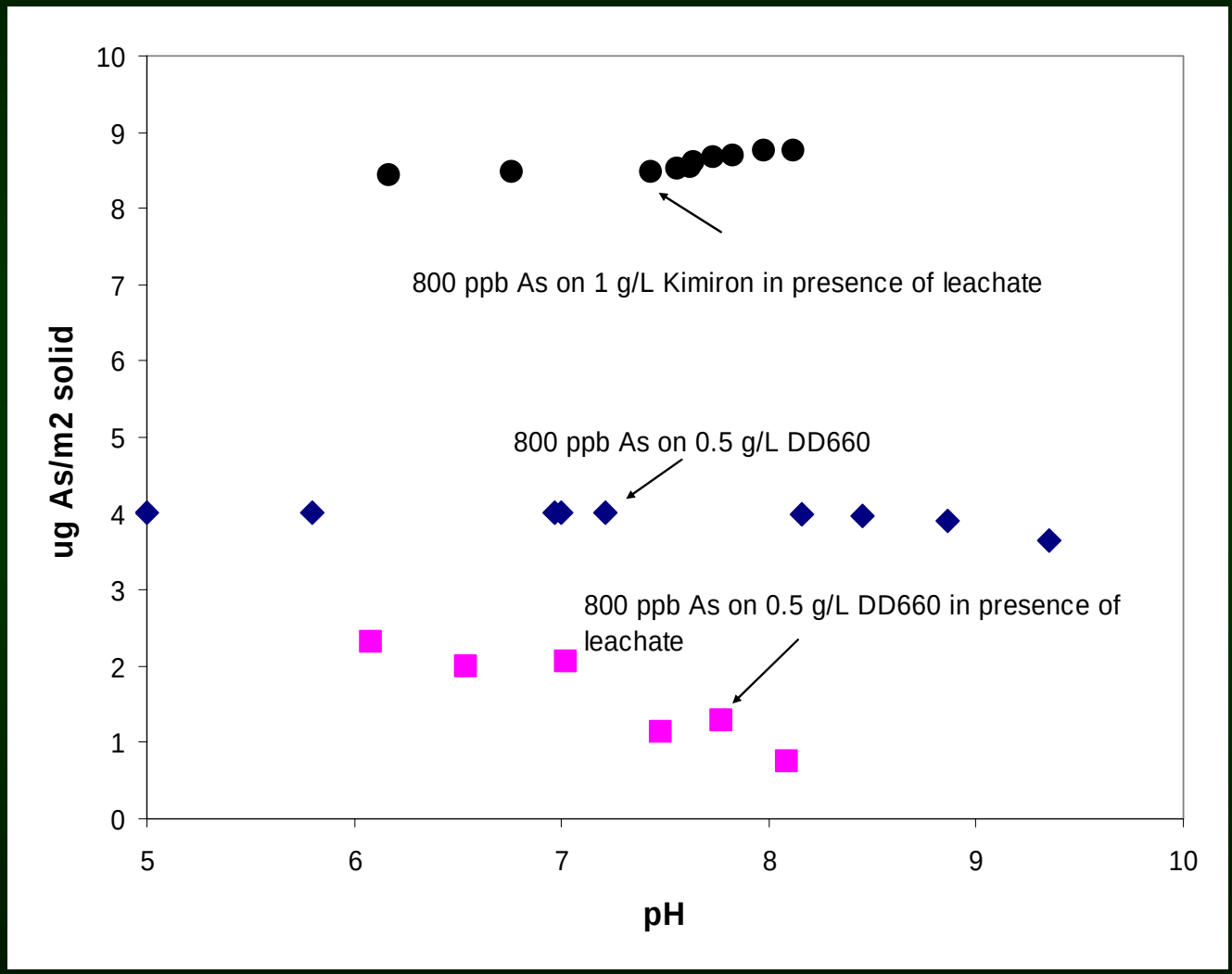
→ North Central Polk County Sampled: 4/21/06

Batch Adsorption Tests



100 ppb As tests on Kimiron gave undetectable aqueous arsenic.

Batch Adsorption Tests



Students Involved

Ryan Locicero (graduating senior) and Austin Roe (first year honor's student) taking a sample of phase II leachate at the North Central Landfill in Polk County

Douglas Oti, Ph.D. student analyzing Samples on the AA. Now trained on SEM and XRD.

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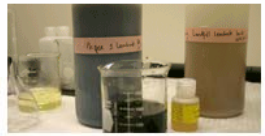
Welcome to Landfillinfo.net. This site is maintained by the Trotz research group in the Department of Civil and Environmental Engineering at the University of South Florida. In 2005 we received a grant from the Florida Center for Solid and Hazardous Waste to research treatment options for Arsenic in landfill leachate in Florida. Whilst this website must provide information on our research progress to satisfy grant requirements, we hope to expand its scope so that we provide useful information on landfills in general on the world wide web.






TAG MEETING: Tuesday May 2nd, 2006
USF, ENG C/III Room 3408
11 am - 2pm

USF COLLEGE OF ENGINEERING

Florida Center for Solid and Hazardous Waste Management

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start 2 Micros... 4 Micros... 2 Windo... 3 Micros... 2 Micros... Adobe Pho... Macromedi... LANDFILLIN... 12:01 AM

The next 6 months

- Complete compilation of landfill leachate information for the 7 identified landfills
- Develop protocol for arsenic speciation.
- Complete batch adsorption experiments using: Kimiron, Bayoxide and GTO Adsorbsia.
- Complete equilibrium modeling experiments.

Acknowledgements

- Mr. Allan Choate, P.E. (Polk County Landfill)
- Mr. William "Lee" Martin, P.E. (FDEP)
- Mr. Ryan Locicero, REU student at USF
- TAG committee members for attending
- Mr. Douglas Oti, PhD. student at USF
- Mr. Austin Roe, Undergraduate researcher at USF

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