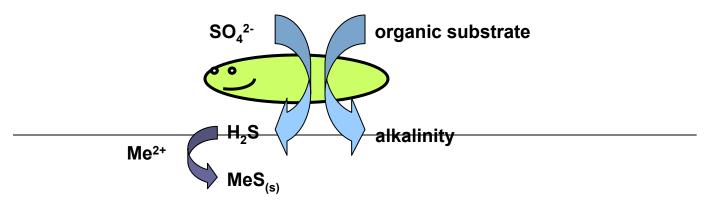
Assessing Sustainability of Organic Substrates in Passive Bioreactors Treating Mining Influenced Water

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Outline

- Introduction
- > Approach
- Field Sites
- Results
- Summary



Issue

Many western states in have environmental problems associated with historic and current mining operations

Needs

Cost effective technologies Low operation and maintenance technologies

Constraints Many sites are remote and are subject to low temperatures Seasonal variations in temperature and flow

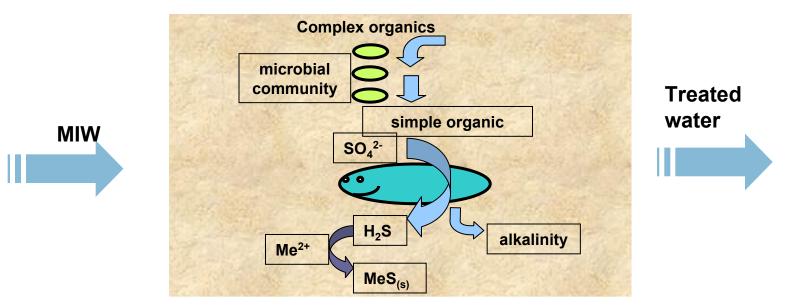






One approach: Passive Bioreactors

Low operation and maintenance Passive flow Inexpensive





Passive Bioreactor

- Bioreactor: Any treatment system that relies on coupled microbial transformations and chemical reactions to remove contaminants from MIW
- Passive: Does not require the active addition of chemical reagents, power or short-term substrate or residual management
 - wetlands
 - permeable reactive barriers
 - sulfate-reducing bioreactors







Mining influenced water (MIW)

Any water whose chemical composition has been affected by mining or mineral processing activities

- May lead to increased levels of
 - Sulfate
 - Acidity
 - Metals (e.g., As, Cd, Cu, Fe, Pb, Se, U, Zn)

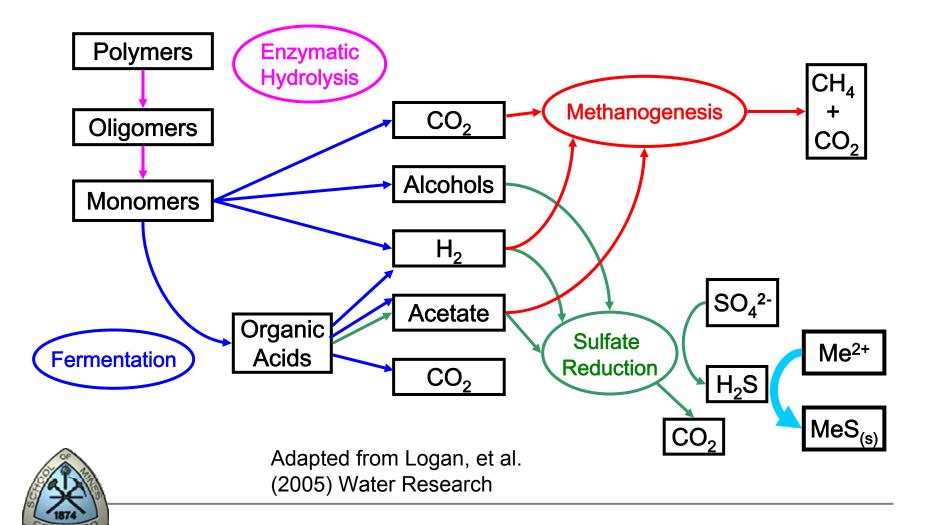


Critical reactions

- $2CH_2O + SO_4^{2-} => H_2S + 2HCO_3^{-}$
 - CH₂O represents organic matter present
 - System will operate as long as there is organic matter present
 - Some practitioners project 20 to 30 years
 - Many systems fail before 5 years
- How can we determine the characteristics of a sustainable reactive mixture (organic substrate)?



Anaerobic Bioreactor Microbial Community



Why Assess Substrate?

- > Tool for planning substrate selection
 - Identify selection criteria
- Determine microbial utilization rate
- Understand declines in system performance
- Indicate when reactive mixture needs replacement
- Sustain system by optimizing "food" available for microbial community



Substrate Assessment Goals

Provide organic substrate for the microbial community

to support target organisms (anaerobes, SRB)
to promote sustainable degradation over time
to maximize achievement of treatment goals

Track substrate alterations

>identify upstream rate limiting steps

- >determine initiation reactions
- >monitor solid phase food consumption



Approach

Measurement of reactants and products

From lab microcosms

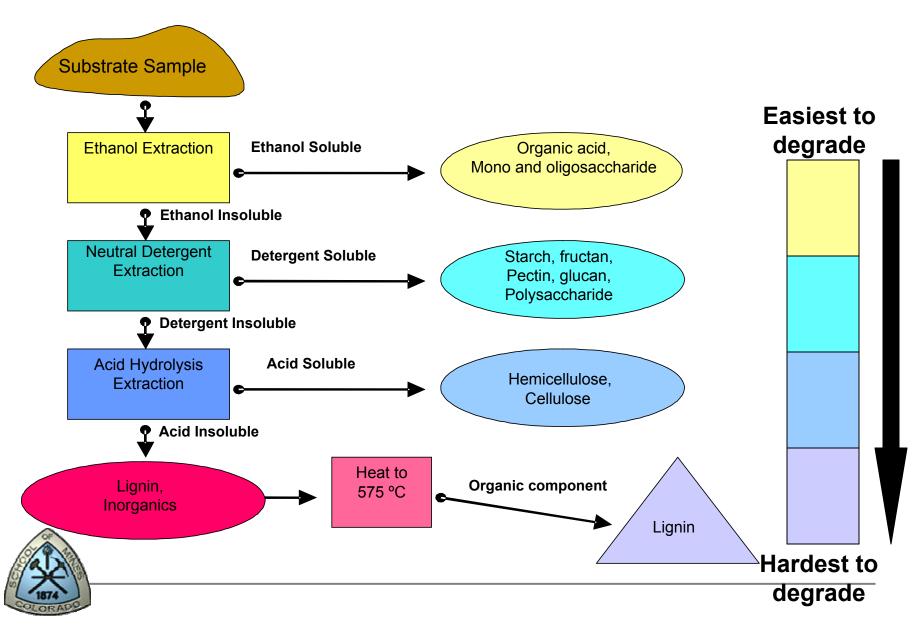
Solution phase
Solid phase
Gas phase

From field sites

Solution phase
Solid phase

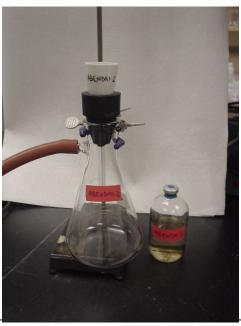


Sequential Extraction Technique



Extraction procedures











Montana Field Sites

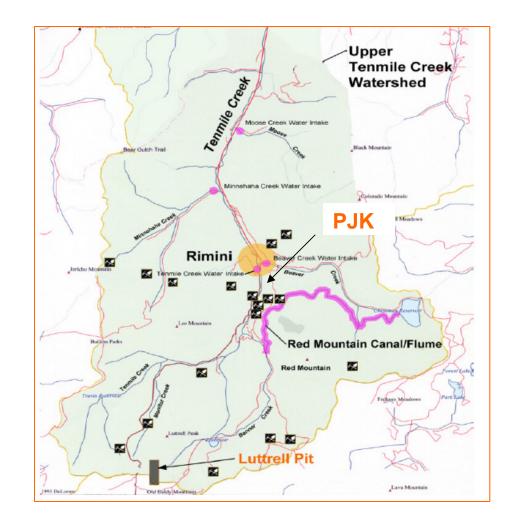
Luttrell Repository

Repository for mine waste

SRBR installed for treatment of runoff from the repository

Peerless Jenny King Mine

Wetland and series of SRBR installed for treatment of adit drainage



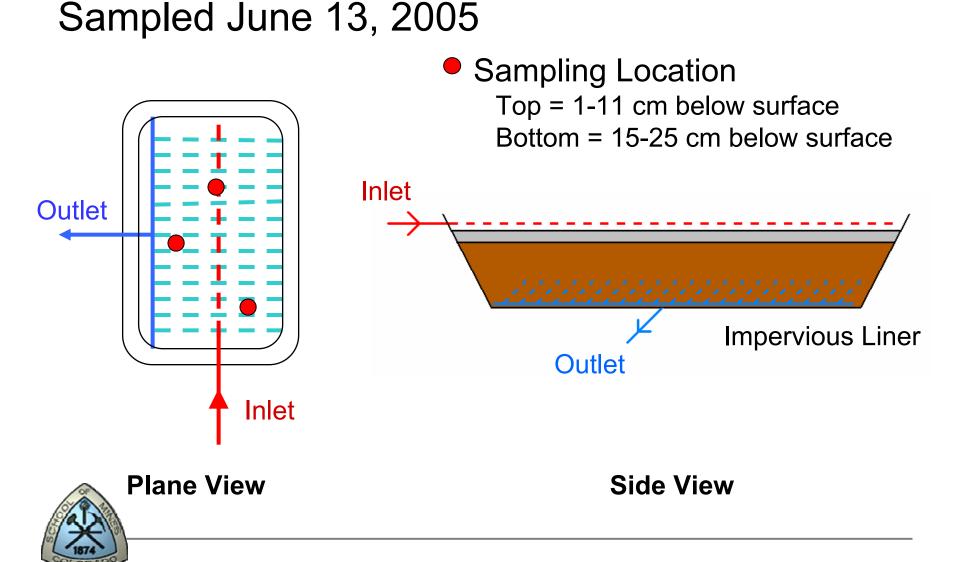


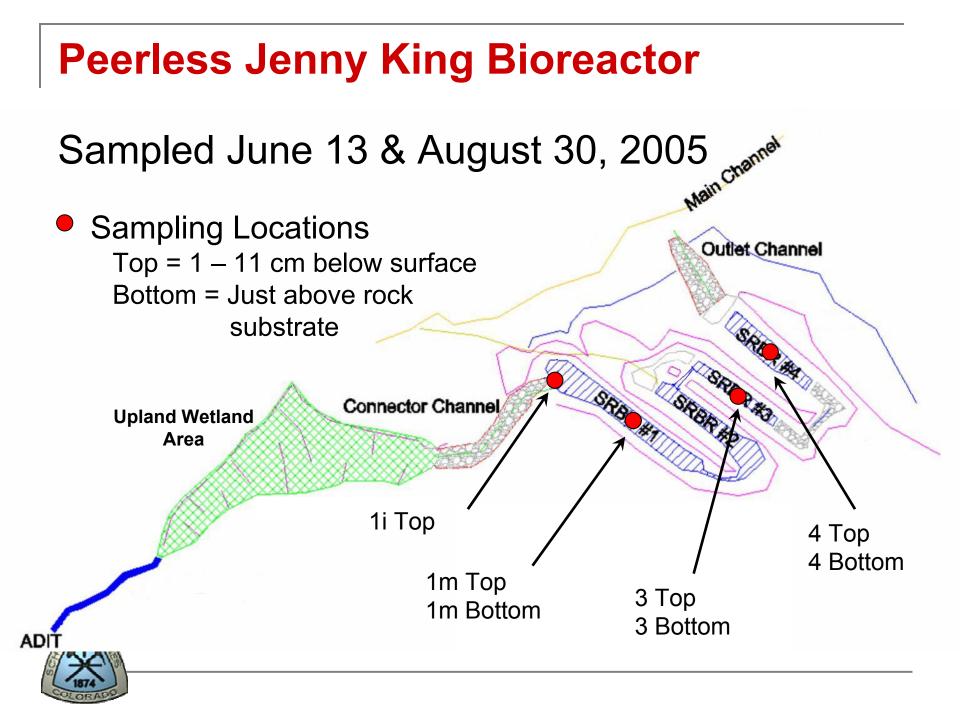
Montana Site Design Comparison

	Luttrell	PJK
Flow Type	Vertical	Horizontal
Reactive zones	1	4 in series
рН	~ 6	~ 6
Sulfates, mg/L	1000	100
Zinc, mg/L	40 - 200	2
Manganese, mg/L	40 - 170	5
Aluminum	Trace	-
Cadmium	Trace	Trace
Copper	Trace	-
Iron	Trace	Trace
Nickel	Trace	-

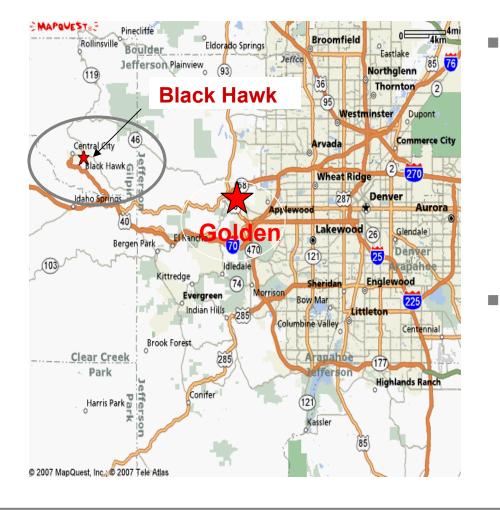


Luttrell Bioreactor





Colorado Field Site



- The National Tunnel discharges MIW into the North Fork of Clear Creek.
 - It is a major contributor to contaminants in the Clear Creek/Central City Superfund Site.
- It is located in Black Hawk, CO, approximately 18 miles west of Golden.

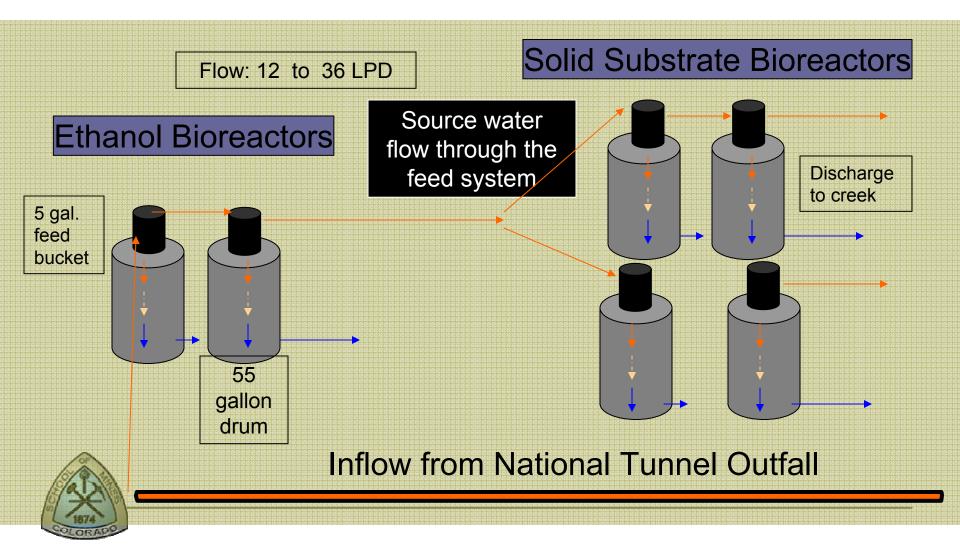


Colorado Site Design Comparison

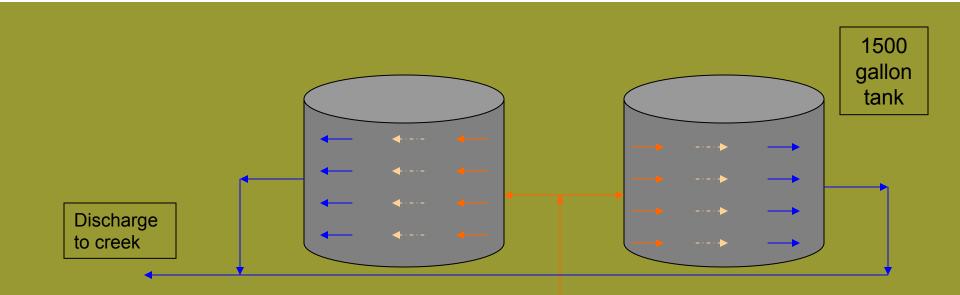
	<u>Study 1</u>	<u>Study 2</u>
Flow Type	Vertical	Horizontal
Ν	MIW Quality	mg/L
-		
p	эΗ	≈ 6
2	Sulfates, <u>mg/L</u>	800-1000
Zinc, <u>mg/L</u>		5-15
Ν	Manganese, <u>mg/L</u>	20-25
A	Aluminum, <u>mg/L</u>	<1
Cadmium, <u>mg/L</u>		-
(Copper, <u>mg/L</u>	0.1-1.0
I	ron, <u>mg/L</u>	30-50
1	Nickel, <u>mg/L</u>	-



Colorado Study 1-Experimental Design Sampled May 15, 2007



Colorado Study 2 - Experimental Design Sampled May 2007



Flow: 1 to 1.5 LPM

Inflow from National Tunnel Outfall

Montana Field Sampling



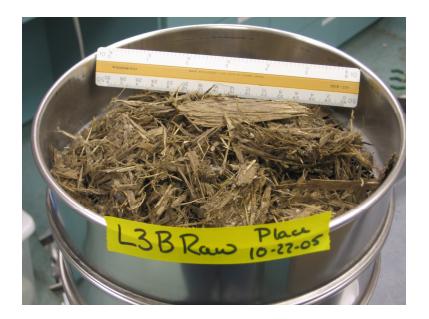








Lutrell sample







Particle size distribution

PJK Cell 1 Front / Bottom (June)				
Size Fraction	Mass of Fraction (g)	Mass of Rock (g)	Mass for Lab Sample (g)	
1	28.0	27.6	0.4	
2	51.4	11.3	40.1	
3	60.9	0.0	60.9	
4	46.7	0.0	46.7	
5	55.5	0.0	55.5	
6	10.2	0.0	10.2	
7	15.5	0.0	15.5	
Total	268.2	38.9	229.3	

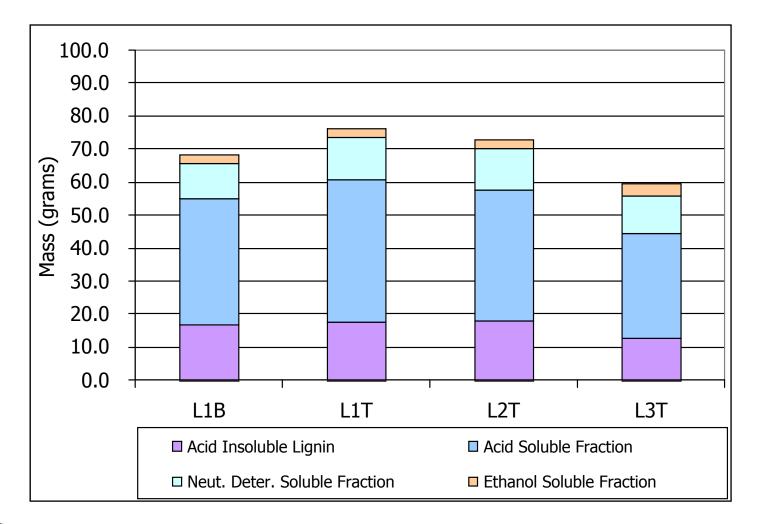


Particle size complications

LUT Hole 1 Bottom (June)				
Size Fraction	Mass of Fraction (g)	Mass of Rock (g)	Mass for Lab Sample (g)	
1	170.7	166.5	4.2	
2	19.1	8.2	10.9	
3	22.5	0.0	22.5	
4	16.3	0.0	16.3	
5	13.6	0.0	13.6	
6	1.6	0.0	1.6	
7	1.8	0.0	1.8	
Total	245.5	174.7	70.8	

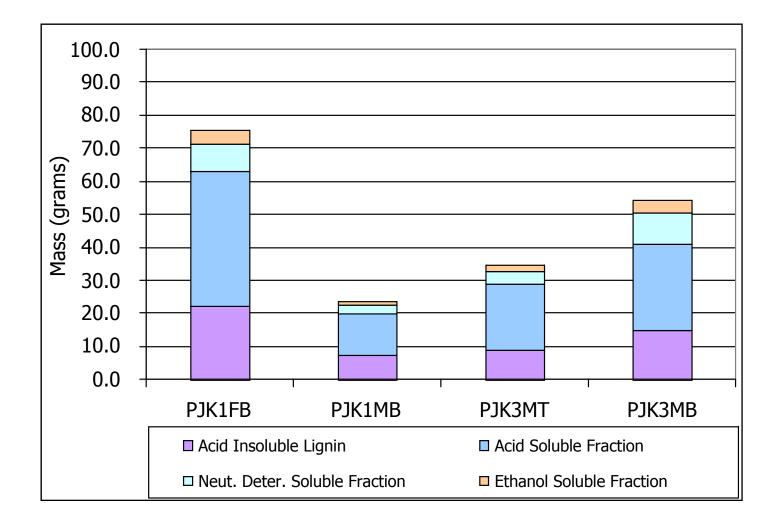


Substrate composition - Lutrell



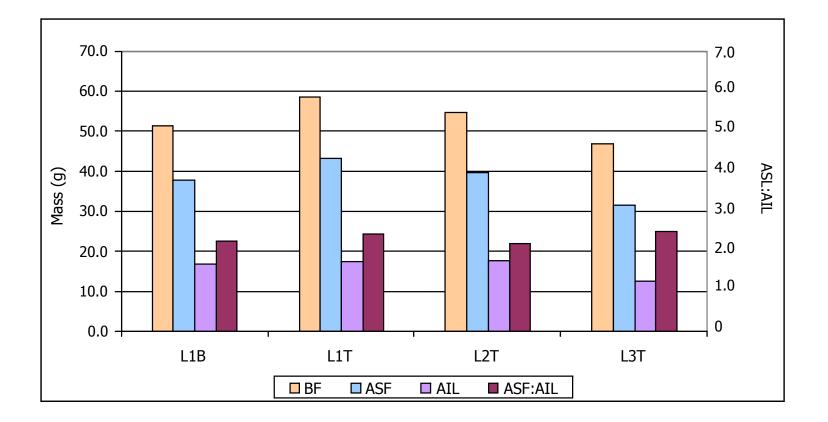


Substrate composition-PJK



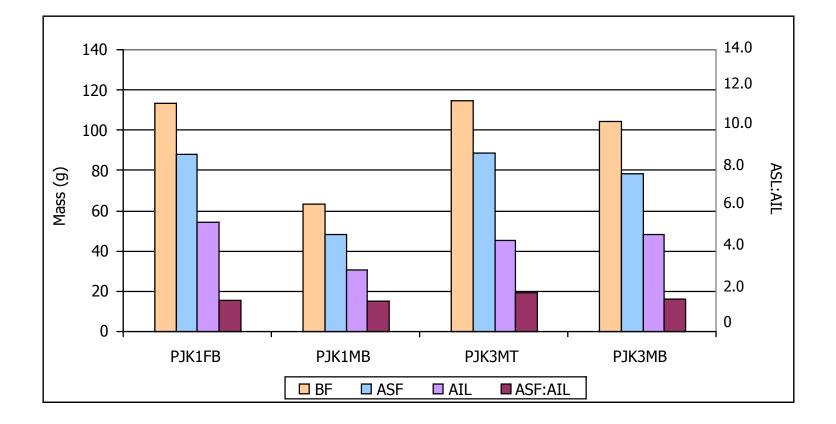


Another way to look at the data-Lutrell



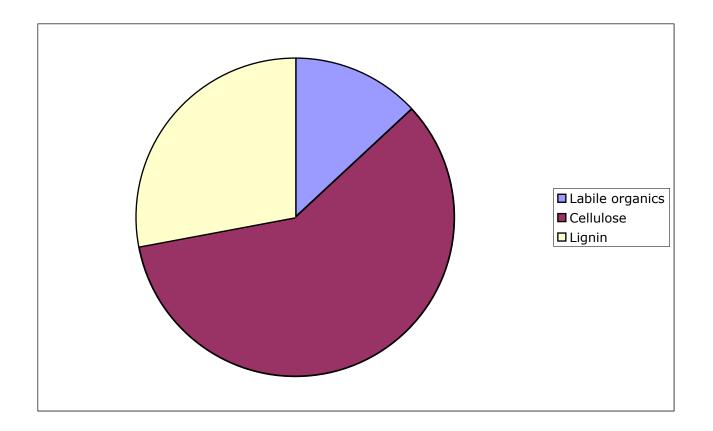


Another way to look at the data-PJK





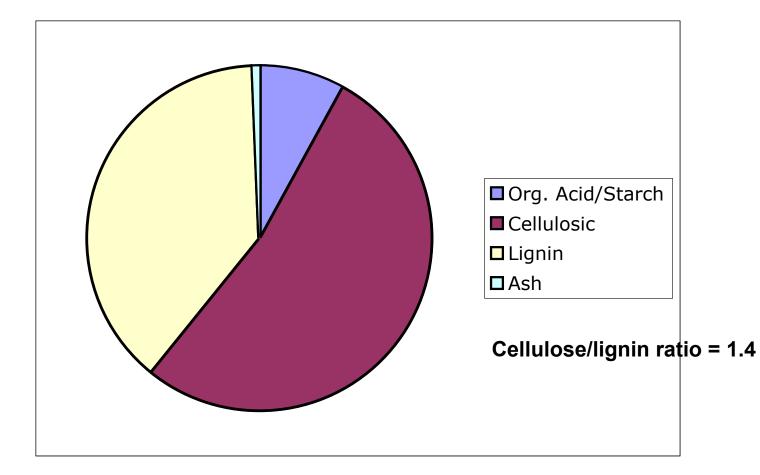
Substrate composition-Colorado Study 1



Cellulose/lignin ratio = 2.2



Substrate composition-Colorado Study 2





Summary

- Bioreactor systems should be designed to facilitate sampling of solid phase materials
- Total cellulose coupled with cellulose to lignin ratio are potential criteria for sustainability
- Bioreactor design affects the rate at which solid phase organic substrates are degrades
- Exposure to oxygen increase the rate of organic substrate depletion
- Assessment of substrate composition from field systems provides information about extent of utilization



Future Work

Biogeochemical reactions module

- Validation of key microbial processes through coupled biogeochemical and transport modeling
- Molecular microbial characterization
 - Identify major microbial functions
- > Quantify changes in organic substrates
 - Characterize soluble organic carbon
 - Simplify sequential extraction protocol
 Bioassay
 - Develop rapid bioassay protocol



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The rest of the crew





Questions



Thank you!