Coal Combustion Byproduct Management in Mined Land Environments

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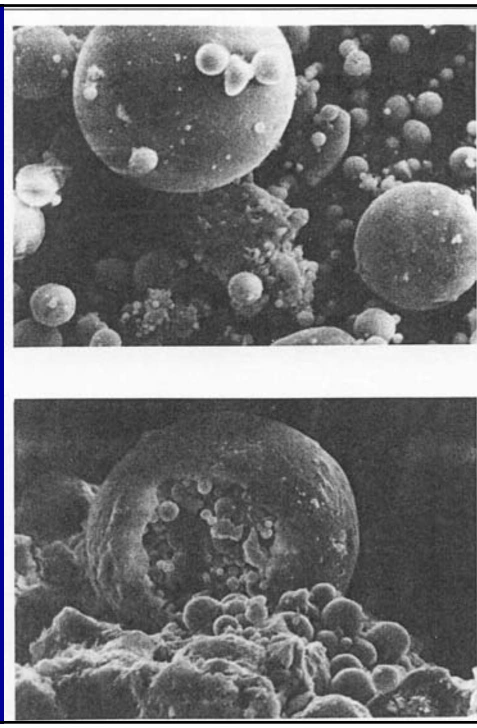
Talk Objectives

Review the Powell River Project's earlier research program on fly ash utilization on mined lands.

Discuss findings from current (2004-2007) PRP funded study entitled: *Properties and Potential Water Quality Effects of Post-2000 Coal Combustion Products*

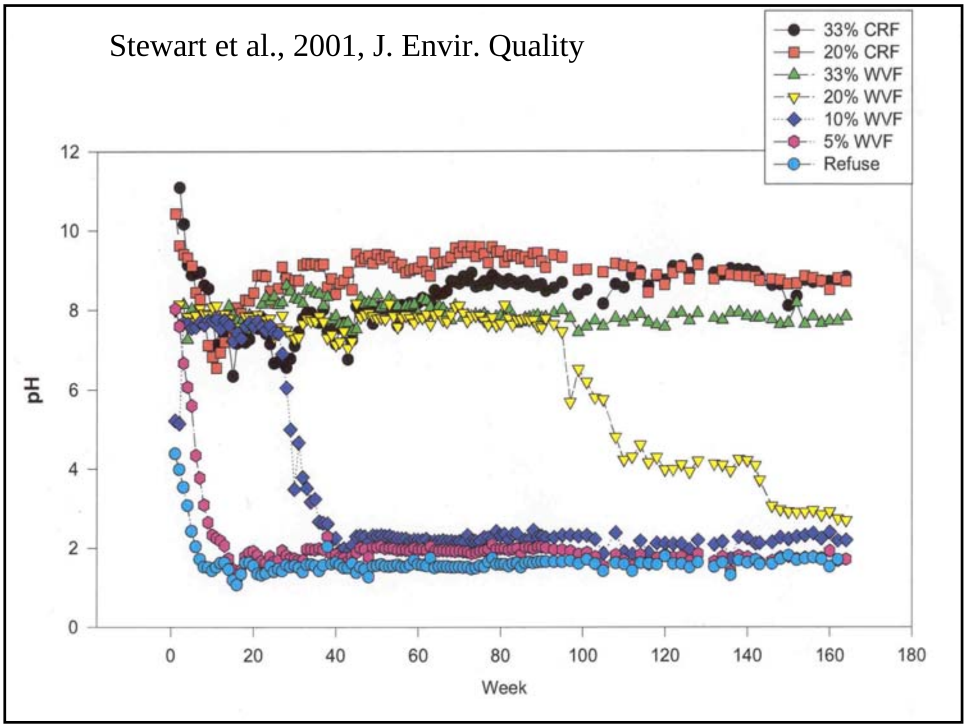
Fly ash is often composed of amorphous alumino-silicates that cool into round spheres as stack gases rise. These cenospheres are often porous and light in density. Heavy metals are usually concentrated on the outer rinds of the spheres. Fly ash also commonly contains shards of minerals like feldspars, unburned C, and other fine sized particles.

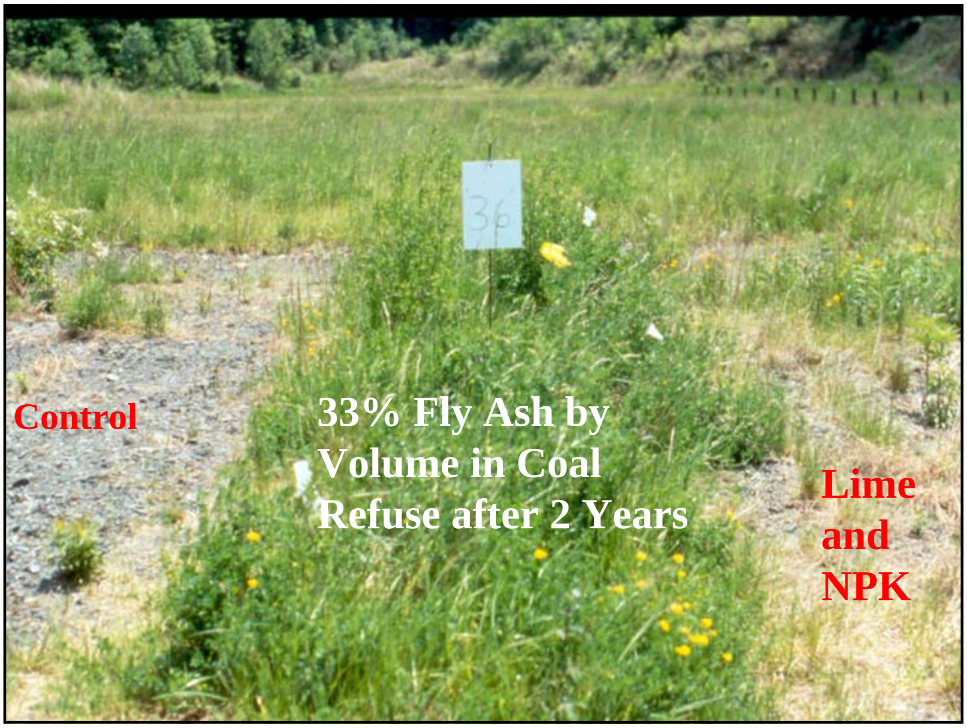


Powell River Project Fly Ash Utilization Research Program

- **Between approximately 1991 and 1998, the Powell River Project and other sponsors supported detailed work by the CSES Dept. on the potential benefits and risks of fly ash utilization in mined land environments.**
- **Our work focused on coal fly ash and not other CCP's as discussed later.**


One of many fly ash impoundments/fills
sampled in early 1990's.

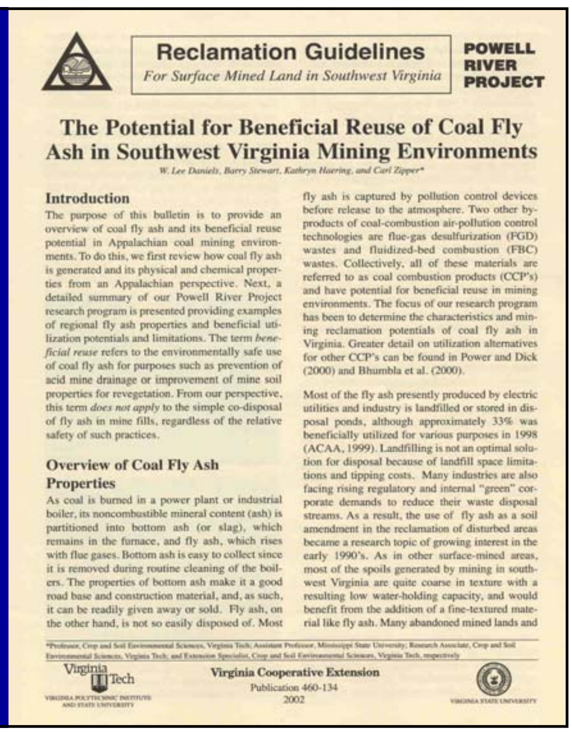

Stewart et al., 2001, J. Envir. Quality
33% CRF
20% CRF
33% WVF
20% WVF
10% WVF
5% WVF
Refuse
pH
Week
0
2
4
6
8
10
12
0
20
40
60
80
100
120
140
160
180


Control
33% Fly Ash by
Volume in Coal
Refuse after 2 Years
Lime
and
NPK

Soluble salt/B damage on soybean plants grown in sandstone mine spoil amended with 10% coal fly ash.

Most legumes are very sensitive to salt damage, so seeding should be delayed until after salts leach where possible.

PRP Reclamation Guidelines Bulletin 460-134 summarizes our findings from all aspects of studies summarized today.



Reclamation Guidelines

For Surface Mined Land in Southwest Virginia

POWELL RIVER PROJECT

The Potential for Beneficial Reuse of Coal Fly Ash in Southwest Virginia Mining Environments

*W. Lee Daniels, Barry Stewart, Kathryn Haering, and Carl Zipper**

Introduction

The purpose of this bulletin is to provide an overview of coal fly ash and its beneficial reuse potential in Appalachian coal mining environments. To do this, we first review how coal fly ash is generated and its physical and chemical properties from an Appalachian perspective. Next, a detailed summary of our Powell River Project research program is presented providing examples of regional fly ash properties and beneficial utilization potentials and limitations. The term *beneficial reuse* refers to the environmentally safe use of coal fly ash for purposes such as prevention of acid mine drainage or improvement of mine soil properties for revegetation. From our perspective, this term *does not apply* to the simple co-disposal of fly ash in mine fills, regardless of the relative safety of such practices.

Overview of Coal Fly Ash Properties

As coal is burned in a power plant or industrial boiler, its noncombustible mineral content (ash) is partitioned into bottom ash (or slag), which remains in the furnace, and fly ash, which rises with flue gases. Bottom ash is easy to collect since it is removed during routine cleaning of the boilers. The properties of bottom ash make it a good road base and construction material, and, as such, it can be readily given away or sold. Fly ash, on the other hand, is not so easily disposed of. Most fly ash is captured by pollution control devices before release to the atmosphere. Two other by-products of coal-combustion air-pollution control technologies are flue-gas desulfurization (FGD) wastes and fluidized-bed combustion (FBC) wastes. Collectively, all of these materials are referred to as coal combustion products (CCP's) and have potential for beneficial reuse in mining environments. The focus of our research program has been to determine the characteristics and mining reclamation potentials of coal fly ash in Virginia. Greater detail on utilization alternatives for other CCP's can be found in Power and Dick (2000) and Bhumbla et al. (2000).

Most of the fly ash presently produced by electric utilities and industry is landfilled or stored in disposal ponds, although approximately 33% was beneficially utilized for various purposes in 1998 (ACAA, 1999). Landfilling is not an optimal solution for disposal because of landfill space limitations and tipping costs. Many industries are also facing rising regulatory and internal "green" corporate demands to reduce their waste disposal streams. As a result, the use of fly ash as a soil amendment in the reclamation of disturbed areas became a research topic of growing interest in the early 1990's. As in other surface-mined areas, most of the spoils generated by mining in southwest Virginia are quite coarse in texture with a resulting low water-holding capacity, and would benefit from the addition of a fine-textured material like fly ash. Many abandoned mined lands and

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Properties and Potential Water Quality Effects of Post-2000 Coal Combustion Products

- **To determine the basic chemical and physical properties of a large set of modern CCP's generated by combustion of SW Virginia coals, including FGD materials and fly ash produced by emerging air emission control technologies.**
- **To estimate the likely effect of changes in coal combustion technologies such as low NOx boilers and various mercury removal strategies on ash chemical and physical properties.**

Properties and Potential Water Quality Effects of Post-2000 Coal Combustion Products

- **To predict the relative leaching risk of oxyanions such as As, B, Mo and Se in common SW Virginia coal mining/ash utilization environments.**
- **To evaluate the full range of CCP products that will likely be available for back-haul utilization and co-disposal for their suitability as (a) topical mine soil amendments, (b) geochemically stable backfill materials, and (c) bulk-blended treatments for acidic coal waste materials.**

Summary of Methods

A. Five CCP's were selected from the larger sample set for a greenhouse bioassay study on the plant growth effects of land-application of CCP's to mine soils at typical soil amendment rates.

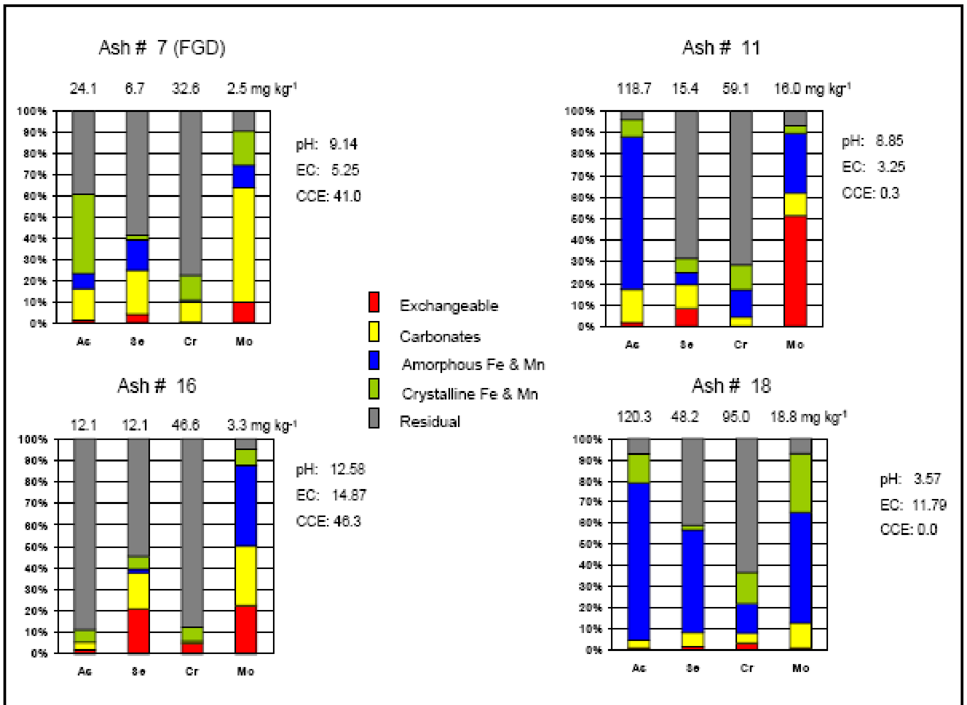
B. Similarly, the same CCP's (with one substitution) were selected for a laboratory leaching study to assess the effect of differing CCP properties and loading rates on leachate quality from acidic coal refuse.

CCP Properties

			Saturated Paste			
CCP #	Type	Bd $g\ cm^{-3}$	pH	EC $dS\ m^{-1}$	CCE %	Ext. B $mg\ L^{-1}$
28	Fly ash	1.12	11.5	3.1	16.3	3.6
11	Fly ash	1.50	8.9	3.3	0	185
16	Fly ash	1.15	12.6	14.9	53	16
27	Fly ash	1.20	11.9	4.5	57	nd
7	FGD	0.80	9.1	5.3	49	23

CCP Properties

CCP #	Total B	As	Se	Cr	Mo
	Total Elemental Analysis via Micro Digestion				
	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
28	82	57	11	70	11
11	574	179	15	130	50
16	789	14	11	73	37
27	841	23	4	86	9
7	225	19	3	36	8

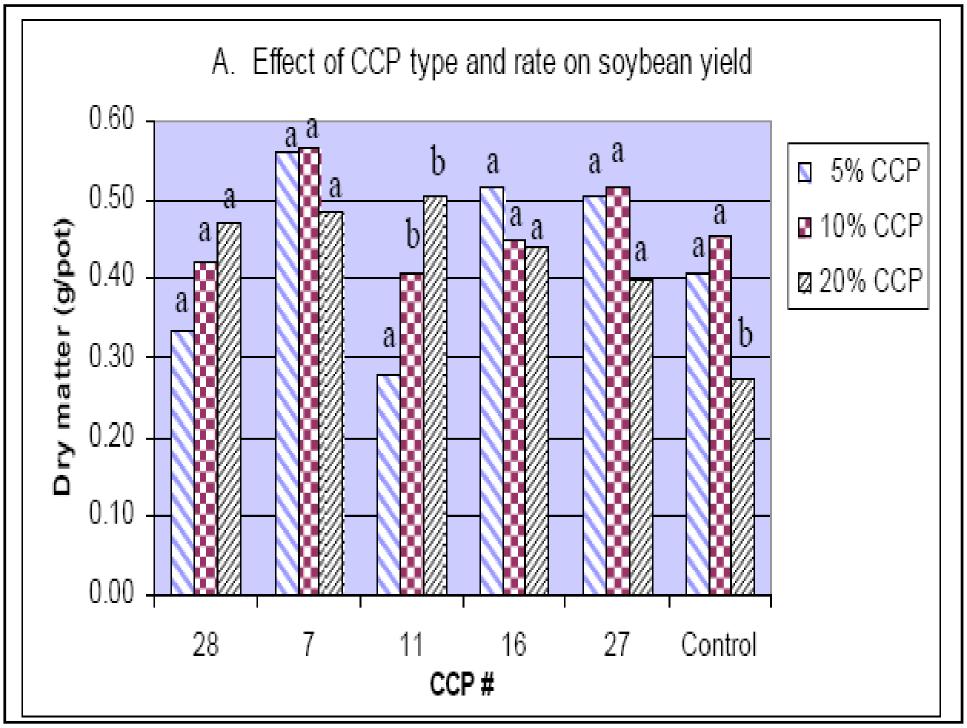


Relatively happy soybean plant in greenhouse pot amended with 5% low EC (salt) fly ash material.

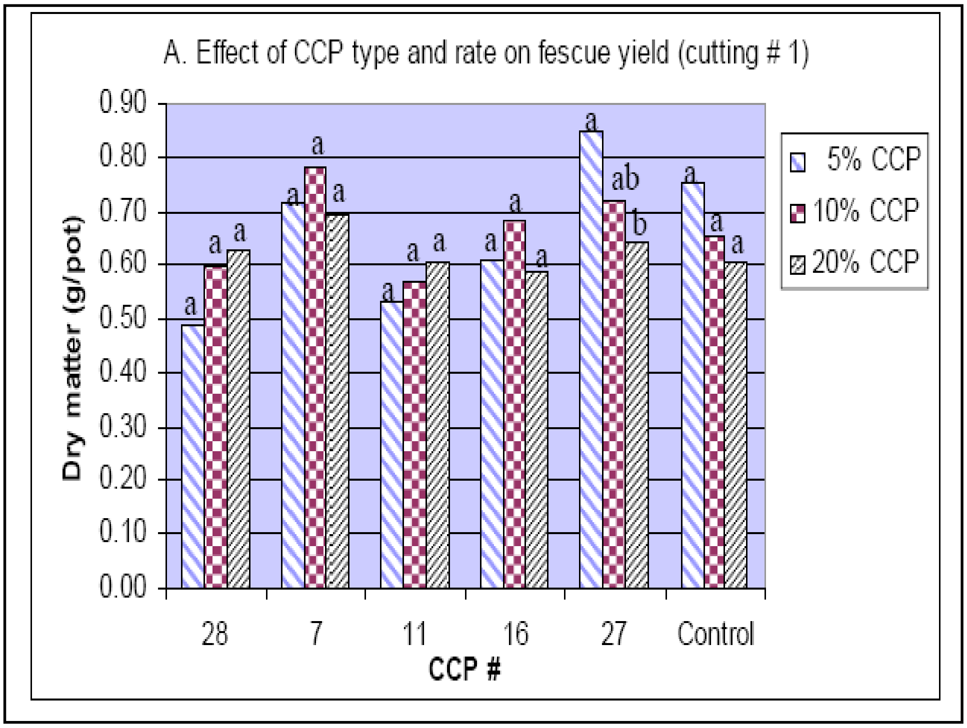
Note minor burning on lower leaves indicative of some "salt effect".

Toasted soybean plant in high loading rate (20%) high EC treated greenhouse pot.

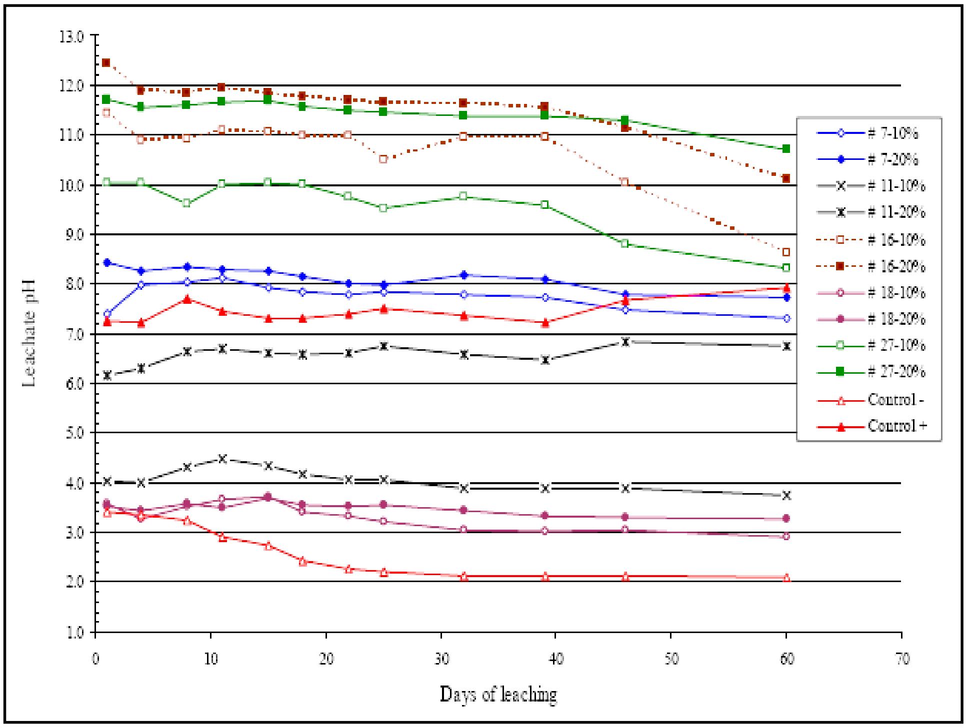
Note fallen leaves in pot; these were summed up in final yield totals, but this plant is clearly under stress!

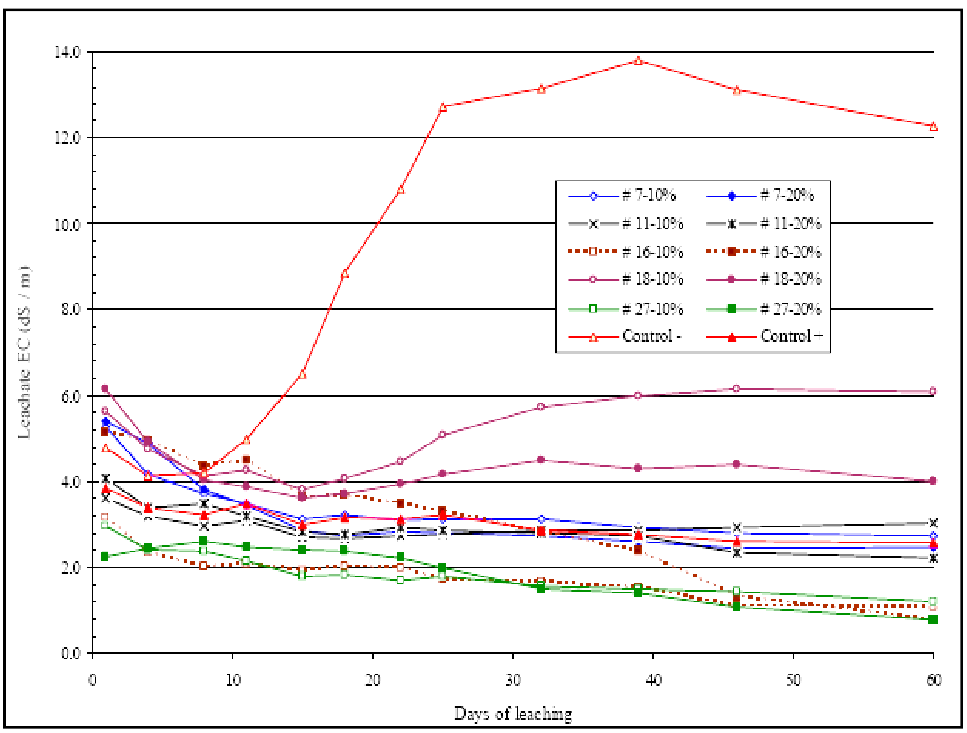


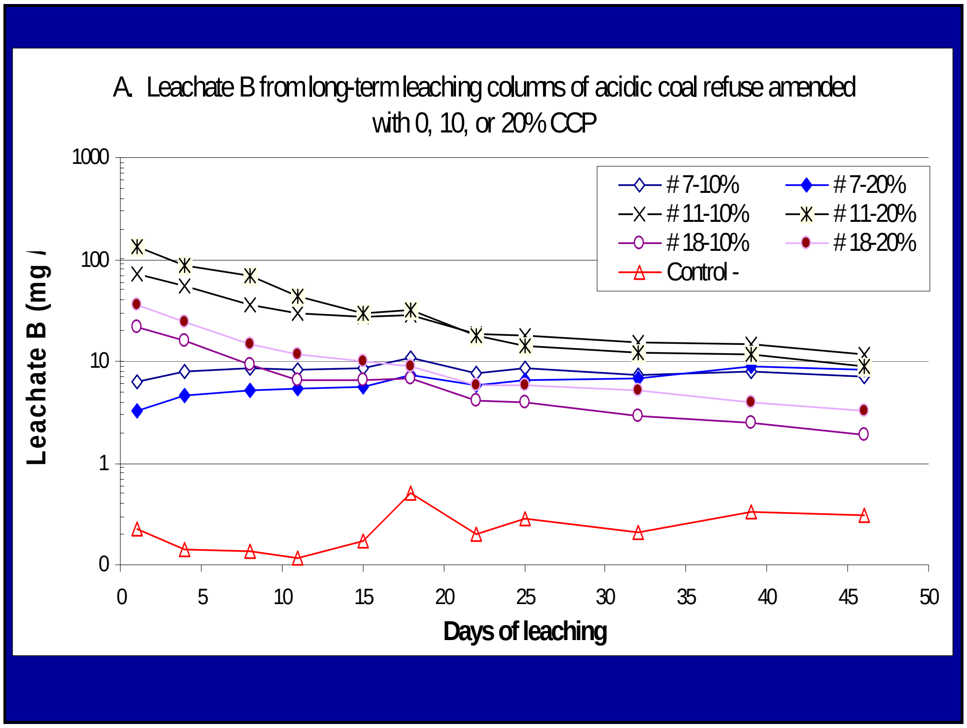
Thirty day old tall fescue plants showing tip burning from high rate of high salt fly ash. Fescue is quite salt tolerant, however, and generally continues to grow well in moderately salty soils.

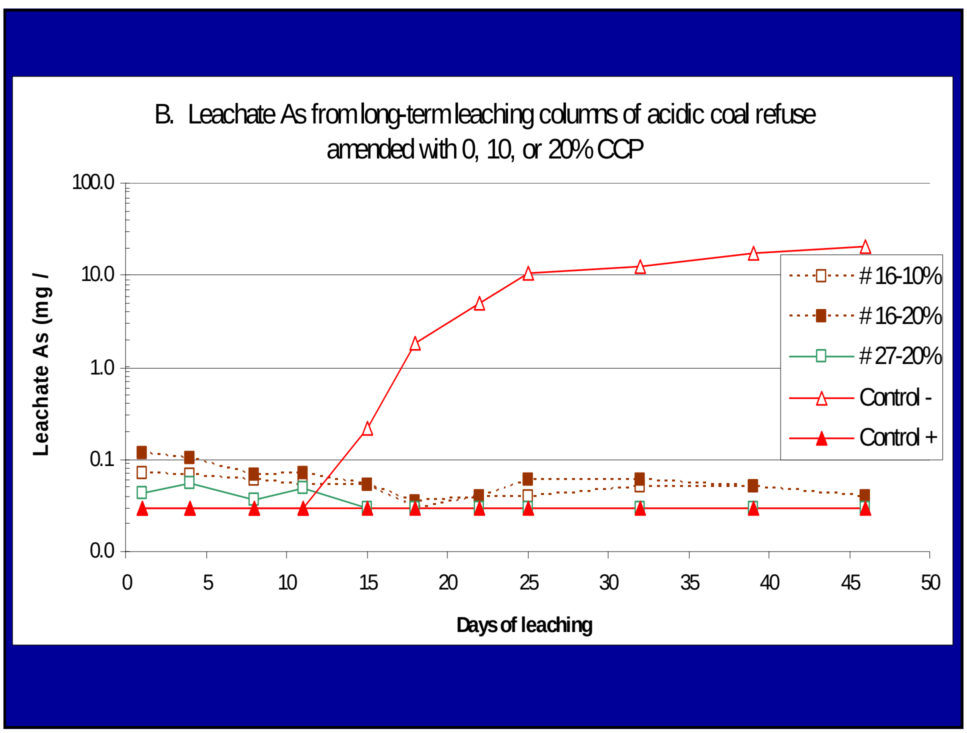


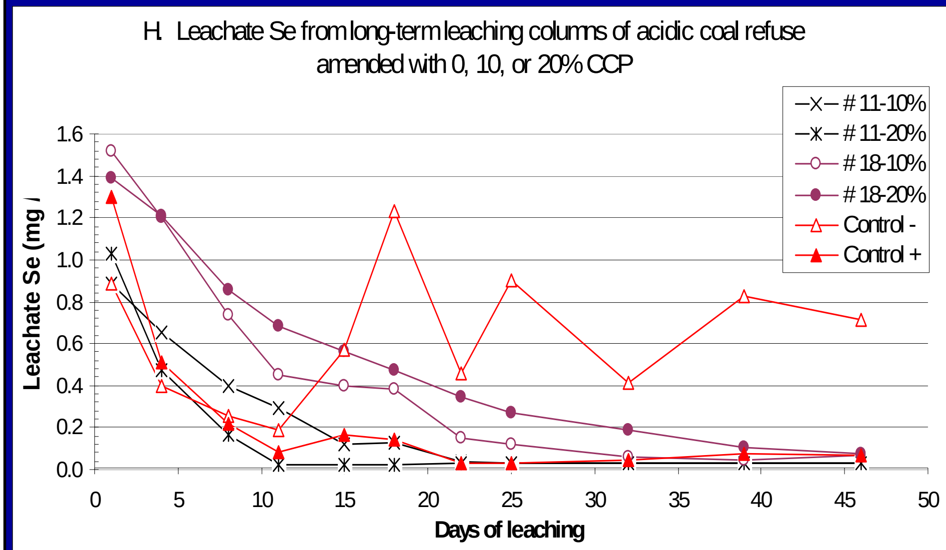
Saturated Lab Leaching Columns Packed with Acid Forming Coal Refuse and Varying Rates & Types of CCPS.


Leachate pH
Days of leaching
7-10%
7-20%
11-10%
11-20%
16-10%
16-20%
18-10%
18-20%
27-10%
27-20%
Control -
Control +


Leachate EC (dS / m)
Days of leaching
7-10%
7-20%
11-10%
11-20%
16-10%
16-20%
18-10%
18-20%
27-10%
27-20%
Control -
Control +


A. Leachate B from long-term leaching columns of acidic coal refuse amended with 0, 10, or 20% CCP
Leachate B (mg l
1000
100
10
1
0
0
5
10
15
20
25
30
35
40
45
50
Days of leaching
7-10%
7-20%
11-10%
11-20%
18-10%
18-20%
Control -


B. Leachate As from long-term leaching columns of acidic coal refuse amended with 0, 10, or 20% CCP
Leachate As (mg l
100.0
10.0
1.0
0.1
0.0
0
5
10
15
20
25
30
35
40
45
50
Days of leaching
16-10%
16-20%
27-20%
Control -
Control +



Conclusions to Date

- **The 28 post-2000 CCPs sampled in this study are generally much higher in alkalinity than those sampled from a similar geographic area in the mid 1990's.**

- **All CCPs tested in the greenhouse showed a positive soil amendment potential when used at moderate rates (5 to 10%), but at higher rates, bulk salts + B will limit plant growth.**

Conclusions to Date

- In general, addition of alkaline CCPs to acid-forming coal refuse results in much improved overall water quality, assuming adequate total alkalinity is maintained over time.
- Post-2000 CCPs contain variable amounts of soluble/bioavailable As, B, Mo and Se, a certain component of which will leach over time to a limited extent from ash/refuse mixing zones.

Conclusions to Date

- However, As and Se leaching from unamended strongly acidic coal refuse poses a much higher leaching risk over time.
- We still have a lot of work to do with this data set!