Guidance for the beneficial use of fly ash on coal mines in Virginia (USA)

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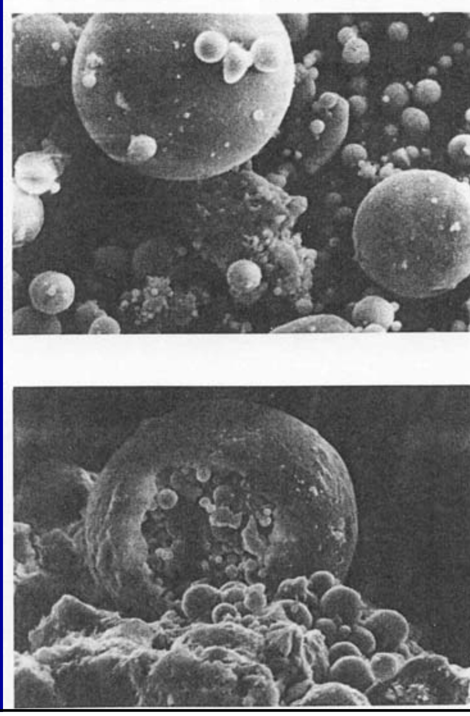
Fly ash is often composed of amorphous alumino-silicates that cool into round spheres as stack gases rise. These cenospheres are often porous and light in density. Heavy metals are usually concentrated on the outer rinds of the spheres. Fly ash also commonly contains shards of minerals like feldspars,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



Properties and Potential Water Quality Effects of Coal Combustion Products

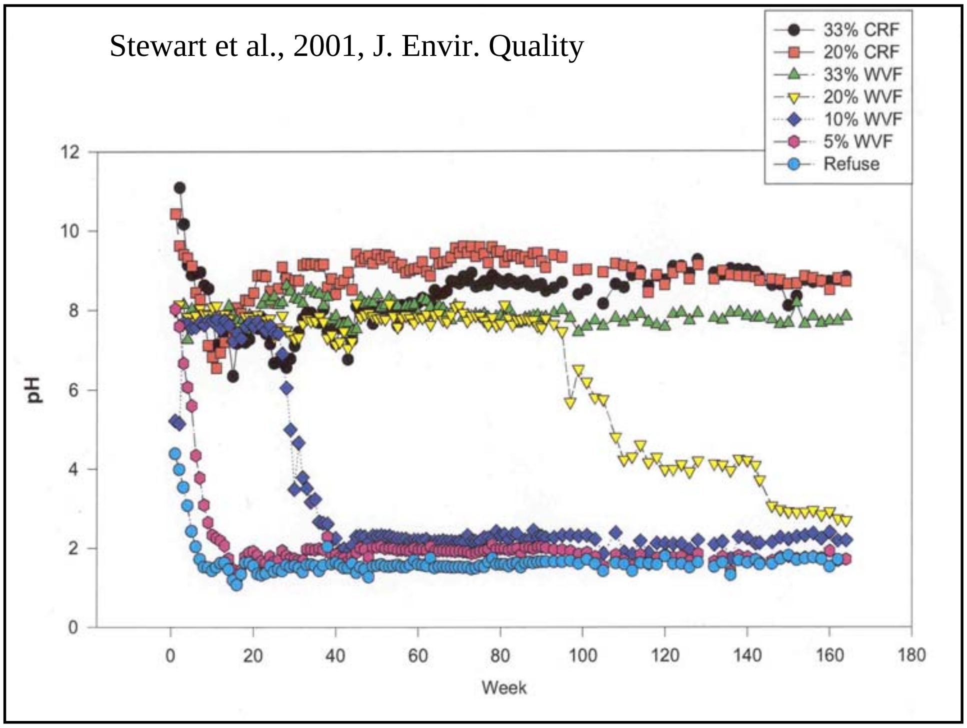
- **To determine the basic chemical and physical properties of a large set of modern CCP's generated by combustion of SW Virginia coals, including FGD materials and fly ash produced by emerging air emission control technologies.**

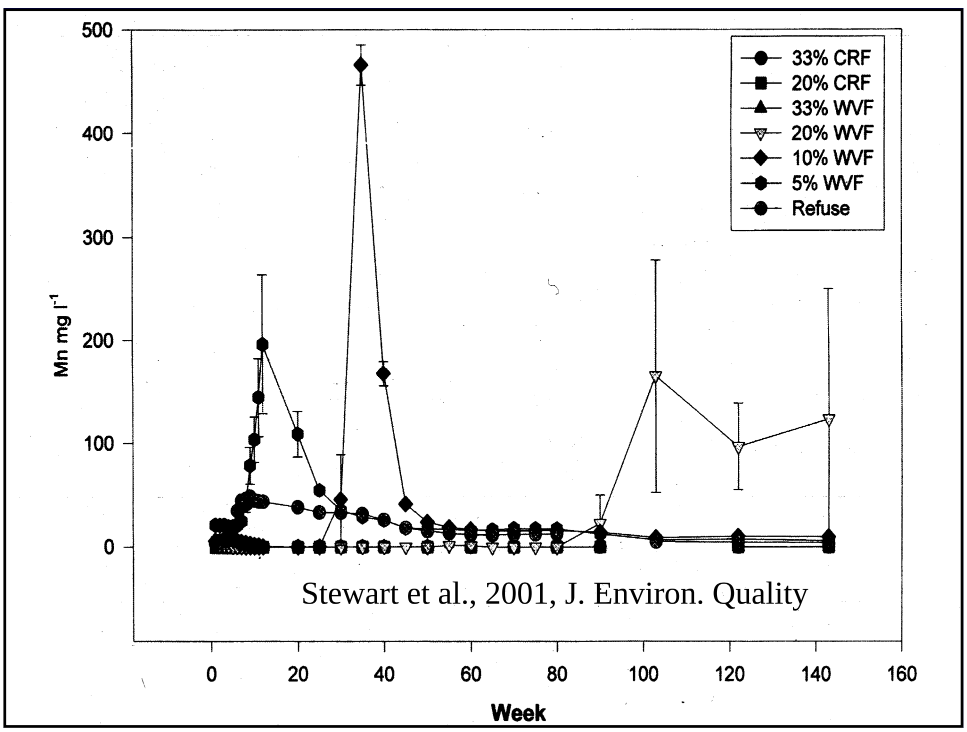
- **To estimate the likely effect of changes in coal combustion technologies such as low NOx boilers and various mercury removal strategies on ash chemical and physical properties.**

Properties and Potential Water Quality Effects of 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.**

Acid mine drainage (pH=2.3; Fe=10,000 ppm) from unsaturated leaching of high S coal refuse (4% pyritic-S).

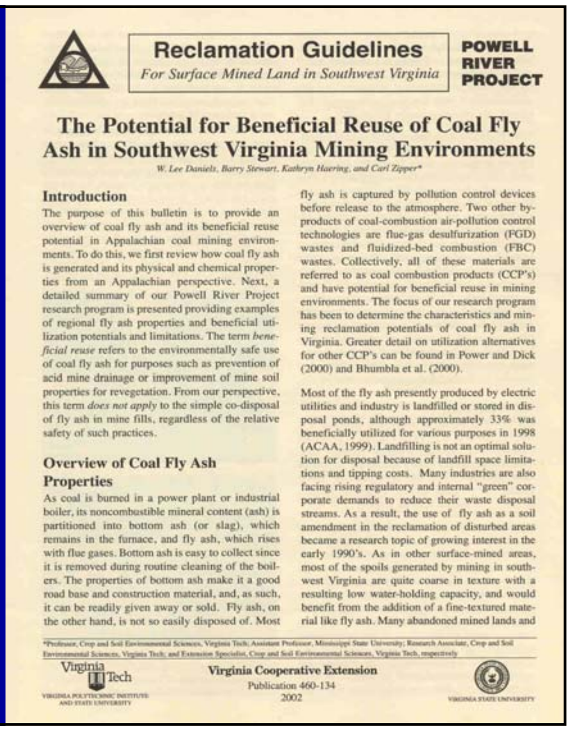

Stewart et al., 2001, J. Envir. Quality
33% CRF
20% CRF
33% WVF
20% WVF
10% WVF
5% WVF
Refuse
pH
Week


33% CRF
20% CRF
33% WVF
20% WVF
10% WVF
5% WVF
Refuse
Mn mg l-1
Stewart et al., 2001, J. Environ. Quality
Week

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 byproducts 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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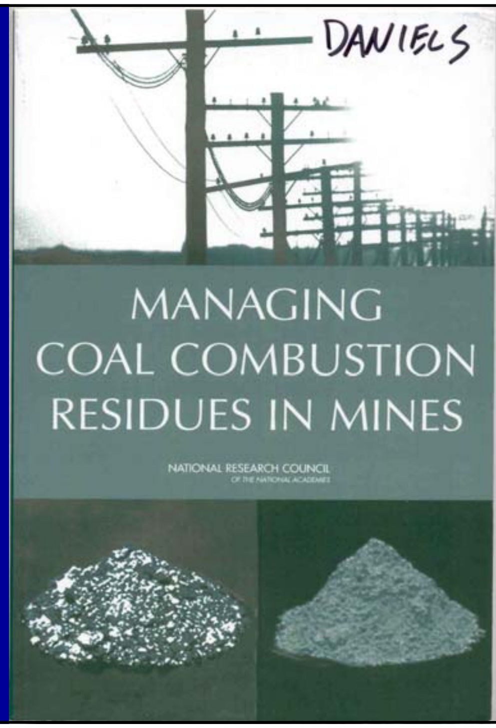


USA National Academy of Sciences Study 2006

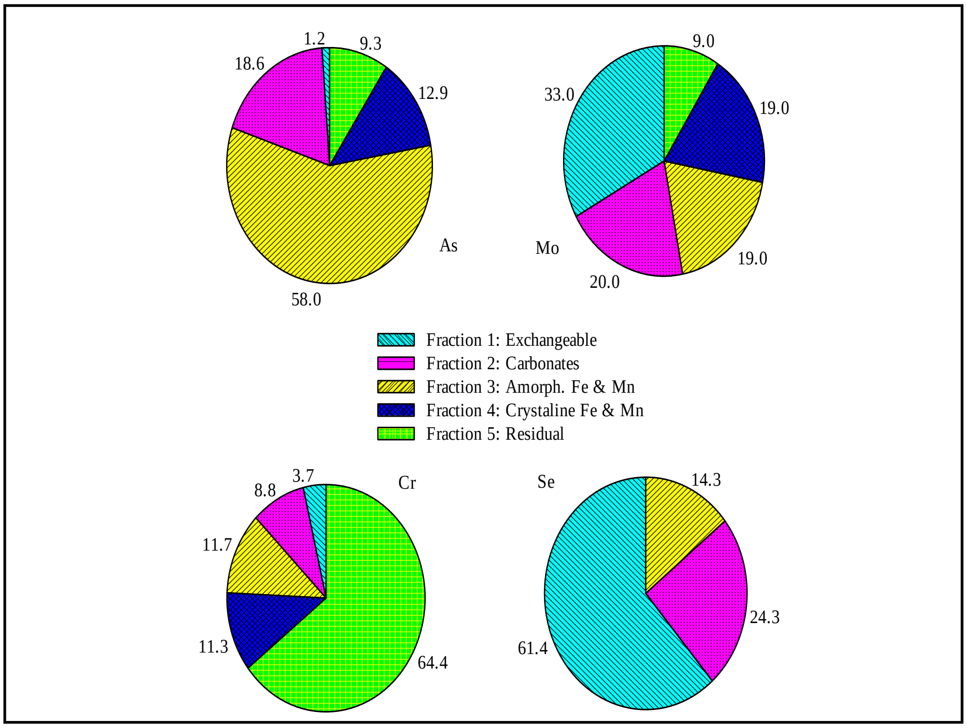
While the report did offer overall support for the beneficial utilization of CCP's in mining environments, it specifically cautioned potential permittees to: (1) Carefully characterize the geochemical properties of both the CCP to be utilized and the mine site; (2) understand and predict long-term reactions and contaminant release patterns; and (3) fully characterize potential site hydrologic impacts.

CCP Properties in 2004

CCP #	Type	Bd g cm^{-3}	Saturated Paste 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

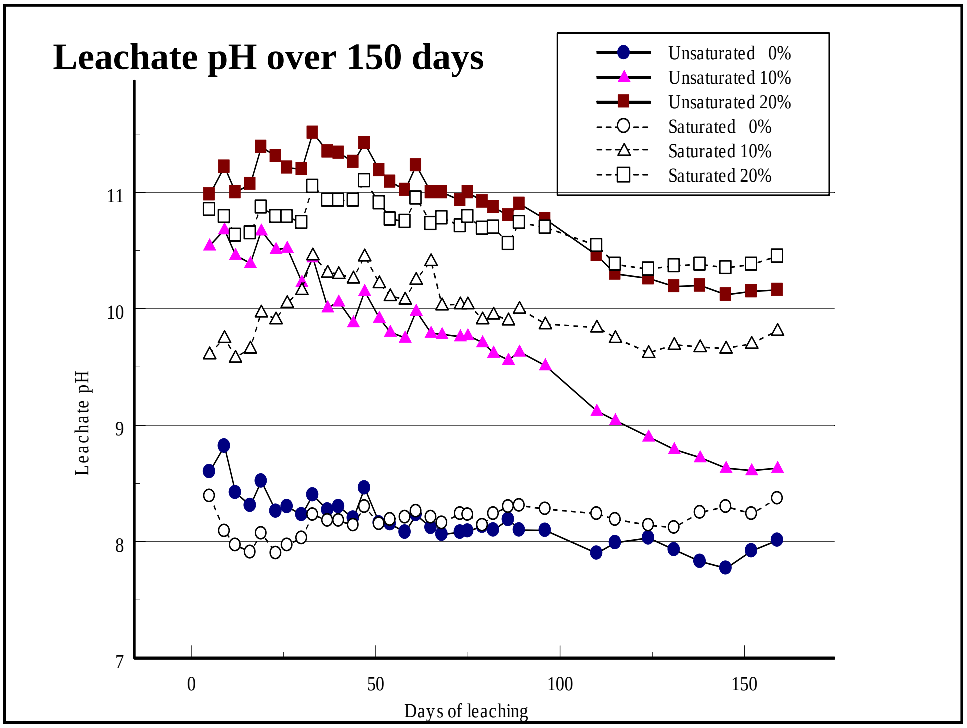
CCP Properties in 2004

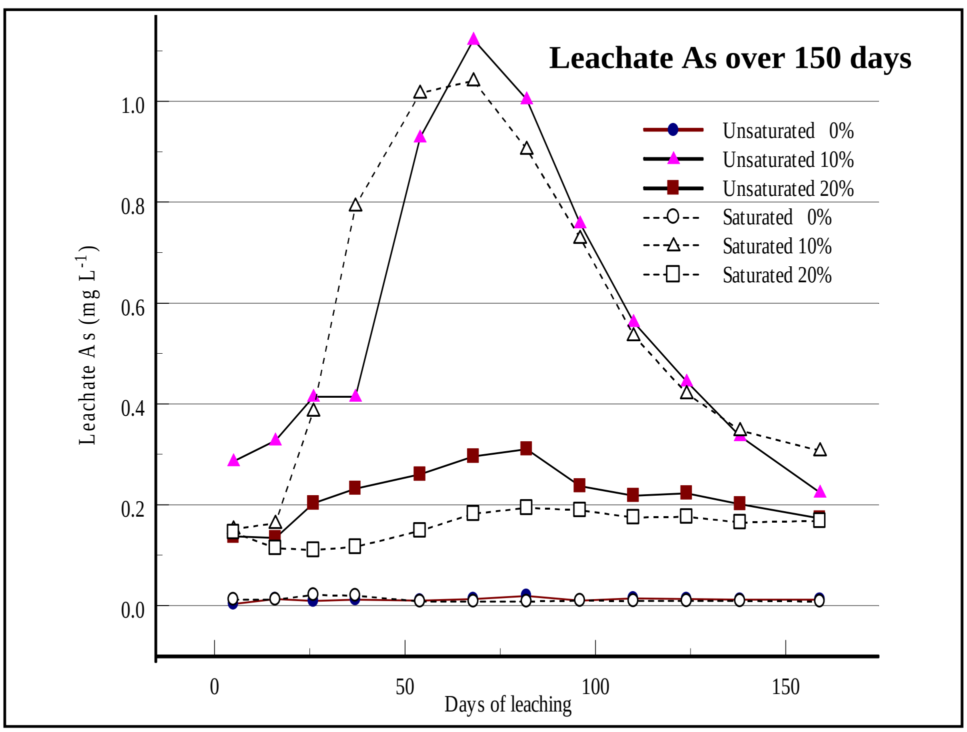
CCP #	Total Elemental Analysis via Micro Digestion				
	Total B mg kg^{-1}	As mg kg^{-1}	Se mg kg^{-1}	Cr mg kg^{-1}	Mo mg kg^{-1}
28	82	57	11	70	11
11	574	179	15	130	50
16	789	14	11	73	37
27	841	23	4	86	9
7	225	19	3	36	8

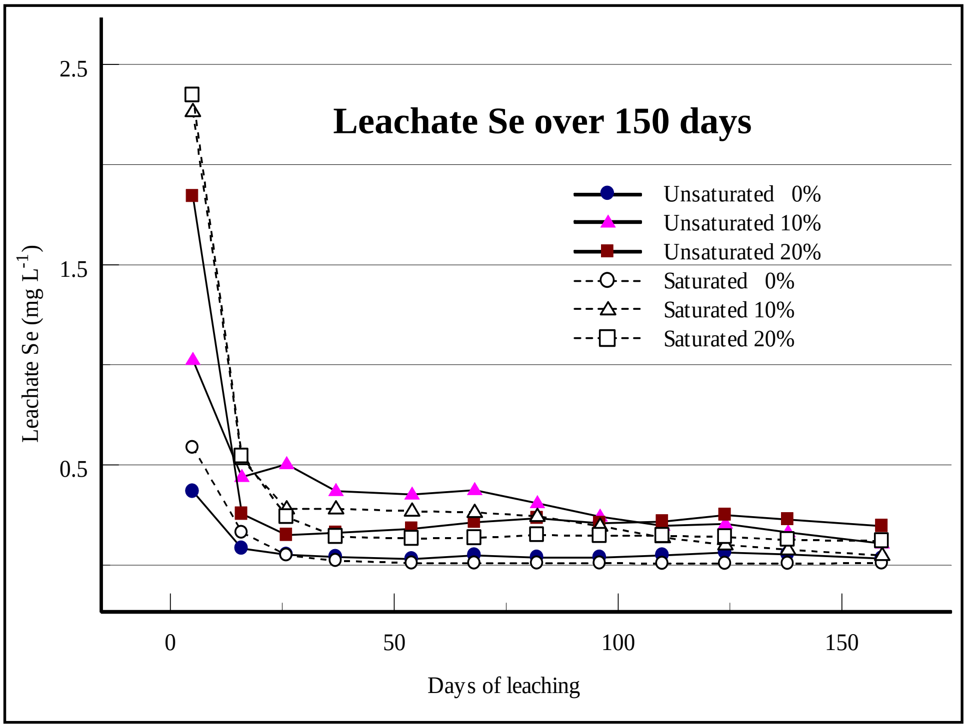


2004/2005 Alkaline Leaching Experiments

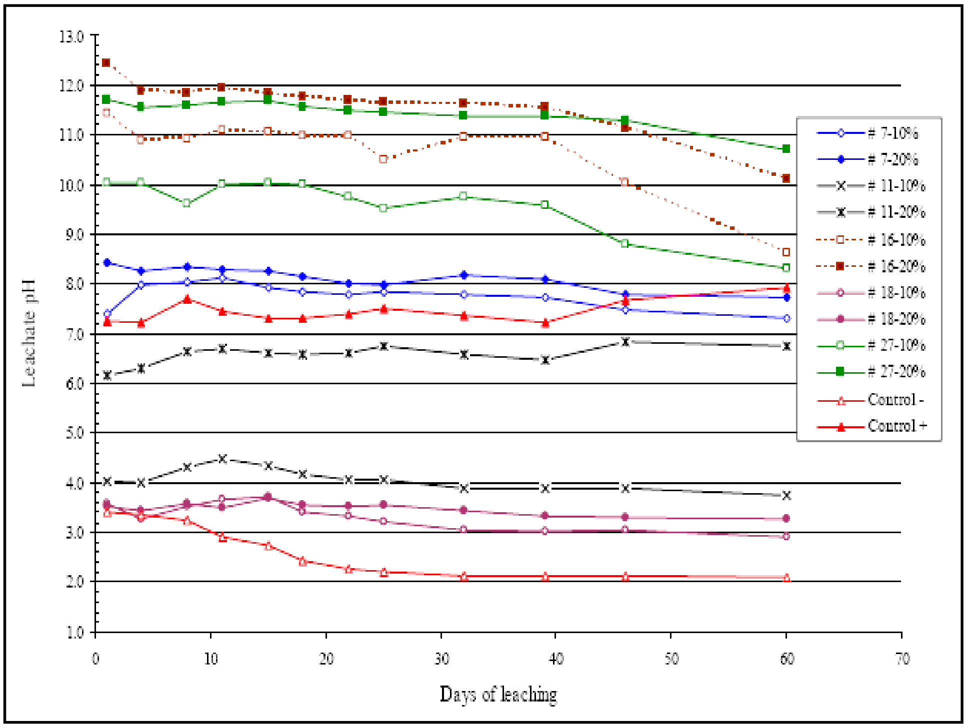
- **Evaluated leaching potentials of alkaline fly ash (pH 11.3) blended with net alkaline refuse for co-disposal feasibility study.**
- **Similar columns to earlier acid refuse experiments were run under saturated and unsaturated leaching conditions.**


Leachate pH over 150 days
Unsaturated 0%
Unsaturated 10%
Unsaturated 20%
Saturated 0%
Saturated 10%
Saturated 20%
Leachate pH
Days of leaching
11
10
9
8
7
0
50
100
150

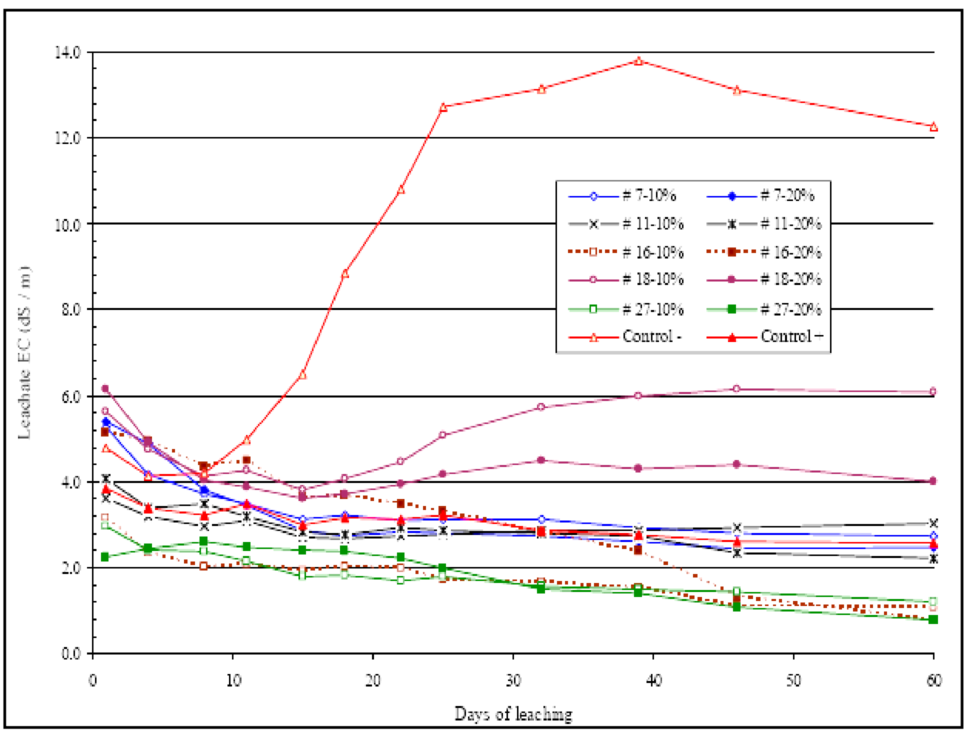

Leachate As over 150 days
Unsaturated 0%
Unsaturated 10%
Unsaturated 20%
Saturated 0%
Saturated 10%
Saturated 20%
Leachate As (mg L-1)
Days of leaching
1.0
0.8
0.6
0.4
0.2
0.0
0
50
100
150



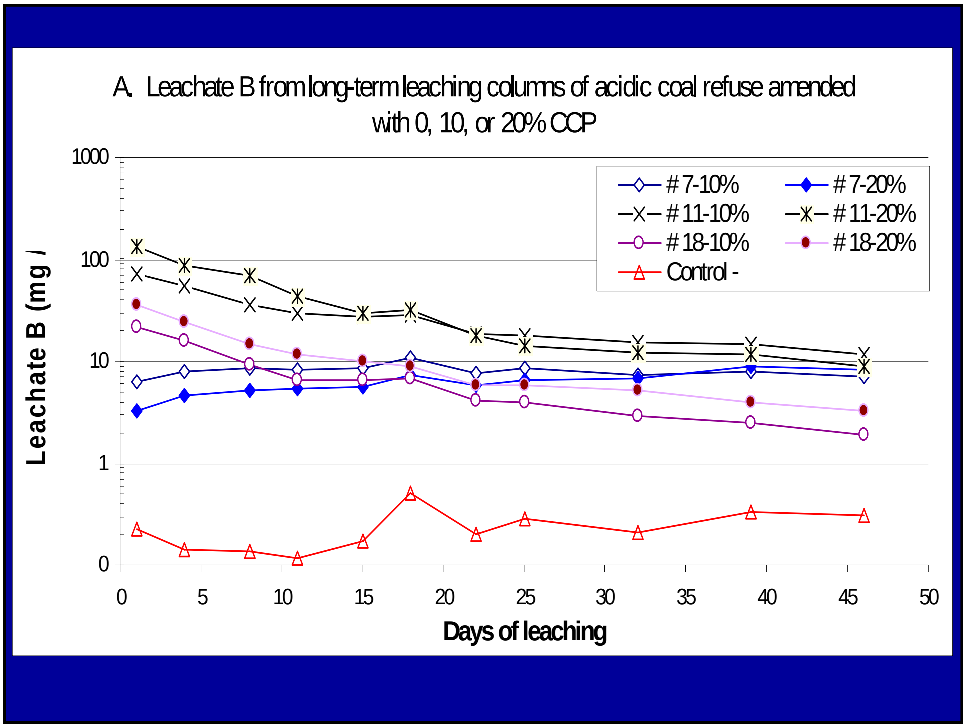
Saturated Lab Leaching Columns Packed with Acid Forming Coal Refuse and Varying Rates & Types of CCPS.

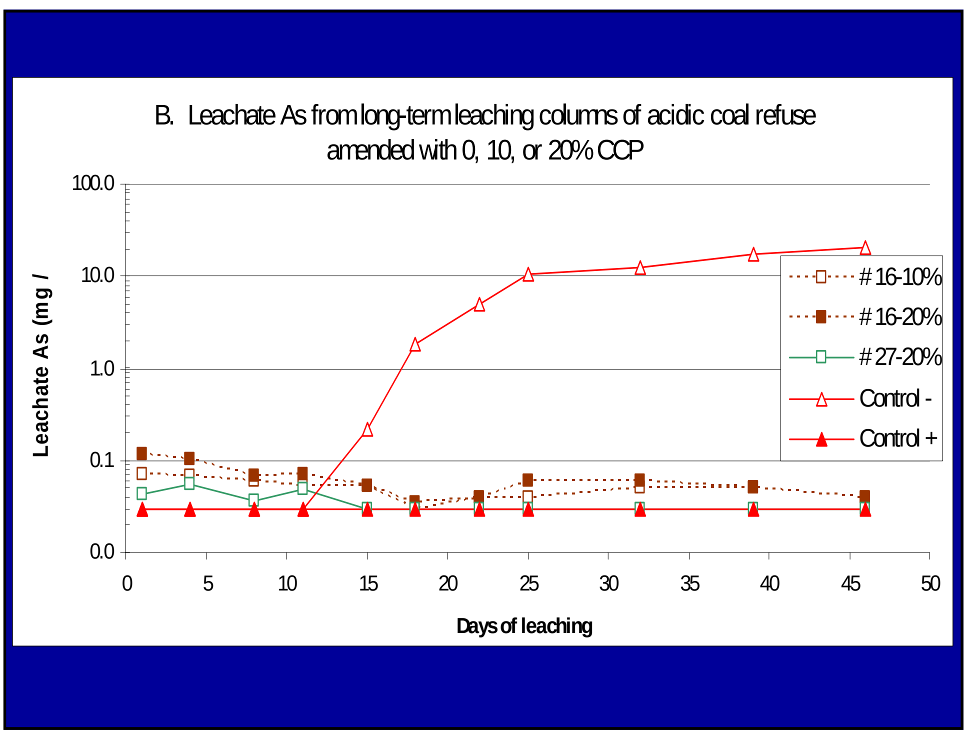


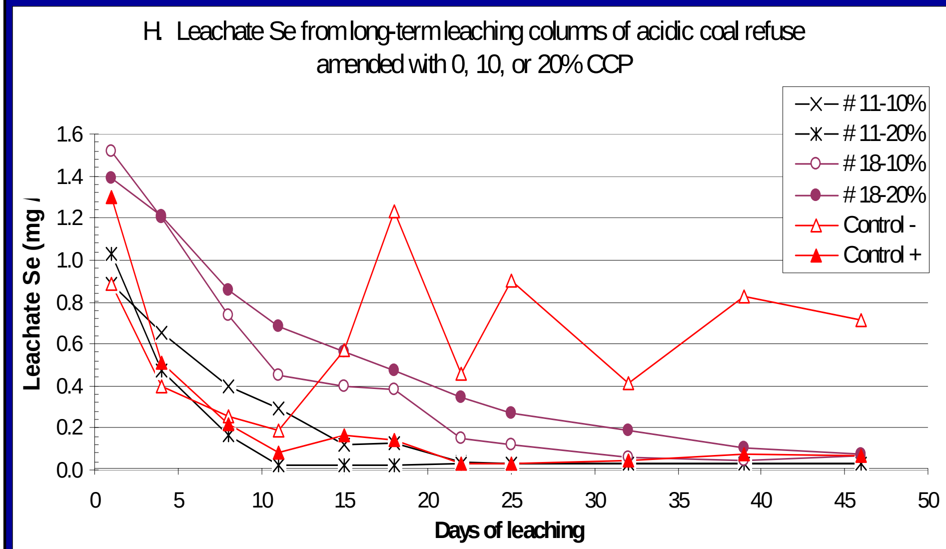
Leachate pH
Days of leaching
7-10%
7-20%
11-10%
11-20%
16-10%
16-20%
18-10%
18-20%
27-10%
27-20%
Control -
Control +



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 /
Days of leaching
1000
100
10
1
0
0
5
10
15
20
25
30
35
40
45
50
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 /
Days of leaching
100.0
10.0
1.0
0.1
0.0
0
5
10
15
20
25
30
35
40
45
50
16-10%
16-20%
27-20%
Control -
Control +



Conclusions

The chemical properties of CCP's, particularly levels of soluble salts, CCE, and potentially soluble oxyanions continue to vary widely and must be carefully assessed and matched to utilization site geochemical and hydrologic conditions.

Conclusions

Alkaline CCP’s can be safely and beneficially utilized to offset acid drainage potential in sulfidic mine wastes if provisions are made to ensure sufficient net alkalinity is present to meet long-term acid-base balance demands.

Conclusions

Similarly, if the CCP utilization/disposal environment is allowed to become strongly alkaline, CCP fills or layers should be expected to be internal sources of high pH soluble oxyanions such as arsenate, borate and selenate if those constituents are elevated in the inbound CCP materials.

Conclusions

While not currently a common practice, utilization of CCP’s as a topical amendment to mine soils and coal waste for soil improvement and revegetation purposes is viable, but application rates will be limited to less than 10% (100 Mg/ha) for most CCP’s due to deleterious effects of soluble salts on initial plant growth.