COAL COMBUSTION ASH HAULBACK

by

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Abstract. Coal mining disturbs large tracts of land which must be reclaimed. Unfortunately, iron sulphides which are common in most coals and the adjacent strata weather, forming acid mine drainage (AMD) which degrades surface and ground water. Burning of coal produces combustion by products, most of which are placed in ponds or landfills. Suitable disposal areas are difficult to find and permit, especially in urban areas. This has led to ash haulback - where the waste generated during coal burning is hauled back to a mine for disposal. The potential advantages of coal combustion ash haulback are:

- Disposal occurs in a disturbed area (mine) rather than disturb additional land near the power plant.
- The same vehicles used to haul coal from the mine can be used to return the ash to the mine.
- Ash, if alkaline, may provide neutralization of acidic water or mine overburden commonly found at coal mines.
- Low permeability ash could reduce ground water flow through the mine backfill, thus reducing leaching of acid forming constituents or metals.

Placement of ash in surface mines provides an efficient, cost-effective method of disposal while at the same time contributing to reclamation of the mine. Wise natural resource management suggests a reasonable approach to disposal of coal ash is to return it to its original location - the mine.

Additional Key Words: coal ash utilization, coal ash disposal, mine reclamation, acid formation control

Introduction

The United States contains vast coal reserves which should be utilized rather than imported fuels for our energy needs. U.S. coal production was 1,042 million metric tons in 1996. Almost 65 percent of this came from surface mines (Reid 1997). Surface coal mining disturbs large tracts of land which must be reclaimed. Unless full extraction occurs, underground mines may subside many years after mining. Both surface and underground mining expose iron sulfides which are common in most coals and the adjacent rock strata to air and water. Weathering of these sulfides often produces acid mine drainage (AMD) which degrades surface and ground water.

Approximately 80 percent of the coal produced in the United States is used by utilities to generate electricity. Burning of coal produces combustion by products, some of quantities produced, most are placed in ponds or landfills by which are utilized by society. However, due to the large utilities. Recently new equipment has been installed so that utilities can meet clean air provisions - these greatly increase the volume of coal combustion by products (CCBs) requiring disposal. Fluidized bed combustion (FBC) and flue gas desulfurization (FGD) are the two most common technologies for controlling sulfur emissions. It is estimated that 125 million tons of CCBs will be produced by the year 2000 (Tyson, American Coal Ash Association 1997).

The environmental disposal practices of CCBs are an important issue impacting the coal mining and utility industries; regulatory agencies; electrical utility rate payers, and the public (Hassett 1991). Suitable

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disposal areas are difficult to find and permit, especially in urban areas. Disposal areas utilize undisturbed ground that could be used for other purposes. This has led to ash haulback - where the waste generated during coal burning is hauled back to a mine for disposal. This paper presents information on coal combustion ash haulback, its potential advantages and environmental impacts. For ash haulback to succeed, two criteria must be met: (1) the haulback CCBs must be disposed of in an environmentally safe manner; and (2) the haulback operation must be cost competitive.

Ash Haulback

Most sulfur related constituents and metals found in CCBs come from the coal. CCBs derived from FBC and FGD are alkaline.

The potential advantages of CCB haulback are:

- Disposal at a surface mine occurs in a disturbed area (mine) rather than disturb (green space) land near the power plant.
- Placement into underground mines may prevent or reduce surface subsidence.
- Vehicles used to haul coal from the mine may be used to return CCBs to the mine.
- CCBs may provide neutralization of acidic water or mine overburden commonly found at coal mines.
- Low permeability CCBs could reduce ground water flow through the mine backfill (surface or underground), thus reducing leaching of acid forming constituents or metals.
- Savings could reduce the cost of electricity and make United States coal a more cost competitive fuel.

The potential for neutralization of acidic water commonly associated with coal mines could prove to be a major benefit. Alkaline CCBs may have a beneficial impact on AMD through four possible mechanisms (Kim and Cordone 1997):

1. Neutralize acidic groundwater.
2. Increasing pH inhibits bacterial activity and the production of acid should decrease.
3. Encapsulating acid forming materials isolates them from air and water and prevents formation of AMD.
4. Low permeability CCBs could divert water or reduce the amount of water in contact with acid forming materials.

CCBs have been used for many years for filling underground mines to prevent subsidence. Federal agencies involved in this work include the former U.S. Bureau of Mines and the Office of Surface Mining Reclamation and Enforcement (OSM). Also, most states having abandoned deep mines have used federal funds for injection of CCBs. CCBs have also been used for soil amendment to reclaim abandoned mine lands and AMD mitigation in many states. The U.S. Department of Energy has sponsored research on coal ash haulback in West Virginia, Kentucky, and Illinois.

Fixated scrubber sludge (FSS) was injected into an abandoned underground coal mine in southwestern Indiana (R. Gray, et al. 1996). The project was undertaken to evaluate using FSS to control mine subsidence and reduce AMD. Pre-injection laboratory testing included characterization and analysis of the effects that the mine environment has on the FSS. Bench scale testing determined the composition for optimum flow, minimization of free water, and physical characteristics.

A total of 16,351 cubic yards of FSS was injected over an eight-week period in late 1994. This resulted in filling about five acres of the mine. Permeability of the material six months after injection was 1.0×10^{-6} to 5.0×10^{-7} cm/sec.

The hydrogeologic environment surrounding the mine was monitored by sampling ground water over a six month period prior to injection and then quarterly for one year after injection. There were some changes in the concentration of chemical parameters in the mine pool water, particularly in close proximity to injected FSS, but no significant changes in ground water chemistry surrounding the mine.

The OSM and the state of West Virginia, in cooperation with local utilities, coal companies, and the Electric Power Research Institute (EPRI), are conducting a mine filling demonstration project with 98 percent CCBs and 2 percent cement to remediate a serious AMD problem. The collection and treatment costs to West Virginia for the AMD are $300,000 per year (T. Gray, et al. 1997).

CCB waste disposal sites are subject to state and local solid waste laws and regulations. Forty-two states regulate CCB disposal under the state solid waste laws. In Ohio certain CCBs are regulated under a separate industrial waste category. In the remaining seven states (Kentucky, Tennessee, Oklahoma, Washington, New Jersey, Maine, and California) CCBs are tested to determine whether they will be regulated as solid or hazardous waste. Criteria for disposal vary from state to state (GAI Consultants, Inc. 1995).

Disposal of CCBs in surface coal mines is used most frequently in the western United States. Power plants in this region are often located near the mine supplying the plant. However, as haulback has developed, many states now permit this procedure.

For some sites, placement of ash in surface mines provides an efficient, cost-effective method of disposal while at the same time contributing to reclamation of the mine. In many cases, mine fills are considered to be utilization or beneficial use of ash, rather than disposal. Ash can be placed at either active surface mine operations or at abandoned mine sites. Ash placement must be integrated into the mine plan so that it does not interfere with mining operations. Reclamation of abandoned mine lands with CCBs is being practiced and, in fact, encouraged by some states. Improvement of water quality and the restoration of the terrain and vegetative cover for aesthetic purposes can be achieved via ash placement in abandoned mine lands (GAI Consultants, Inc. 1995).

State regulations on haulback vary; however, they all require the following:

- Landowners' concurrence
- Disposal plan
- Waste characterization
- Water monitoring
- Hydrogeologic consequences of the CCB disposal
- Reclamation plan

Environmental Impacts

The Commonwealth of Pennsylvania has permitted placement of CCBs in surface mines since 1978. Data is available on thirty-five sites through 1995 and indicates that the placement of CCBs in mines may contribute to the control of acid formation and trace element concentrations are generally below fresh water aquatic life criteria (Kim and Cardone 1997). Over the last 10 years, the Pennsylvania Department of Environmental Protection, in monitoring abandoned mine reclamation projects on which coal ash had been used, has not detected any significant off-site water pollution problem associated with the use of coal ash (Commonwealth of Pennsylvania 1997).

West Virginia's Coal Ash Policy permits use of CCBs having a low hydraulic conductivity to encapsulate potentially toxic material. Also, non-acid CCBs may be used as a partial replacement for soil in covering coal refuse disposal facilities. Dick, et al. (1994) report that dry FGD by products applied at rates equivalent to spoil neutralization needs can aid in the revegetation of acid mine spoil with little potential for introduction of toxic elements into the water or the food chain.

Hamric (1993) in reporting on CCB haulback in West Virginia suggests that low permeability ashes can be used to line the mine pit floor to prevent groundwater from coming into contact with acid producing shales below the coal seam. Also, placement on top of a graded area could reduce infiltration into the mine backfill, thus reducing seepage. He also suggests encapsulating toxic overburden with CCBs. Hamric describes lining a pit with CCBs. This material was also placed against the highwall to cover the exposed coal seam. The pit was then backfilled with overburden and graded to approximate original contour. The backfilled pit was then covered with a thin layer of CCB which was covered with topsoil. Monitoring showed the CCBs to be effective in controlling acid formation. No mobilization of heavy metals from the CCBs was observed.

Dyer (1994), in a comparison between coal ash from an Indiana power plant and local overburden materials, found that the ash did not exhibit compositional abundances significantly different from the overburden materials. Leaching tests on mine spoil from the Viking Mine and Indianapolis Power and Light's (IPL's) CCBs produce very similar results which compliment the study by Dyer (Meiers 1997).

Unweathered rock in the mine overburden when it is removed by mining and then replaced as backfill will be more permeable than CCB and has a greater leaching potential and a much greater volume than CCB, particularly if the volume of CCB is restricted to the amount of coal mined. The fragmented mine spoil provides much surface area for chemical reactions (adsorption and precipitation) to occur.

Rocks associated with coal seams are generally not good aquifers. Water quantity is limited and quality is often poor. Mining often degrades these aquifers. Surface mined areas generally exhibit increased ground-water storage and recharge. The backfill is several times more permeable than unmined overburden, particularly rock overburden (Corbett, 1968). Because of their low permeability and limited extent, aquifers will not be affected unless adjacent to the reclaimed pit. Any condition related to ground-water quantity resulting from the disposal of CCB should be minimal and should not be discernible from the conditions which result from mining and reclamation activities alone.

The quality of ground water within the CCB disposal area will also be somewhat different than that in unmined overburden. Based on the bulk chemical analyses of the CCB material, it is anticipated that total dissolved solids in ground water associated with disposal areas (predominantly aluminum, calcium, iron, magnesium and sulfate) will increase slightly. Considering the volume relationships of overburden to CCB in the mine backfill and the relative permeabilities of these materials, any leachate from CCBs is not significant when compared to the total flow from the mined site due to dilution and dispersion in groundwater and precipitation and adsorption in soil and rock.

EPRI has evaluated the environmental performance of CCBs used in structural fills, road base, embankments, soil amendment, and placed in active mines through haulback. Although haulback is relatively recent, CCBs have been used for a relatively long time in these other applications. All are similar in that CCBs are placed as fill and subjected to precipitation and weathering. Thus, the results can be extrapolated to haulback sites.

EPRI initiated the Waste-Use Environmental Effects Study project in 1987, conducting field meausrements at a cross-section of ash utilization sites to generate information for an environmental performance database. Their objective was to evaluate long-term changes, if any, in soils, vegetation, and groundwater quality where fly ash, bottom ash, and scrubber sludge have been used. Field investigations were conducted at two existing ash use sites: a structural fill in Little Canada, Minnesota, and an embankment site in Waukegan, Illinois. Investigators selected these two sites because: 1) at least seven years or more had elapsed after ash placement; 2) more than 25,000 tons of ash were used; 3) these sites were geographically in moderate to heavy rainfall regions; and 4) permission to study the site could be obtained in a reasonable time frame. Nearly eight years after ash was used to backfill the low-lying area of the Little Canada site, sampling and analysis of subsurface waters showed very localized changes due to leaching of ash constituents. The study also concluded that:

- Concentrations of all trace metals in water samples collected below the ash deposit were under detection limits or unchanged from background water quality measurements.
- Only shallow groundwater wells located directly underneath the ash deposit evidenced elevated concentrations of sulfate, boron, calcium, manganese, molybdenum, and strontium. None of these constituents migrated into the deeper groundwater zone or groundwater outside the ash fill.
- Vegetation samples growing directly on the ash fill showed an accumulation of boron, magnesium, and molybdenum as well as a reduction in phosphorus (EPRI 1990a).

Nearly 15 years after ash was used to construct a highway overpass embankment in Waukegan, Illinois, sampling and analysis of groundwater, soils, and vegetation showed localized changes due to leaching of ash constituents. Researchers concluded that:

- There existed little evidence of accumulation of ash-derived chemicals in sandy soils beneath the ash.
- Toxic trace metals such as arsenic, selenium, chromium, cadmium, and vanadium, did not migrate and contaminate groundwater (EPRI 1990b).

Investigations were also performed by EPRI at five road construction sites which involved the use of CCBs to gather data for assessment of leaching and migration of chemicals to soils, groundwater, and vegetation. The sites selected provided a range in climates (arid to humid), contrasting soils (acidic to alkaline), and various depths to groundwater. Samples collected at upgradient and downgradient locations, in the ash, in the soil below the site, and in the groundwater provided information to assess the leaching and subsequent transport of chemicals in the subsurface environment. At all sites, regardless of age (7 to 17 years), climate, and soil type, the impact of chemicals leached from the CCBs was limited to the soil immediately below (0 to 6 feet) the road base or embankment (EPRI 1995).

More recent studies at ash haulback sites produce similar results. Ground water in natural soil and rock just a few feet downgradient of the haulback sites was of acceptable quality due to water dilution and dispersion, and precipitation and adsorption (Murarka 1997).

This research indicates that ground-water quality will not be significantly influenced by the disposal of CCBs in the mine backfill. Any adverse condition resulting solely from the disposal of CCBs should not be discernible from any conditions which may develop due to mining and reclamation activities alone.

Surface mining regulations require groundwater monitoring of parameters related to the suitability of the ground water for current and approved post-mining land uses and to the protection of the hydrologic balance. Monitoring of surface mines as required is also adequate for mines containing ash haulback for the reasons noted previously.

Conclusion

Coal combustion ash haulback is a logical and exceptional method for disposal and is useful in mine reclamation. Much data is available on CCBs, their leachates, and their disposal in surface and underground mines. Utilization of CCBs having a high pH and high net neutralization potential can provide beneficial passive treatment of AMD. Science and engineering indicate utilization of CCBs demonstrating low trace element mobility in mine land reclamation is environmentally sound. Existing surface mining regulations provide the necessary environmental safeguards and opportunities for public participation to safely and responsibly reclaim coal ash placed at mine sites. Wise natural resource management suggests a safe approach to disposal of coal ash is to return it to its original location - the mine (Beaver, et al. 1987).

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