The Use of Leachate Data and other Factors in Evaluating CCB's for Placement at Coal Mine Sites in Pennsylvania

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Abstract

Leachate data, proposed site characteristics, and various other factors are all part of the assessment process that is utilized to evaluate a proposed coal ash utilization permit for a mine site. The assessment evaluates the likelihood of the coal ash degrading the ground and surface water associated with the proposed utilization site, and serves as the basis for approval or denial of the proposed site. Some factors employed in the assessment are more important than others, but all factors should be utilized to determine the feasibility of a proposed coal ash utilization site.

Introduction

The assessment process utilized to evaluate a proposed coal ash site has been developed, critiqued and refined over the past fifteen to twenty years; as each site is evaluated and reevaluated in respect to what effect the coal ash placement had on the site and surrounding areas. Additional items to review have also been identified during the refinement period, as well as scientific information that has been obtained through coal ash research and several coal ash demonstration projects. State regulatory requirements and the type of beneficial use are also an integral part of any application review and assessment. All of these items serve as the basis for our review process and conclusions related to the beneficial use of coal ash for mine reclamation.

Regulatory Framework

Coal ash is defined in Pennsylvania's Solid Waste Management Act as fly ash, bottom ash, or boiler slag resulting from the combustion of coal. This includes the ash generated from coal refuse; however, ash generated from burning waste material (e.g. petroleum coke) with coal is not considered coal ash under this definition. The addition of waste from pollution devices (e.g. wet scrubber sludge) to the coal ash also excludes that ash by this definition.

The beneficial use of coal ash in Pennsylvania is regulated under the Solid Waste Management Act, the Surface Mining Conservation and Reclamation Act, the Coal Refuse Disposal Act, the Clean Stream Law, and Air Quality Control Act.

Beneficial use of coal ash was authorized under the 1986 amendment to the Solid Waste Management Act (SWMA). SWMA authorized the beneficial use of coal ash for mine site reclamation along with other beneficial uses. Prior to 1986, DEP required a residual waste disposal permit for the use of coal ash at mine sites. In 1992, the residual waste management regulations were amended in accordance with SWMA to regulate the beneficial use of coal ash at mine sites (under 25 Pa. Code Sections 287.661 to 287.666). The regulations were further revised in 1997 in regard to water monitoring, volumes of coal ash that may be used at mine sites, and certification guidelines for coal ash. In addition, the DEP developed a Memorandum of Understanding between its waste and mining programs and three technical guidance documents to further coordinate and manage the beneficial use of coal ash on both active and abandoned mine sites.

Types of Beneficial Uses Permitted on Mine Sites

Pennsylvania currently defines the following four uses of coal ash on active mine sites as beneficial uses: (1) alkaline addition; (2) low permeability material; (3) soil substitute or additive; (4) placement.

Alkaline addition takes advantage of the potential for some coal ashes to generate alkaline leachate and is used to offset the potential for on-site materials to generate acid mine drainage. Brady and Hornberger (1990), Perry and Brady (1995), and Skousen et al. (2002) have shown in empirical studies of completed mine sites that post mining water quality correlates more strongly with the amount of alkaline material on a mine site than with the amount of sulfur in the rocks. According to Pennsylvania's current guidelines, to qualify for use as an alkaline addition agent the coal ash should have a neutralization potential (NP) of at least 100 parts per thousand and a pH of between 7.0 and 12.5. The amount of coal ash needed to offset potential acid production can be calculated using the methods described by Smith and Brady (1998).

Using coal ash as a low permeability material usually entails sealing or encapsulating materials on site that have the potential to produce acid mine drainage. Potential uses for coal ash as a low permeability material on a mine site include, paving the pit floor, capping material segregated from the rest of the mine spoil due to its potential to generate AMD, encapsulating reject material on coal refuse reprocessing operations, and in some cases capping entire sites or significant parts of sites. For use as a low permeability material on a mine site coal ash should have pozzolonic characteristics and should be capable of achieving permeability equal to or less than 1.0×10^{-6} cm/sec under laboratory conditions.

As a soil supplement, alkaline coal ash is used as a liming agent and also to improve the physical characteristics of the soil or soil substitute being used as site cover. In some re-mining settings soil is not readily available, especially on coal refuse reprocessing operations, and coal ash can be used to enhance the characteristics of other on-site material to produce an acceptable growth medium. The soil/coal ash mixture must result in a pH between 6.5 and 8.0 to be considered suitable, and the amount of coal ash used must otherwise be commensurate with the need to establish a growth medium.

The term "ash placement" involves the use of coal ash on a mine site to backfill pits or re-contour refuse piles on re-mining sites. The pH of the coal ash must be in the range of 7.0 to 12.5 at the generator's site for placement approval.

In practice, coal ash use on a mine site typically fulfills more than one of the above beneficial use criteria. For example, coal ash being returned to a refuse reprocessing site may serve as an alkaline addition agent, an encapsulating agent (capping), as a soil additive, and for backfilling and re-contouring.

Summary of Present Permitting Requirements

The following discussion presents only some of the most significant of the permitting requirements for coal ash use on mine sites. For more detailed information the reader should view the program guidance documents, permit modules and regulations, (25 Pa Code Sections 287.661-287.666) that are pertinent to ash use on mine sites and that are available on DEP's website at www.dep.state.pa.us. The reader should keep in mind that each mine site is different, and the data and information requirements may vary according to site-specific considerations.

Administrative Requirements

Beneficial use of coal ash on a surface mine site can be requested as part of an original permit application or as a permit amendment. Either way, public notice and public participation are an integral part of the review process for all beneficial uses of coal ash on mine sites, with the exception of use as a soil amendment or supplement, which involves the use of very small volumes of coal ash.

For mine sites where coal ash is used as an alkaline addition agent, low permeability material or for placement, the applicant must place a public notice in a local newspaper explaining the proposal. The public has the right to comment on the proposal and may request a public meeting or public hearing, if desired. The applicant must provide written approval from the landowner for the proposal, and the DEP office reviewing the application provides notice of the proposal to the local municipality, the county planning agency, and other state agencies. The review process is an open one with opportunity for input from individuals, organizations and local governments and other state agencies.

The application for use of coal ash on a mine site must include a detailed operational plan, which includes:

- Identification of the coal ash source(s);
- A certification from the coal ash generator(s);
- Amount of coal ash to be used;
- Purposes(s) of coal ash utilization;
- Operational details of how the coal ash is to be handled and incorporated into the site;
- A demonstration that the coal ash is chemically and/or physically suitable for the proposed use;
- Documentation of the hydrogeology of the coal ash-use area;
- A monitoring program, including background data collection, designed to show any influence of coal ash use on surface and groundwater quality.

Pre-testing of Coal Ash: Leachate Testing and other Requirements

An application for use of coal ash on mine sites must include chemical analyses of the ash proposed for use. An SPLP [synthetic precipitation leach procedure] leachate analysis is required for pH, sulfate, chloride, plus sixteen metals. Coal ash must meet the maximum acceptable leachate limits for contaminants, based on the minimum requirements for an acceptable waste at a Pennsylvania Class III residual waste landfill. Pennsylvania DEP and numerous other state and federal regulatory agencies use the SPLP to evaluate the leaching behavior of coal ash and other residual wastes. The Synthetic Precipitation Leaching Procedure (SPLP) is Method 1312 in the EPA manual entitled Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, and it is designed to determine the mobility of both organic and inorganic analytes present in samples of soils, wastes, and waste waters.

This test method provides leachate data that serves several useful purposes in evaluating coal ash for mine placement. These purposes include: (a) comparison of the relative abundance of chemical elements in the solid ash to their relative concentration in the leachate, (b) determination of the leachability of an element of concern (e.g. aluminum or arsenic) in various coal ash samples, and (c) comparison of leachate data to a set of regulatory guidelines in a pass/fail context. An example of these guidelines is the "maximum acceptable leachate concentration" used by the Pennsylvania DEP waste management program and mining program, wherein the guideline numbers were developed by multiplying 25 times the drinking water standards for cations, and 10 times the drinking water standards for anions (e.g. Al=5.0 mg/l, As=1.25 mg/l, SO_4=2500 mg/l).

The use of SPLP data in comparing the relative abundance of chemical elements in the solid ash and leachate associated with two anthracite cogeneration plants is shown in several tables and figures in Hornberger et al. (2004, 2005). The leachate concentrations of major, minor and trace elements can easily be compared to the solid ash analyses, and it is evident that the relative abundance of certain elements in the solid ash is not matched by their relative abundance in the leachate. For example, aluminum and potassium are more concentrated in the leachate than iron, and barium concentration in the leachate are higher than manganese or zinc, while the barium content of the solid ash is several times greater than the manganese and zinc.

Some limitations or criticisms of the usefulness of the SPLP test deal with the pass/fail or go/no go nature of the results, as compared to other types of leaching test methods where the goal is to produce data on leaching rates over some unit of time. Therefore several researchers in government agencies, academia and industry are either developing new leaching test methods or evaluating the usefulness of other existing leaching tests for coal ash evaluations.

Sorini (1997) from the Western Research Institute conducted a survey for the American Coal Ash Association of 56 leaching methods used in many countries, that were classified into 8 types of test methods. Some of these leaching methods were developed under a major national program in the U.S. (e.g. Argonne National Laboratory, Pacific Northwest Laboratory) to study nuclear waste leaching processes as described in Scheetz et al. (1981), White (1986), Ebert and Bates (1992) and numerous other references. In the nuclear waste industry, a significant amount of research was done on leaching processes leading to the development of ANS 16.1 (American Nuclear Society, 1984) and the MCC1 leach test (Pacific Northwest Laboratory, 1980). An example of the use of the MCC1 leach test on nuclear waste is described in Ebert and Bates (1992), while Zhao (1995) provides extensive data on leach testing of flyash and fluidized bed combustor (FBC) ash cements using the MCC1 test.

Currently Dr. Barry E. Scheetz and Associates at the Materials Research Institute at the Pennsylvania State University are investigating modifications to the MCC-3S Agitated Powder Leach Test Method on the leaching behavior of a variety of FBC and PC coal ashes. Also, Ziemkiewicz et al. (2002) developed the Mine Water Leaching Procedure (MWLP) to evaluate the environmental risk of backfilling mines with coal ash. This MWLP method sequentially leaches the CCB material with a sample of the mine site groundwater until the alkalinity is exhausted and the pH of the leachate returns to that of the mine water samples. (p. 6)

In addition to the SPLP test results, results of a neutralization potential test must be provided if the proposed use is for alkaline addition, and a hydraulic conductivity test must be provided when the proposed use is as a low conductivity material. Coal ash generators may obtain statewide certification of their ashes for specific uses through DEP's Bureau of Mining and Reclamation by submitting a request along with the analyses discussed herein, or the analyses data may be submitted to a DEP district mining office as part of a specific mine permit proposal. Periodic (typically biannual) re-certification and/or monitoring of the coal ash quality are required as long as the coal ash is being used on the mine site. The coal ash shipped from most power plants usually includes proportions of both fly ash and bottom ash, and analyses should be provided of both.

When the proposed use of coal ash on a site is as a soil supplement or additive, the applicant must also provide a background soil analysis (from the mine site) for pH, PCB's, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc so that potential plant up-take levels may be considered as part of the permitting process.

Monitoring

Groundwater monitoring is required for all coal ash applications on mine sites, except for sites where the only application is as a soil amendment. The volume of coal ash used on soil application sites is so small as to negate the need for water monitoring. Surface water monitoring is required on coal ash sites where the coal ash may potentially affect any surface water in the vicinity of the proposed mine site.

For all other applications of coal ash on mine sites, groundwater monitoring is required before, during and after ash placement on the site. Monitoring points are chosen so as to best show the effects, if any, of ash placement on the site. On many sites, especially re-mining sites, directly downgradient groundwater seeps, springs and discharges may provide the most representative monitoring points for the site. Typically, the hydrologic connection of such groundwater discharges to the site is relatively clear, especially in re-mining cases, where the water quality data often prove the connection. Care should be taken to choose points that are perennial under most climatic conditions and that are not subject to complicating influences. The monitoring program should include monitoring wells, where existing groundwater discharge points are inadequate in number or character to fully monitor the site. Special attention should be given to well location, depth and construction to ensure that what is being monitored will reflect any influence from the ash placement site that may occur. Upgradient wells, while they may not need to be as numerous as the downgradient points are important, especially in an area where potential upgradient influences on water quality, such as other mine sites are present. In some upland settings, upgradient groundwater monitoring is not possible.

For most mine sites, Pennsylvania requires a minimum of six monthly background samples for each monitoring point, and coal ash monitoring points are no exception. The coal ash monitoring points must be sampled for a suite of standard mine drainage parameters plus aluminum, arsenic, cadmium, calcium, chloride, chromium, copper, lead, magnesium, mercury, nickel, potassium, selenium, sodium, and zinc. During operations, monitoring must be done, at a minimum, quarterly for the mine drainage parameters and annually for the additional metals and chloride. More frequent monitoring is required on some sites. Once the site is completed, monitoring continues until the site is judged stable or reclaimed, and there is no evidence of ground or surface water degradation from the coal ash.

Coal ash generally must be placed no closer than within eight feet of the top of the regional groundwater table. However, this requirement may be waived under the regulations if there is a demonstration that contamination will not occur or if DEP approves the placement as part of a demonstration project.

Basic Assessment and Mine Site Evaluation Criteria for Coal Ash Placement

The first step associated with any coal ash placement scenario should be the testing of the proposed coal ash to be utilized at the site. If the coal ash does not meet the regulatory guidelines or limits, the project cannot proceed. Should the coal ash meet the regulatory guidelines or limits, the next step is to review the proposed site information. The site information reviewed should include, but is not limited to the following: depth to groundwater, geologic/hydrologic site characterization, site volume calculations, proposed site reclamation plan, water uses in and around the proposed site (both surface and groundwater), location of any adjacent public or private buildings, any suitable or unsuitable site characteristics related to the proposed placement, and the potential to mitigate any safety or pollution issues once the site is reclaimed. Some of these items may limit the type of coal ash that should be proposed for utilization at the site, and one must not forget that not all types of coal ash are suitable for all proposed placement scenarios.

If the coal ash and the proposed site meet the regulatory requirements and/or guidelines, the project design phase should begin. The project design or operational plans should include a number of basic requirements or specifications related to fugitive dust control, coal ash placement criteria, final grading, erosion and sedimentation controls, and final cover and revegetation. The proposed site monitoring plan should also be included in these plans, and a thorough review of the adequacy of the plan should be conducted. Once the coal ash and site design or operational plan are reviewed and deemed adequate, the overall site and assessment of the proposed coal ash placement can be conducted. This assessment considers all the pertinent site factors and the characteristics or properties of the coal ash itself. The assessment is also based on known historical or scientific information, or data related to the coal ash and sites with similar geologic and hydrologic site characteristics, and other pertinent site information.

Some basic site evaluation factors that have been established by the approximately 20 years of coal ash placement and site monitoring, as well as scientific research and modeling are:

A. Is the tested and approved coal ash being placed in or above groundwater?
B. Is the tested and approved coal ash going to be conditioned to the optimum moisture content and compacted to 90% Modified Proctor Density if the use requires such compaction?
C. Is the groundwater degraded or impacted by acid mine drainage?
D. Is the final cover or capping designed to promote positive drainage and the development of vegetation?
E. What type of coal ash is planned to be utilized: FBC (Fluidized Bed Combustion) or PC (Pulverized Coal)?
F. What are the chemical and physical characteristics of the coal ash to be utilized?

G. Are the site's operational and monitoring plans adequate and practical?
H. What resources exist in or around the site that could possibly be impacted if something unplanned occurs?
I. What is the nature and the scale of the abandoned mine features to be reclaimed, and what is the value of that reclamation in terms of dollars and public safety.

These are only a few of the questions that are entertained in a site assessment or selection, but they represent the core of what a decision to approve or deny an application is usually based on by a reviewer for the following reasons:

A. If the proposed coal ash placement is above groundwater, and if the coal ash meets all regulatory beneficial use requirements, and the coal ash is going to be placed in accordance with generally accepted practices, the likelihood of any adverse impact from the ash placement is very low.
B. If the coal ash is FBC ash or alkaline PC ash, the likelihood of degradation from any coal ash leachate should be minimal; as the metals within the coal ash are less likely to be leached by any water that may come in contact with the coal ash.

These conclusions or generalizations are based on data, testing, and scientific information that has been developed over the past 20 years from actual coal ash placement sites, coal ash demonstration projects, scientific testing and a host of other measures. However, each proposed coal ash placement site or project must be reviewed individually, and if necessary, additional testing or permit required actions should be implemented for any potential issues that may arise from the proposed coal ash placement. In fact, we have determined that there are specific coal ash types and mine site scenarios that should not be approved for various chemical, geological or other scientific reasons, even though the sites may represent significant abandoned mine land hazards. The risk of the potential solution creating a bigger problem should never be dismissed. For example, in the Bituminous Region, where coal ash has been used as an alkaline addition agent on some surface mine sites to offset large deficiencies in overburden quality, the results have generally not been favorable and additional AMD was produced. The coal ash itself caused no problem or damage, but it did not prevent AMD, just as limestone addition has sometimes failed to prevent AMD on sites with clearly bad overburden. Based on these results, using alkaline ash to offset large deficiencies in site overburden as in most cases would not be an advisable practice.

Conclusions and Closing Thoughts

This paper has presented descriptions of the regulatory and assessment procedures that were utilized to review project sites in Pennsylvania where coal ash has been beneficially used in mine reclamation and mine drainage remediation. Most of the beneficial sites have been clear success stories: abandoned mine lands and their associated safety and environmental hazards have been reclaimed at no cost to the taxpayer; water quality has been improved; a waste material has been recycled to a useful end rather than being landfilled. None of the approved sites represent environmental damage groundwater pollution cases attributable to the coal ash quality. However, a few of the mine sites cannot be counted as successes, because existing mine drainage worsened as a result of the re-mining of the sites. The production of AMD on these sites occurred because the ability of the alkaline ash to remediate and prevent the AMD was overestimated; on at least one site, poor mining and reclamation techniques were also a factor.

Are the sites where AMD worsened "coal ash damage cases?" Some investigators, particularly those associated with various advocacy groups, have argued "yes," but the correct answer to this important question is clearly "no." To be meaningful and useful the term "coal ash damage case" must be reserved for sites where the application of coal ash has caused some deleterious effect. The cause-effect relationship is critical to the integrity of the term. Where other site activities, such as additional mining has caused problems, it is important those problems be identified and understood so that the conditions that led to them are not repeated. However, incorrectly labeling such sites as "coal ash damage cases," serves to obscure the causes and potential remedies for the production of AMD on those sites, and only muddies the discussion over when and how coal ash may be beneficially used at mine sites. The determination of whether a site represents a damage case should be based on science, not semantics.

Recently, attention has been given to the potential effects of coal ash placement on groundwater quality and in the many criticisms of coal ash use on mine sites. That attention is well founded, because land reclamation benefits should not be achieved at the cost of water quality degradation. That principle has been a centerpiece of Pennsylvania's coal ash beneficial use program from the beginning and will continue to be so.

Finally, the Department has obtained some significant new information on the interactions between coal ash and minewater that has not been previously published. These findings were set forth in a book detailing the Beneficial Use of Coal Ash in Pennsylvania. The book describes several waste demonstration sites where the coal ash was placed directly into the minewater, or mixed with the minewater in the ash slurry application (and are further described in the preceding sections of this chapter). The presence of significant sulfate concentrations in the minewater, which is characteristically the dominant anion in acid mine drainage and neutralized AMD, fortuitously promotes the formation of ettringite and other similar mineral phases. These minerals enhance the cementitous behavior of the coal ash and also sequester arsenic and other constituents of concern found in the ash and in coal refuse. These findings suggest that, while the traditional practice of maintaining a separation distance between the coal ash and the groundwater table was a prudent practice, there may be applications beyond these waste demonstration permit sites where some types of coal ash should be permitted to be in contact with minewaters, in order to reclaim abandoned pits, abate mine hazards or remediate mine drainage problems. This is not to suggest the wholesale application of the techniques employed at the waste demonstration sites, but rather to provide alternatives for consideration by those engaged in defining the range of acceptable practices in the beneficial use of coal ash.

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