COAL MINE RECLAMATION USING PRODUCTS OF FOSSIL FUEL COMBUSTION - RISKS AND BENEFITS

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Abstract

In April 2000, the U.S. Environmental Protection Agency (EPA) issued its regulatory determination with respect to the **disposal** of *coal combustion products (CCPs).* The agency determined that these CCPs (fly ash, bottom ash, bottom sludge, fuel gas desulfurization materials and fluidized bed combustion ash) did **not warrant treatment as hazardous wastes**...but, rather, should be managed as potentially dangerous with enforcement authority passing to the various States and local authorities. **In effect, EPA said that the materials could be hazardous if mismanaged but that intelligent management of the CCBs would negate these risks.**

EPA also stated that it did not, at that time, have enough data on **mine fill** practices to be able to pass judgment on the benefits of mine fill **using CCPs in mine reclamation.** The practice of mine fill is a common one, and various States have their own enforcement procedures. The different geochemistries and hydrologies, and the varying waste materials, together with past mining practices that have in many cases seriously damaged the local environment, make the practice controversial. **In the US there are many thousands of abandoned and polluting mine sites, typically evidencing acid mine drainage, that might benefit from reclamation using waste materials of high alkalinity. We address both deep and surface mines.**

EPA began in 2001 a data collection effort aimed at determining what is happening at mine placement sites. These were all been coal mining sites, **but there is no reason why, in principle, these same coal combustion products might not be used to reclaim non-coal mining sites scarred and damaged by mining.** All would depend on the chemistries and of course on the economics of haul-back.

We began by collecting summary data of varying quality from some 65 sites. As the result of funding shortages attributable to 9/11, the data collection effort did not produce all the data and analysis we would have wished. Nonetheless, through the mechanism of continuing dialogue and meetings, a number of rules have begun to take shape ...rules that will both help prevent unwise disposal (eg near clean water) while enabling reclamation of many polluted old mine sites.

The following are all working on this project: EPA, other US government agencies, the Universities of West Virginia and North Dakota, representatives of Canadian utilities, several US states and their representatives, US industry, US environmental interests, and a number of very experienced consulting firms.

It is these rules, in context of overall risk assessment, we will discuss today. Hopefully they will have value in your nation also. It is absolutely essential to appreciate that *perfection* is not the goal...temporal and spatial *improvement* - cleanup- of polluted areas is the goal.

(End of abstract)

A. Risk analysis of disposal in landfills and surface impoundments (lagoons)

EPA found that the potential for groundwater risk to both human health and the environment exists from improper **disposal** of these wastes. It was recognized that the cost associated with risk mitigating options can be high, given the huge amount of wastes generated in the USA...**approximately 130 million tons per year by the power industry alone. It should be recognized that of this total, only about 30% go into uses that are considered to be of low risk...the so-called "beneficial" uses. Coal use is increasing in the US, so that investigating these risk and use issues is becoming more and more important.**

The following chemicals, as expected, were found as trace constituents: arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, zinc, calcium, iron, magnesium, manganese, and potassium. Using the data available, existing transport models, and the body of current toxicological science, only arsenic was found to present a potential human health risk, while selenium, boron, arsenic, cadmium, lead and mercury suggested ecological risks. ***It is extremely important to note that, as emission controls are improved, the levels of contaminants in the wastes can only go in one direction...up.*** Mercury levels, for example may go up dramatically. Mercury, of course, also poses special speciation and transport problems beyond the scope of this paper.

Potential risk of **disposal** in landfills and lagoons was found for both electricity producers (utilities), and all other industrial and miscellaneous users of coal. For the groundwater pathway, subject to our continuing review of the model used, we found long term risks from arsenic. For the above-ground paths (e.g airborne particulate matter and surface runoff) we did not find risk potential. However, when the residue is used for agricultural purposes, the judgement of "little potential for risk" was exceptionally close and could change if scientific judgement as to the toxicity of arsenic changes. Potential risk to animal life was found from various inorganics in ash surface impoundments and nearby overflow basins or lakes.

Again, EPA's finding was that even the minimal risk denoted below may be avoided by proper separation from water, use of barriers and liners, closure of lagoons and other measures It is important to understand that EPA's methods for estimating risk are very safe-sided; EPA traditionally is intolerant of even a very slight added risk of cancer or non-cancerous effects, as discussed below. ***As noted, where air emissions become better controlled, the solid wastes must become more contaminated. This may be very significant in parts of Europe where even marginal current risk exists.***

B. Specific disposal risks

Landfills - For the huge coal ash landfills, we found the potential for risk from arsenic to be at the 10-4 level, meaning better than a one-in-ten thousand added lifetime chance of cancer. These landfills are generally homogeneous and alkaline, posing special leach chemistry problems beyond the scope of EPA's current leach test procedures.

Surface Impoundments (lagoons) - The potential risk here was found to about the same, a one-in- ten thousand incremental probability of cancer over a lifetime. These lagoons too can be huge. Most leaching occurs in the early years of such a waste unit, with special implications for waste management...***ie phased closing of the lagoons was deemed a sound policy.***

Agricultural Use - Here we had a very difficult decision. The risk as measured, also from arsenic, was very close to being at a regulatory level. This risk pathway is quite complex, embodying seven sub-paths: direct inhalation and ingestion, and consumption of leaf vegetables, root vegetables, fruit, and dairy and beef products. The mechanism for human processing is also very complex, and very controversial. Further, arsenic toxicity thresholds have now changed.

Ecological Risks - Due to the millions of end-point biological species, ecological risk assessment can be even more complex than human health risk assessment. EPA concluded that there is the potential for risk to animal life finding its way into the ash basins or ponds, and possibly even from excessive exposure to ash piles. Risks were found, potentially at least, for exposed mammals, birds and amphibians. However no policy action was taken pending management under non-hazardous waste regulations.

C. Analysis of Mine Fill and Mine Reclamation

The practice of placing such residues in active or abandoned surface and deep mines is growing. The basic contention of this project is that such disposal ***may help remediate the pre-existing mine situation***. However, there may be situations where ***increased*** risk may result if extreme care is not exercised. Careful analysis of all chemical and hydrogeological conditions is necessary. The author believes that procedures now in use and in development in the US can largely prevent risks from the minefilling itself and is likely to have a corrective or mitigative impact on pre-existing situations if certain guidelines are followed. *(We of course do distinguish between placement above, and placement below, the water table. Put differently, there must be a geochemical and remedial reason for allowing placement in the water table.)*

Chemical properties of the specific CCP must be very carefully characterized, as must be the local site geology. For both the surface mines and the deep mines, the proper disposal strategy is a calculable, deterministic issue; quantities of ash of certain characteristics must be matched to local conditions in a way that should *not worsen the existing situation..*which should, in fact, improve local conditions. Laboratory and field studies at West Virginia University are now testing various procedures. The methods are summarized below. (We will be very pleased to receive visitors to whom these experiments and the minefilling question in general may be of interest.

In the US, because of the many different US states, regulations for minefilling are quite varied. In some cases, states confuse "disposal" with "minefill", or don't adequately define either. We should be careful to assert as we start that placement of CCPs in or near clean water makes no sense at all, no matter what it is called. It is only where acid mine drainage, surface subsidence, or through-flow of up gradient clean water exists and may conceivably be blocked, as examples, that the use of CCPs as geochemical fill may be termed beneficial ...if geochemical analysis of a given site supports that use.

Three cases may be thought of as we start: the clearly unwise case (eg, placement into or near clean water), the questionable case, and the case where a clear cut benefit (as for example acid neutralization or the establishment of a barrier to clean water inflow) may be expected. What are the variables to be considered in a given case? The below is a generalized list to be used in site characterization:

- nature of pollution problem to be corrected (eg acidity/alkaline)
- type and characteristics of proposed CCP
- contaminants in the proposed CCP (and concentrations)
- characteristics of spoils area
- pre and post mining empirical contaminant data; up and down gradient
- placement (in or above groundwater/saturated zone/fluctuating groundwater)
- existing acidic mine pool with outflows

- pH trends
- net acidity or alkalinity; reducing or oxidizing expectation
- groundwater table and flux (seasonally)
- volume of fill needed
- usefullness of acid based accounting at a given site
- existence of a similar site with pre and post fill empirical data
- availability of sufficient volume of fill
- **in sum, full and accurate/precise site characterization**

Reduced to essentials, the questions to be answered are:

1. Why dispose of these materials in a landfill or lagoon, where no good can occur, if an alternative (mine fill) aimed at correcting a pollution problem may exist?

2. Are polluting (abandoned) mine sites a problem in a given region?

3. What is the specific nature of the pollution or other geophysical problem?

4. Are available fill materials appropriate to the given pollution issue?

5. Are they available in sufficient volume to ensure continuing benefit? (Eg, exhaustion of alkaline potential can lead to additional contaminant release.)

D. The US Procedure Now Being Developed

- The essential sine qua non

A number of different reasons are often given in justification of the use of CCPs for mine fill. They range from simple topographic restoration, including correction of unsafe abandoned mine walls and voids, all the way to remediation of acidic site pollution. **The author believes that first priority must be given to groundwater protection as a minimum, and improvement where possible.** Simply put, clean water comes first. No mine fill project should be undertaken unless site experts agree that water may be protected or improved, with site specific long term monitoring. **Abandoned or active mines are not disposal areas; landfills are disposal areas.**

- The risk screen procedure

The following procedure is under study as a means of initially assessing a site as a potential area for CCP placement. Again, there must be an existing groundwater problem or issue for a site to be a candidate. And, to re-state, each candidate site must be carefully characterized to generate the below data.

From the full set of variables noted above, six derivatives were selected as offering useful insight into site potential. These are: groundwater velocity, degree of saturation, hydraulic conductivity, expected change in groundwater chemistry using pH or the MWLP (see following), partition coefficients (Kds) for contaminants of concern as proxies for mobility, and net neutralizing potential of the selected CCP in that setting.

Each of these is given a possible weighting ranging from 1 to 5, with 1 having the most beneficial or remedial potential, and 5 the most risk. The possible scores therefore will range from 6 to 30, from the least to most risky. Clearly, a site with a score at the high end **is of high risk and not a candidate. Similarly, sites with intermediate scores may not be worth the risk. At the low end are sites whose potential to be remediated are worth careful evaluation. These are sites that may be reclaimed using CCPs.**

- The MWLP, a new test

The standard tests (TCLP, SPLP) used for landfill leaching are of no value with CCPs. **Accordingly, scientists at West Virginia University developed the "Mine Water Leaching Procedure" (MWLP), a test aimed specifically at mixing a given CCP with mine water and/or mine spoils.** This procedure has been peer reviewed and published and is available for use. It enables the predictive measurement of all contaminants and balances in mine water both before and after CCP placement; in effect measuring the efficacy of the CCP placement. **A full discussion of the MWLP is beyond the scope of this paper (please contact Dr. Paul Ziemkiewicz at email pziemkie@wvu.edu, tel 304 293 2867, ext 5441, or the author.)**

- How much fill material is needed?

Because of the potential for long term release of contaminants if adequate fill (buffering) is not available, we typically use the following equation to get an understanding of our ability to start and complete a project.

A = (W x %S x 3.125 x Fs) divided by NNP

where:

A = required amount of CCP, in tons
W = estimated amount of waste rock, spoils or tailings to be neutralized, in tons
%S = percent sulfur in waste materials (3.125 converts % to mass of acidity)
%NNP = percent net neutralization potential of CCP (%NP-%MPA)
Fs = safety factor (subjective); eg 1.1 = Fs of 10%

Use of the MWLP will help to determine whether outcomes will be neutral, acidic or alkaline.

E. Summary

Increased use of CCPs to reclaim polluted mine sites is planned in the US. While the CPPs may themselves present certain problems when used in site-specific settings, depending on the site geochemistry, the use of the tests and procedures noted above can help to select and/or reject a proposed site. Such a site must show evidence of polluted groundwater to even be a candidate; abandoned mines are NOT disposal areas.

The placement of the materials in or near clean groundwater is not justified. But the placement either in or above groundwater that is already unfit for human use can, if done properly, result in a remediated site.