Biological solutions for containing fly ash from coal-fired power plants

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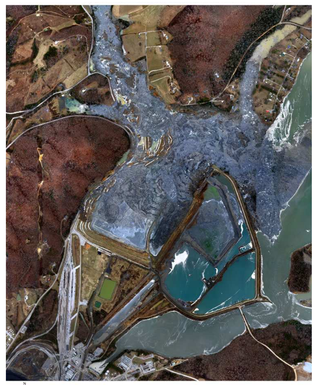
Abstract

When pulverized coal is burned as a fuel it also leaves particulate residues known as “fly ash” which contains harmful levels of trace elements that can enter the environment when managed inadequately. Over a hundred million tons of fly ash is produced every year, some of which is reused in construction projects and even as an amendment for degraded soils. Nonetheless, most of the ash is buried in a landfill. My thesis evaluates the efficacy of these various methods of containment, as well as the regulatory pathway that fly ash takes. Using Saint John’s power plant as a case study, I found reuse in cement production and landfilling to be the most effective means of containment. Since current regulations are inadequate, I propose revegetation as a biologically-sound means for stabilizing fly ash dumps.

The Fly Ash Problem

- Approximately 1/3 of fly ash is reused in the US.
- The vast majority is stored as a slurry in containment ponds or landfills.
- Regulated as nonhazardous waste under RCRA: responsibility is deferred to the states.
- Effectiveness of containment strategies is inadequate, especially considering the TVA spill in December ‘08 (at right).



Aerial photo of the TVA fly ash lagoon spill in Tennessee/

Proposed Solutions

Over a hundred million tons of fly ash are produced every year. Therefore, economically-beneficial reuse is highly desirable. Currently, about one third of the fly ash produced in the US is reused. There are two main methods for fly ash reuse: as a cement substitute and as a soil additive. Both solutions require fossil fuels for transportation, pose potential health and environmental risks and, at their best, can only make up a fraction of current disposal methods.

Cement

- Glassy silicate particles that make up fly ash can react with lime to form cement.
- Reusing yields a similar product to concrete, and can save energy, money, and resources.
- The concrete market, already at saturation, is susceptible to economic downturn and is a potential health hazard.

Soil Additive

- Trace essential elements, such as boron and silica, make it a potential additive to degraded soils.
- Particles are similar in morphology to soil and can help retain moisture.
- Susceptible to soil compaction.
- Potentially toxic effects upon biota.
- Cement-forming properties can inhibit plant growth.

The Necessity of Revegetation

Landfilling can be made more safe by taking advantage of metal-tolerant species that may reduce the threat of particulate suspension and groundwater contamination. A biological approach would be both environmentally safe and cost-effective, and could provide essential services such as metal immobilization, improved nutrient status, and erosion control.

Benefits of Revegetation

- Certain trees can hyperaccumulate toxins in their leaves
- Bacteria use metals as electron donors or acceptors to drive metabolic processes.
- Mycorrhizae, fungal mutualists of plants, can help plants tolerate stressful environments by increasing their ability to obtain nutrients.
- Metal-tolerant species that form relationships with nitrogen-fixing bacteria can add usable nutrients for plants.
- Organic soil amendments can help plants obtain nutrients and enhance microbial activity.

Myorrhizal fungi can increase the absorptive capacity of plant roots by up to eighty times.

Conclusion

For most fly ash producers, including Saint John’s, landfilling is the most effective means of containment. Nonetheless, containment methods show a wide range of effectiveness across state and international boundaries. Revegetation at sites polluted by fly ash is highly desirable because it can help stabilize these sites, thus increasing the safety of containment. Such a strategy would be both ecologically sound and cost-effective. Although these mechanisms can potentially help make polluted areas safer, tighter federal regulations on fly ash are needed. Policies for renewable energy technologies should be promoted to reduce this hazardous waste.

The Journey of Saint John’s Coal

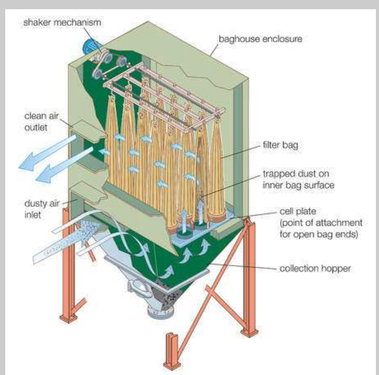
Decker Mine - East Montana

- Low-sulfur coal
- 25th largest mine in the US

Train

Saint John’s Coal Plant

- Uses upflow-style bag house to collect particulates (seen at right)
- Apprx. 500 tons ash/year



Truck

Rolling Hills landfill—Buffalo, MN

- Operated by Veolia.
- Maintains groundwater monitoring, liner, and leachate pumping system (seen at right).
- Trucks leachate to St. Michael for treatment.
- Revegetation after capped
- Has 3 years remaining in its lifespan.