Slag Soil Remediation

Text by John Buck, Civil and Environmental Consultant

What is slag?

In producing steel, iron ore is introduced into a blast furnace along with limestone and coke. The limestone decomposes and melts into a slag that removes phosphorus and sulfur impurities from the liquid iron. Slag is highly alkaline (pH 9.5-11) and does not retain enough water for plants to germinate.

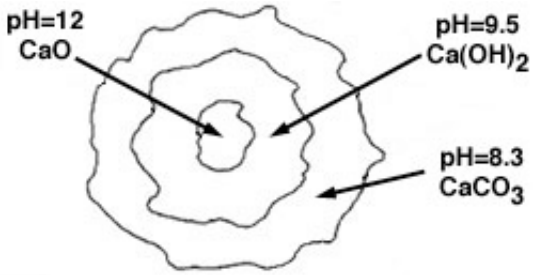

Diagram of a slag particle.

Element	Average Amount	Element	Average Amount
Carbon	1.70%	Nitrogen	0.03%
Phosphorus	0.12%	Sulfur	0.10%
Potassium	0.02%	Calcium	4.35%
Magnesium	1.34%	Zinc	0.03%
Copper	0.01%	Aluminum	0.27%
Manganese	0.85%	Iron	6.18%
Molybdenum	0.00%	Cadmium	30.69 ppm
Chromium	671.4 ppm	Lead	167.1 ppm
Mercury	0.02 ppm	Nickel	88.53 ppm
Arsenic	6.1 ppm	Selenium	0.52 ppm

Chart from Nine Mile Run: A Study of the Reclamation and Sustainable

Redevelopment of a Brownfield Site by the Department of Engineering and Public Policy, H. John Heinz School of Public Policy and Management, and Department of Social Decision Sciences of Carnegie Mellon University.

What do plants need to survive?

Absence of intolerable physical stress (e.g., landslides).
Absence of intolerable chemical stress (phytotoxicity or plant toxicity).
Adequate water storage to avoid drought (soil that retains water).
Adequate nutrient availability.
Anchorage (a soil that is penetrable by roots, stable support).
Aeration (free exchange of soil gasses with the atmosphere).

Every soil (and alternative growing medium) has assets and deficits with regard to the above plant-support criteria. In response to the range of soil conditions, particular plant species have evolved adaptations to less-than-idea soil conditions. Adapted plant communities have sprung up on the Nine Mile Run slag.

So what kinds of plants grow on slag?

Characteristics of Trees Growing on Slag

Common Name	Scientific Name	pH	Root Pattern	Longevity
Boxelder	Acer negundo	(6.5-7.5)	Deep laterals	Short
Red Mulberry	Morus rubra	(6.3-8.0)	Taproot or Deep Laterals	Short
Sycamore	Planatus occidentalis	(6.6-8)	Shallow	Long
Bigtooth Aspen	Populus grandidenta	(5.1-6.3)	Shallow	Short
Smooth Sumac	Rhus glabra	(6.1-7.0)	Shallow	Short
Staghorn Sumac	Rhus typhina	(6.1-7.0)	Shallow	Short
Black Locust	Robina pseduacacia	(5.1-7.7)	Shallow	Short
American Elm	Ulmus Americana	(6.6-8.0)	Shallow to Deep Lateral	Medium

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So what has to be done if we are to grow plants in slag?

Successful vegetation establishment requires a combination of the following:

1. Introduction of species adapted to soil conditions and
2. Modification of soils to allow a wider range of species to become established.

To that end, the soil treatment options include the following:

- Regrading slag to reduce slag/soil creep.
- Breaking up fused slag to increase root penetration (e.g., "ripping" with a bulldozer).
- Mixing materials into the slag to improve water retention. Water retention amendment systems could be temporary, lasting long enough to establish plants with deep root systems, or permant, widening the range of species.
- Adding fertilizers, chemical additives, and/or organic nutrient sources (e.g. compost, manure) to improve nutrient availability.
- Introducing nitrogen-fixing plants (legumes) to naturally maintain nitrogen fertility. Examples include clovers, birdsfoot trefoil, black locust, bristly locust.
- Covering or "capping" the slag with topsoil, or the use of slag/soil mixtures as growing media.
- Heavy mulching to minimize erosion, shelter seed and seedlings, and reduce moisture losses.
- Use of adapted plant species, and a successional process (starting with fast growing plants and transitioning over time to more desirable species).

Case Study: Squirrel Hill Slag Heap Remediation

Spring 1986:
I developed a remediation plan for the northern slopes of the Squirrel Hill Slag Heaps with funding from the Pennsylvania Conservancy. These steep slopes were planted by rappeling, augering and chopping planting holes through the slag. Bare-root bristly locust seedling were placed and back filled with a slurry of peat and manure. Another element of the remediation plan involved surface remediation and application of seeds. A mixture of mushroom compost and fertilizers was laid down by volunteers working in bucket brigade style. Black locust, grasses, wildflowers, buckwheat and birdsfoot trefoil seeds were spread in seed form. The bottom images shows the same site six years later. Note the 12 foot high black locust established from seed.