TESTS INDICATE PERSISTENCE OF VEGETATION ON TOXIC SPOILS

By Paul Sutton, Professor of Agronomy, Ohio State University

Many studies have been conducted on the establishment of vegetation on acid coal mine spoils in the eastern United States. Acidity results from expc re of sulfur-containing minerals to air during the ining operation. When exposed to air and moist , iron disulfides oxidize to produce soluble sa and sulfuric acid. Exposure of toxic materials .s now eliminated by selective placement of spoils during mining. Under present mining methods, the toxic materials are buried and materials suitable for vegetation, usually topsoil, are replaced on the surface.

Topsoil, limestone, and municipal sewage sludge were tested as aids in establishing vegetation on acid coal mine spoils at the Eastern Ohio Resource Development Center, Unit II, near Caldwell, Ohio. The test area was contour strip-mined for number nine coal in 1966 and reclamation grading was completed in 1967. The overburdened material consisted of soil, sandstone, and a dark gray shale. The spoil material on the surface of the spoilbank had a pH of 2.3 and was composed of sand (25.1%), silt (43.7%), clay (31.2%), and sulfur (1.5%). It contained 45.8 meq/100 g (milliequivalents per 100 grams) of exchangeable hydrogen and 6.6 meq/100 g of extractable aluminum.

The toxic materials are associated with the gray shales in the overburden between and above the coal seams. The surface layers of this spoilbank are predominantly gray shale. The spoil was very acid and initially contained a high level of soluble salts (40,000 ppm). Although the analyses indicate approximately two-thirds of the spoil was sand and silt, the material was very compact and had very poor structure. This prevented rapid infiltration of water. These dark-colored spoils may develop high surface temperatures, lethal to emerging seedlings.

It is important that these areas have good vegetative cover to prevent erosion and reduce acid mine drainage. Sediments from this area have filled nearby stream channels and road ditches. Also, leaching of salts and acid will improve the spoil if erosion is controlled to prevent the removal of the weathered materials. In a leaching study conducted in the laboratory, the spoil remained highly acid after large amounts of salts and acid had been removed. However, leaching will reduce the amount of limestome required to raise the pH to a level where plants can be successfully grown.

Paul Sutton is professor, Department of Agronomy, Ohio State Agricultural Research and Development Center, headquartered at Caldwell, Ohio. This article is reprinted from the Sept.-Oct. 1979 issue of Ohio Report on Research and Development.

Topsoil and Forages

In spring 1968, eight plots (10 ft. x 10 ft.) were established by covering the spoil with soil material having a pH of 6.5, 14.5 lb/A of available P (phosphorus), and 288 lb/A of exchangeable K (potassium). The material was an Upshur soil removed from a road bank cut. A border of wooden planks held the soil in place. Depths of uncompacted soil were 2, 4, 6, 8, and 10 inches. Plots were seeded with Kentucky 31 fescue. The following spring, Korean lespedeza and orchardgrass were also seeded.

Some vegetation was established on the 4, 6, 8, and 10-inch depths of topsoil, but a good vegetative cover was sustained only on the 6, 8, and 10-inch depths.

First year growth of Kentucky 31 tall fescue was poor and a good vegetative cover was not obtained. The second year, growth was mostly from Korean lespedeza, suggesting a need for additional nitrogen for good growth of grasses. Using topsoil with a higher organic matter content would have reduced the need for additional nitrogen. However, grass growth should not be stimulated with fertilizer nitrogen to the point where it would eliminate the legumes.

Listed in Table 1 are the pH's of samples taken in August 1978. Initially, one major concern was that the acid from the spoil would move up into the topsoil, making it too acid for plant growth. Although there has been a decrease in pH of the topsoil, there has also been an increase in the pH of the spoil beneath the topsoil. Since the forage from the plots was not harvested, it appears that some of the bases from the topsoil moved into the spoil and acid from the spoil reduced the pH of the topsoil. After four growing seasons, the plant roots were found penetrating to within one-half inch of the spoil. After 11 growing seasons, plant roots were starting to penetrate into the spoil approximately one-fourth inch. The spoil was sampled from 0 to 0.5 inches and the pH measured. The pH's (Table 1) showed an increase as compared to the check, but pH was too low for good root growth.

The change in conditions suitable for root growth when a toxic spoil is covered with topsoil appears to be rather slow. Limestone mixed into the spoil ahead of topsoiling would probably speed up root penetration. This would become a more important consideration if shallow layers of topsoil were being applied or if steep slopes were being topsoiled where a root contact between the topsoil and spoil would reduced the possibility of the topsoil sliding.

This study shows that vegetation can be established on toxic spoil by topsoiling with a minimum of 6 inches of topsoil. Erosion control would be essential when the minimum depth of topsoil is used.

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Also, the topsoil should be limed and fertilized according to soil test recommendations.

Sewage Sludge and Forages

Another study conducted on this spoil used sewage sludge to help establish vegetation. Digested sewage sludge was obtained from the Caldwell (Ohio) treatment plant. It was removed from the drying beds and applied to the spoil at the rate of 294 air dry tons per acre. One area had sludge incorporated with a disc to a depth of approximately 6 inches. In a nearby area, sludge was applied to the surface but not disked in.

In fall 1971, both areas were seeded to rye and in March 1972, Kentucky 31 tall fescue, orchardgrass, and sweet clover were broadcast seeded. The pH of the 0-4 inch layer was 5.4.

One initial question with the use of sewage sludge was: "Will the sludge oxidize over a period of time and the spoil become too acid to support plant growth?" This situation did not occur during seven growing seasons. Vegetative growth and the pH of the spoil indicates that this area will continue to support vegetation. Also, bluegrass has started to appear in part of the area.

Where the sewage sludge was not incorporated, vegetation was established but the plant roots were confined to the sludge layer. Although there was no visual difference in growth, this shallower root system may result in a more severe drought stress.

Limestone and Forages

In an earlier attempt to establish vegetation on this type of spoil, 31 tons per acre of limestone were applied but the spoil remained too acid to support plant growth. In fall 1969, 2 pounds of limestone per square foot were applied to spoil and mixed to a depth of 6 inches. An additional 2 pounds of lime per square foot were applied in fall 1970 and incorporated to 6 inches. Following these lime applications, equivalent to 87 tons per acre, the area was seeded to rye and fertilized with 544 lb/A 6-24-12. In March 1972, a mixture of Korean lespedeza, sweetclover, Kentucky 31 tall fescue, and orchardgrass was seeded. At first, plant growth was very poor, probably because of a shortage of moisture and a nutritional disorder associated with the acid spoil. Plant growth increased with time. The pH of the limestone-amended spoil was 5.6 in August 1978. Possibly, an increase in the organic matter of the spoil, resulting from the decay of plant roots, increased water infiltration and moisture availability.

When limestone is added to toxic spoil for establishing vegetation, a sufficient amount must be added to neutralize both the spoil acidity and the acid spoil. Plant growth increased with time. The pH of the limestone-amended spoil was 5.6 in August 1978. Possibly, an increase in the organic matter of the spoil, resulting from the decay of plant roots, increased water infiltration and moisture availability.

Results

- at least 6 inches of topsoil is needed over toxic spoil for plant establishment
- fertilizer is necessary for initial growth
- additional fertilization is critical for growing in materials that consist largely of subsoil
- digested sewage sludge is an excellent material for reclaiming toxic spoils
- trees can be established on toxic spoil if enough topsoil is used to support root growth
- amendments should be thoroughly mixed with the spoil

TABLE 1—The pH Values for Topsoil and Spoil with Different Treatments.

Treatments	Topsoil	Spoil 0-4" Under Topsoil	Spoil 0-0.5" Under Topsoil
	pH	pH	pH
2 inches topsoil	2.8	2.9	—
4 inches topsoil	4.5	2.8	—
6 inches topsoil	5.2	2.7	2.8
8 inches topsoil	5.5	2.9	3.0
10 inches topsoil	5.7	2.9	3.6
Check		2.4	

Topsoil and Trees

A study was conducted to establish trees on the outer slope of a toxic spoil by making holes approximately 12 inches in diameter and 15 inches deep. The holes were filled with soil and one-year-old black locust and European black locust and European alder trees were planted in spring 1969. Initial tree survival was good but growth was poor. After 10 growing seasons, the roots are confined to the soil material and the trees have made very little growth. In some cases, there was movement of acid into the soil and the trees died.

This method could be used if large enough holes were made to give a sufficient volume of soil for root growth to support the trees. In another area where 18 inches of nontoxic spoil were used to cover toxic spoil, trees have made relatively good growth and cover over a period of 8 years.

Summary

At least 6 inches of topsoil cover over toxic spoil was needed for establishment of healthy plants. Initial growth of grass without the addition of fertilizer was poor. This emphasizes the need for fertilizing in accordance with soil test recommendations. Also, maintenance applications of fertilizer may be needed to maintain a good vegetative cover. The need for additional applications of nitrogen will be critical where the forage stand consists of grasses growing on materials that largely consist of sub-soil.

Excellent plant growth was obtained with 294 tons per acre of air dry sewage sludge. Because of varying composition, each source of sewage sludge must be evaluated to determine its value in reclamation. If sludge does not contain substances detrimental to plant growth, it is an excellent material for use in reclaiming toxic spoils.

When sufficient quantities of limestone are added to neutralize most of the acidity, vegetation can be established. When large quantities are added, the limestone should be thoroughly mixed with the spoil to obtain a uniform pH throughout the mixing zone. Also, the area should be fertilized according to soil test recommendations. Regular soil tests used for undisturbed lands will not measure the acid-producing potential resulting from unoxidized sulfur in spoils. Direct oxidation of reduced sulfur to acid with hydrogen peroxide has been used to evaluate the acid potential of spoils.

Trees can be established on toxic spoil if a sufficient volume of topsoil is used to support root growth. Drainage should be good or acid seepage into the root zone may reduce growth or even Kill the tree. **WTT**