STABILIZATION AND FERTILITY ENHANCEMENT OF A HIGHLY ERODIBLE SANDY SOIL IN NORTHEAST ARIZONA

by

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Abstract: This paper describes a soil amendment technique which was used in a recently completed (October 1997) abandoned mine land reclamation project in the Monument Valley area of the Navajo Reservation in northeastern Arizona. An openpit uranium mine was backfilled with on-site radioactive mine waste. Finally, on-site sand dune material was used as surface cover material over the 25 acres of reclaimed area to reduce radiation emission from the surface. Preserving the thickness of the cover material was important from the radiation control perspective. Therefore, physical and vegetative stabilization of the sandy cover material was necessary to prevent or minimize its loss by wind. The objective of this study was to assess the mechanical and chemical properties of this sandy soil to understand its particle binding ability and potential as a plant growth medium. The soil was evaluated to select a stabilizing chemical (SOIL MASTER WR) which would not retard native vegetation seedling establishment, yet at the same time, create a crust to stabilize the soil surface. A study was conducted to identify the native plant species growing on similar soils in the arid project area. Additionally, chemical analysis of the soil was undertaken to collect information on soil nutrients and fertility. The information guided the authors in selecting an appropriate seed-mix, fertilizer, and erosion control technique for reclamation of the disturbed land. A hydraulic planting technique was chosen for mixing 125 gallons/acre of SOIL MASTER WR, 300 lbs/acre of fertilizer containing 181 lbs of active ingredients, 25 PLS lbs/acre of seed-mix, 2,000 lbs/acre of hydraulic mulch, and 2,000 gallons/acre of water to ensure uniform application. The soil modification technique is expected to achieve the dual purpose of soil stabilization and vegetative enhancement at a relatively low cost.

Additional Key Words: soil productivity, soil particle binding.

Introduction

An openpit uranium mine and its associated highwalls in the Monument Valley area of the Navajo Nation in northeastern Arizona was reclaimed by backfilling it with on-site radioactive mine waste materials present around the perimeters of the openpit. To reduce the residual radioactive emission from the backfilled openpit, suitable surface material placement was necessary. Approximately 25 acres of the reclaimed surface was covered with a layer of 18-24 inches thick sand dune material present in abundance in the project area since other type topsoil was in short supply. Preservation of the thickness of this cover material is vital from the standpoint of controlling radiation. However, the use of dune sand material substrate created two potential problems. First, it was very prone to wind erosion. During March-July, the wind velocity may reach as high as 35 miles/hour with occasional gusts of over 50 miles/hour. At this velocity, significant loss of cover material can result in a relatively short period of time. Second, the intention of the project was to reclaim the land for livestock grazing, but the somewhat excessively droughty, nutrient-deficient sandy soil was difficult to vegetate. Therefore, physical and vegetative stabilization of this material was the primary goal of the project. A vegetation survey was also conducted in the study area to identify the native species.

The objective of this study was to assess the mechanical and chemical properties of the sandy soil to understand its particle binding ability and its potential as a plant growth medium, and then to design an appropriate soil amendment technique to prevent or minimize soil loss by wind erosion (for 2 to 3 years during which the vegetation was expected to establish) and enhance vegetative growth.

[1]Paper presented at the 15th National Meeting of the American Society for Surface Mining and Reclamation, St. Louis, Missouri, May 17-22, 1998.

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Proceedings America Society of Mining and Reclamation, 1998 pp 589-592
DOI: 10.21000/JASMR98010589

Materials and Methods

Soil Chemistry

A 10-pound composite soil sample was collected and analyzed for its physical and chemical parameters at the soils laboratory of the Navajo Agricultural Product Industry. Additional insight on nutrient deficiencies was provided by the Colorado State University Soil, Water and Plant Testing Laboratory. Table 1 shows the results of the soil analysis. According to Colorado State University's guide (Ludwick *et al*, 1977) to fertilizer recommendation, the levels of nitrogen, phosphorus and potassium, macronutrients essential for vegetative growth, were low for native and improved range grass species. From laboratory analysis (Table 1) and visual observation, the dune sand appeared to be a very fine material with very low cohesion and approximately 95% sand content (see attached Table 1 for additional soil species analysis).

Table 1: Soil Analysis

Composition, parts/million									
NO_3	P	K	Zn	Fe	Mn	Cu	Ca	Mg	Na
3.48	7.01	29.8	0.13	1.87	1.28	0.09	946.0	43.9	4.02
Percentage composition/Other Parameters									
Total N	S	Organic matter	Sand	Clay	Silt	pH	Elec Cond	% SP	SAR
0.004	0.00	0.00	95.2	4.2	0.6	8.39	337.0	15.8	0.39

Selection of the soil stabilizing chemical, plant materials and fertilizer was based on soil analysis, laboratory recommendations, and vegetation survey results. Hydraulic mulch was used to augment seed germination. Specifications of the materials were as follows:

Soil Stabilizer

A co-polymeric (synthetic resin) emulsion, SOIL MASTER WR, supplied by Environmental Soil Systems, Inc., was the erosion control material of choice. The material formulation included the following: silicates to facilitate the penetration of the compound into the earth, thus creating a crust through the cohesive bonding of the surface particles to a depth sufficient to stabilize the soil surface; an anti-foaming agent to allow the material to be mixed and applied with standard hydraulic equipment without foaming; and a temporary color additive which assisted the applicator in the uniform application of the material after mixing with water; and tripolycate to provide maximum elasticity to assure protection in adverse weather conditions and provide maximum resistance from degradation by ultraviolet radiation or sunlight. Soil Master WR is readily miscible in water, non-injurious to seed or to animal life, non-flammable, and capable of providing temporary (2 to 3 years) surface soil stabilization in various soil classifications without totally inhibiting water infiltration. When the emulsion is mixed with water and applied to the soil, it will not impact soil pH more than one (1) pH unit. The emulsion will normally air cure within 36 to 48 hours after application and is transparent after drying. An application rate of 125 gallons/acre was determined to be the best rate to ensure soil stabilization without affecting vegetative growth.

Seed-mix

Selection of appropriate plant materials is important for successful revegetation. The study area is an arid desert region approximately 5,000 feet in elevation. The primary land use of the area is livestock grazing by the local Navajo people. The seed-mix shown on Table 2 was selected because of the following characteristics: indigenous attributes; drought resistance; palatability for livestock; soil binding capability; erosion control qualities; potential productivity; adaptability to high elevation and sandy and alkaline soil; and prolific seed producing capabilities.

Fertilizer

The laboratory recommendation for the fertilizer was 40 lbs/acre of nitrogen, 30 lbs/acre of phosphorus (as P_2O_5) and 30 lbs/acre of potassium (as K_2O). A free flowing fertilizer (22-16-16) suitable for application with hydraulic type equipment was selected and applied at a rate of 181 pounds/acre.

Table 2: Seed-mix

Species	% of Mix	PLS pounds/acre
Indian Ricegrass	18	4.5
Sand Dropseed	9	2.3
Alkalai Sacaton	11	2.8
Shadscale	11	2.8
Four Wing Saltbush	13	3.2
Galleta Grass	12	3.0
Winter Fat	13	3.2
Blue Grama	13	3.2
Total	100	25.0

Table 3: Hydraulic Mulch Specifications

Moisture Content (total weight basis)	12% ± 3%
Organic matter (oven-dried weight basis, minimum)	99.3%
Inorganic (ash) content (oven-dried weight basis, maximum)	0.7%
pH at 3% consistency in water slurry (avg.)	4.9
Water holding capacity (minimum)	1.2 gal./lb

Hydraulic Mulch

Hydraulic mulch was composed of 97% thermally produced, air dried virgin wood cellulose fiber. Table 3 shows the specifications for the mulch. The soil stabilizer compound acted as a tackifier for the hydraulic mulch, so traditional tackifier was not used. The hydraulic mulch was mixed with water, fertilizer, and the soil stabilizer compound in the form of a slurry for application with hydraulic equipment on the reclaimed surface. The mulch contained a green-colored water soluble dye to provide visual indication of the areas that had been applied with the slurry.

Soil Stabilization and Revegetation Procedure

The following four-step process was used to facilitate soil stability:

1. Foreign material, debris, shrubs, and boulders were removed from the sandy cover material and the surface was disced to a depth of 6-9 inches.

2. The area was drill-seeded with 25 PLS pounds of seed-mix per acre to a maximum depth of 1½ inches. The distance between drilled furrows was 12 inches.

3. The area with newly drilled plant materials was irrigated sufficient to moisten the soil surfaces.

4. Finally, the soil stabilizing compound (SOIL MASTER WR) was thoroughly mixed with water, hydraulic mulch, and fertilizer within a hydraulic mulching equipment to form a slurry in the following proportions (per acre basis): 125 gallons of SOIL MASTER WR (in concentrate form), 300 lbs of fertilizer mix (containing 181 pounds of actual fertilizer components), 2,000 lbs of hydraulic mulch, and 2,000 gallons of water. The slurry was then applied in two passes using the hydraulic mulching equipment, creating a soaking homogeneous spray to promote maximum soil penetration and crust thickness. The equipment was capable of spraying as far as 200 feet and the droplets of the slurry were proportionate sizewise to those encountered in a moderate rain storm. Care was taken to avoid excessive runoff during slurry application. The timing of the work was carefully planned to avoid rainy or freezing weather during the 48 hours curing time of the soil stabilizer.

Results and Discussions

The target low cost soil amendment application method has proven to be effective thus far. Pre-wetting of the soil and the furrows created during seeding operation enhanced soil penetration by the soil stabilizing chemical and reduced runoff. Once the material had cured, the resulting crust was found to be reasonably hard and it remained unaffected by subsequent rainfall events. Additionally, no significant wind erosion was visually observed on windy days following the soil amendment application compared to considerable soil movement observations before treatment. The decreased soil movement has significant potential to reduce wind borne radionuclides on the site. From casual field observations, it is estimated that the crust thickness is between 1½ and 3 inches. The crust was too hard to crumble under foot while walking over the matrix. Based on product longevity, it is expected that the soil cover will remain stable for 2 to 3 years as vegetation becomes established on the site. The project was completed recently, so it will take at least a year for vegetation to establish. The

material cost for the soil stabilization work (cost of SOIL MASTER WR, fertilizer, hydraulic mulch, and seed) was approximately $1,200.00/acre (site preparation cost is not included in this estimate).

Conclusions

This study demonstrates that soil testing and vegetation survey play important roles in the selection of proper soil amendment techniques for long term site stability. Appropriate soil amendment techniques can effectively provide temporary physical and vegetative stabilization for non-cohesive, nutrient-deficient sandy soil at a low cost until vegetation is established in 2-3 years. Several years will be required to fully access the success of this project, but the end result of reclamation should be a natural system that is stable, erosion resistant, and aesthetically pleasin. The project should also offer an array of benefits to wildlife, livestock, and the Navajo people. Uptake of radionuclides in established plant materials through root absorption is not a matter of concern; thus the reclaimed area is open for livestock grazing.

Acknowledgements

The authors sincerely thank Dr. Blake Onken, Soils Laboratory Director of the Navajo Agricultural Product Industry for conducting the soil analysis and recommending soil amendments. The project was funded by the Office of Surface Mining Reclamation and Enforcement with the Abandoned Mine Lands Reclamation fund. The Navajo Abandoned Mine Lands Reclamation Department was responsible for the design and implementation of this project. The contractor was Weeminuche Construction Authority, an entity of the Ute Mountain Ute Tribe.

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