THE ASSESSMENT OF A PHOSPHOGYPSUM STACK IN TEXAS[1]

by

Patrick McGuire[2], Suzie duPont, and Kurt Rubsam

Abstract. An assessment was conducted on a phosphogypsum stack in Texas. The stack is a by-product of phosphate fertilizer production that was discontinued in 1974. The objectives of the assessment were to obtain data to define alternatives for long-term stack stabilization, leachate management, and maintenance. Fieldwork was conducted to describe existing vegetative cover, surface physical conditions, phosphogypsum chemistry, hydrologic characteristics, and stack stability. Trenches were excavated on the stack to characterize physical conditions such as bedding or fracturing that may affect stability or surface hydrology. Samples of phosphogypsum were collected within the trenches and at surface sample locations for laboratory analysis of physical and chemical parameters. Borings were advanced through the stack using rotosonic-drilling methods to characterize the subsurface phosphogypsum, leachate, and base soils. Monitoring wells and piezometers were installed in borings to measure water levels/ hydraulic potentials and to collect water quality samples. Leachate samples were collected at the base of the stack. The existing vegetation includes weed and grass species. The particle size fractions of phosphogypsum samples from highest to lowest were silt, sand, and clay. The typical USDA texture classification was silt loam. The dry bulk density of in-situ samples was about 1.1 g/cm^3. The hydraulic conductivity of in-situ samples was about 10^{-3} cm/s. The paste pH of samples ranged from 5.4 to 3.7. The electrical conductivity of phosphogypsum samples was about 2.5. The depth to groundwater from the surface of the stack is about 9.1 m (30 ft). Groundwater pH ranges from 2.3 to 6.4. Leachate and groundwater samples have elevated ammonia, phosphorus, and sulfate concentrations. The native soils at the base of the stack are alluvial clays and silty sands. A numerical model will be used to assess the water balance for management alternatives. The data will be used to select the most cost effective management alternatives.

Additional Key Words: reclamation, water balance, plant productivity.

Introduction

An assessment was conducted on a phosphogypsum stack in Texas. The stack is a by-product of phosphate fertilizer production that was discontinued in 1974. The present stack has a height of about 24 m (80 ft) and a base of 8 ha (22 acres). The stack is relatively level on the surface with sideslopes that often exceed 40 percent. Leachate that discharges at the base of the stack is continuously recycled through the stack by pumping it up to the top surface for redistribution and infiltration.

The objective of the assessment was to obtain data to define alternatives for long-term stack stabilization, leachate management, and maintenance. Management alternatives that will be considered include practices or technologies that promote water loss through evaporation and/or transpiration (evaporator, vegetation), diverts runoff from the stack surface (grading), reduces infiltration into the stack by use of hydraulic barriers (liners) and/or improves leachate quality through active or passive biological treatment (wetlands).

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[2]Patrick McGuire is a Senior Soil Scientist with Earth Tech, 4135 Technology Parkway, Sheboygan, Wisconsin 53083. Suzie duPont is a Senior Geologist with Earth Tech, 2 Market Plaza Way, Mechanicsburg, Pennsylvania, 17055. Kurt Rubsam is a Project Scientist with Earth Tech, 4135 Technology Parkway, Sheboygan, Wisconsin 53083

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The fieldwork was conducted in November 2000. An inventory of the existing vegetation types on the stack was completed. Surface infiltration tests using a disc infiltrometer were conducted at seven locations on undisturbed phosphogypsum and loose particles representative of a tilled condition. Seven test pits were excavated to depths of about 1.2 m (4 ft) on the surface of the stack to characterize bedding or fracturing that may affect stability or surface hydrology. Rotosonic-drilling technology was used to advance six borings from the surface of the stack to a depth of 30 m (100 ft) or about 6 m (20 ft) into native material at the base of the stack. Five borings adjacent to the stack were advanced to depths of about 15 m (50 ft). Piezometers were installed in the eleven borings to depths that ranged from 7.6 m (25 ft) to 24 m (80 ft). Phosphogypsum samples were collected from the trench locations at depths from 0 to 1.2 m (4 ft). Samples were also collected from near surface sampling locations on the stack surface and sideslopes. At phosphogypsum sample locations, bag and core samples were collected for laboratory analysis. Core samples (5 cm diameter by 15 cm length) were analyzed for dry bulk density and saturated hydraulic conductivity. Clod samples were also analyzed for dry bulk density. Phosphogypsum bag samples were analyzed for physical and chemical parameters. Physical parameters included soil moisture content, particle size distribution, and development of soil moisture tension curves. Chemical parameters included paste pH, buffer pH, electrical conductivity, AB-DTPA extractable nutrients (N, P, K), AB-DTPA extractable metals (Zn, Fe, Mn, Cu, Pb, Cd, Ni, Mo, B, Mg, Na, Cr, Sr, Ba, Al, Ti, V, Si) total metals (Ca, Mg, Na, K, P, Al, Fe, Mn, Ti, Cu, Zn, Ni), anions (F, Cl, SO_4), cation exchange capacity, and SMA buffer test (lime requirement). Soil samples collected from the base of the stack were analyzed for Atterberg limits, unconfined compressive strength, direct shear strength, and unconsolidated/consolidated undrained triaxle shear strength. Leachate samples were collected from the base of the stack. Depth to groundwater was measured in the eleven piezometers and groundwater samples were collected. Leachate and groundwater samples were analyzed for pH, eH, dissolved oxygen, specific conductivity, temperature, total dissolved solids, acidity, alkalinity, nitrogen ($N0_3$/NO_2 /NH_3), dissolved metals (P, K, Mg, Ca, Na, Mn, Fe, Zn, Ni, Cu, B, Al, Si), and anions (F, Cl, SO_4).

The vegetation on the surface and sideslopes of the stack is predominantly herbaceous and includes little bluestem, dogfennel, ragweed, hairy hawkweed, bermuda grass, and wandlike goldenrod. Fractures were observed on the stack surface and in some of the trenches. Some of the fractures are extensive and more than 1.5 m (5 ft) in depth. Some fractures may function as preferential flow paths directing surface water through the subsurface to discharge channels observed on the sideslopes. The texture of phosphogypsum samples based on the USDA Soil Classification System ranged from sandy loam to silt loam with a typical texture of silt loam. The particle size fractions of phosphogypsum samples from highest to lowest were silt, sand, and clay. The dry bulk densities of in-situ and loose samples were about 1.1 g/cm^3 and 0.7 g/cm^3, respectively. The saturated hydraulic conductivity based on laboratory analysis of in-situ samples and field infiltrometer tests was about 10^{-3} cm/s. The paste pH of samples ranged from 5.4 to 3.7 with the higher values associated with surface samples. The electrical conductivity of phosphogypsum samples was about 2.5 mmhos/cm at all depths from the surface to 15 m (50 ft) below the surface of the stack. The concentrations of extractable $N0_3$-N ranged from 1.6 to 2.3 ppm. The concentrations of extractable phosphorus ranged from 19.1 to 31.3 ppm. The concentrations of extractable potassium ranged from 7.02 to 14.8 ppm. The cation exchange capacity of the phosphogypsum was less than 10 meq/100 g. The depth to groundwater from the stack surface ranges from 9.1 m (30 ft) to 15 m (50 ft). The pH of groundwater below the stack surface ranges from 2.3 to 4.9. Groundwater pH adjacent to the stack ranges from 5.6 to 6.4. Leachate and groundwater samples have elevated ammonia, phosphorus, and sulfate concentrations. The native soils at the base of the stack are predominantly clays and silty sands based on the Unified Soil Classification System.

The data from the fieldwork will provide input for future numerical hydrologic model simulations. EPIC, a numerical model developed by the USDA-Agricultural Research Service (Sharpley and Williams, 1990), will be used to assess water balance, surface runoff, and erosion for management alternatives. The results of the field investigation and model simulations will provide a basis for selection of the most suitable management alternatives.

Literature Cited

Sharpley, A. N. and Williams, J.R. 1990. EPIC-Erosion Productivity Impact Calculator:Vol.I. Model Documentation. USDA Technical Bulletin No. 1768.