PROGRESSIVE CHANGES IN MINESOIL pH OVER THREE DECADES

Walter H. Davidson, W. Clark Ashby, and Willis G. Vogel[1]

Abstract.--Surface minesoils in the Appalachian and Interior Coal Provinces that include a mixture of overburden materials may experience rapid changes of pH in the early years after mining, followed by slow, longer term changes. Reclamation plantings are commonly made on minesoils atypical in pH for the region. The pH's have ranged from extremely acid to moderately alkaline. Subsequent measurements on these plantings, including soil pH, have shown a high degree of regularity in convergence of pH toward values more typical of regional soils. These changes have been most marked for extremely acid soils. The effects of plant cover may be one cause of the long-term changes in pH.

INTRODUCTION

Pedogenesis embodies the concept of changes in soil properties (Jenny 1980). Many of these changes, such as accumulation of clay, are typically linear and nonreversible in the time frame we are reporting. In the Eastern United States, natural soils may slowly become more acidic with development or maturation over time related to the type of parent material and somewhat to the type of vegetation. Parent materials of upland soils usually are not rich in iron and other sulfides.

By contrast, many coal deposits and associated rock types in the overburden have pyritic materials that rapidly contribute to acidity of minesoils (Ashby et al. 1979). The acidification of fresh minesoils is accompanied by a release of large quantities of hydrogen ions, salts, and bases from affected minerals (Struthers 1964). In his classification of minesoils by pH classes, Limstrom (1960) considered that a pH of 4.0 or less generally indicated conditions lethal to most plants.

[1]Walter H. Davidson is Research Forester, Northeastern Forest Experiment Station, USDA Forest Service, Princeton, WV; W. Clark Ashby is Professor, Department of Botany, Southern Illinois University at Carbondale; and Willis G. Vogel is Range Scientist (Retired), Northeastern Forest Experiment Station, USDA Forest Service, Berea, KY.

Studies in Pennsylvania have identified several species capable of tolerating minesoil pH 3.5 (Davidson 1979). Some species survived at lower pH's, but vigor was greatly reduced. Struthers (1961) postulated that the high concentration of salts in a fresh minesoil may account for the tolerance that many plants exhibit toward high acidity. Thus, other chemical and physical factors of the different geologic materials may interact with the pH. These interactions could partially explain why the reports by Limstrom (1960) and Davidson (1979) appear contradictory.

Acidic soils often occur in localized "hot spots." The conventional wisdom in the reclamation field is that these acidity conditions improve with the passage of time (Limstrom 1960, Geyer and Rogers 1972, and Lindsay and Nawrot 1981). In this paper we present substantial information on minesoil changes in pH and evaluate the nature of these changes.

MINESOIL CHANGES OVER TIME

Areas barren of vegetation, so called acid spots or "grease" spots if high osmotic values keep them moist in dry periods, usually are attributed to extreme acidity and its effects on solubilities of nutrient and toxic ions. Much information on persistence of acid spots can be gained from aerial photo interpretation. Coal companies routinely have mining operations photographed over a period of years. We examined successive photos following mining of an 858-acre area in Saline County,

Proceedings America Society of Mining and Reclamation, 1988 pp 89-92
DOI: 10.21000/JASMR88020089

southeastern Illinois, for light colored, "barren," and presumably acid spots. Obvious disturbances such as roadways or power lines and water bodies were excluded. Spots continuously light colored from 1952 to 1982 totaled 2.3 acres. This compares with 11.5 such acres in 1965 and 184 acres (21 percent of the total) in 1952. Thus, only 1 percent of the area bare in 1952 was still bare 30 years later. There was an exponential decrease in bare areas over the measured period (fig. 1).

We restudied some of the same plots 30 years later. Four were in the 858 acres evaluated in the aerial photo study. One, when planted, averaged pH 3.4. Thirty years later, it averaged pH 4.7 based on 30 soil auger core samples to a 6-inch depth. Twelve of the 23 plots in this study, including all below pH 6.0, showed an average increase in pH of 1.3 units. Nine plots, initially at pH 6.0 to 8.3, showed a decrease in pH. Whatever the mechanism of these shifts in pH, the most acid soil conditions did not persist (fig. 2). The sites appeared to be converging toward pH values more typical of regional soils.

A lateral comparison was carried out to document pH levels on increasingly older minesoils. Soil samples for pH determination in the laboratory were collected at several depths in different parts

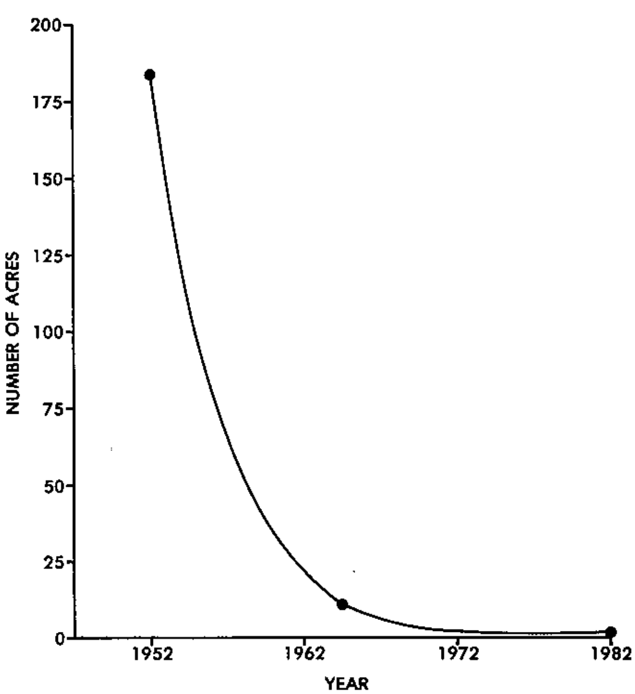

Figure 1.--Changes in acreage exhibiting acid characteristics from 1952 to 1982.

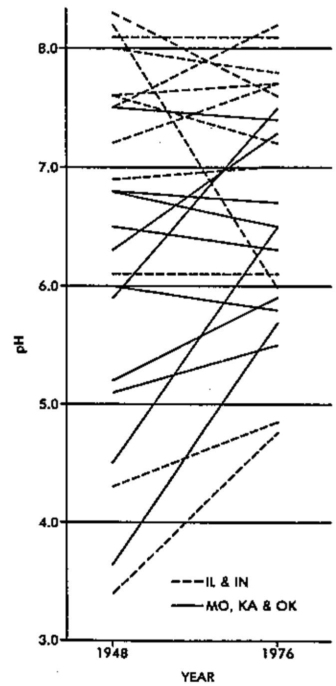

Figure 2. Changes in pH from 1948 to 1976 on 23 plots on midwestern minesoils.

of the Saline County mine approximately 6, 12, and 36 years after mining. Both the 6- and 12-year sites were completely bare of higher plants compared to the 36-year sites, all of which had plant species associated with soil acidity such as three-awn grass (Aristida sp.) and poverty grass (Danthonia sp.)

We found that the 6- and 12-year-old acid spots had lower pH than the 36-year site. A futher finding was that the surface pH showed an increasing tendency to be higher than the pH of deeper soil materials with an increase in minesoil age. The significant findings of these studies are that natural processes substantially decreased soil acidity of extremely acid surface minesoils.

Another USDA Forest Service study in which pH data were compared after 19 years showed similar results. In this study, 60 soil samples were collected from a mined site in southeastern Kentucky in 1965 and 1984. Data obtained from the 1965 samples showed that pH averaged 4.2. The 1984 samples averaged pH 4.5. Data from the 2 sample years were segregated into three groups: pH 3.9 and lower, pH 4.0 to 4.9, and pH 5.0 and above. Table 1 shows the changes that occurred over the 19-year period. These figures suggest that the equilibrium pH for this site will be somewhere in the 4.0 to 4.9 range.

Table 1.--Fluctuations in pH on a Kentucky minesoil.

pH Group	1965 Samples	1984 Samples	No. of Samples Moving Up	Down
3.9 and less	25	7	[1]20	
4.0 to 4.9	26	47	4	2
5.0 and above	9	6		8

[1]One sample moved up to the 5.0 and above group.

Data from a similar Forest Service study in Pennsylvania compared changes in pH on five sites after 14 years. Average change in pH for combined data from these sites was an increase of 0.4 pH units, from 3.3 to 3.7. Seven out of 101 samples had a decrease in pH. Average data, by site, are shown in Table 2.

These data are beginning to show the same tendencies as data from the other, longer term studies we have examined in this paper. In time, these sites should reach a pH equilibrium typical for forested sites in this region in the pH 4.0 to 4.9 range.

IMPLICATIONS OF NATURAL AMELIORATION OF EXTREME ACIDITY

Various concepts of soil acidity have affected public policy and economic costs for many years. Much legislation, vast amounts of labor, fuel, and equipment use, and huge sums of money have been expended in eliminating potential acid spots on lands currently being mined. Acidic areas are a high priority in allocating funds for reworking abandoned mined lands. A broader understanding of the role of natural processes and management possibilities in alleviating acidity could lead to better reclamation practices, and also influence our conception of problems associated with "acid rain."

A promising management technique is to increase levels of soil organic matter. Organic matter contributes to improved soil physical and chemical conditions. The recovery of barren acid spots may well result from inputs of organic matter from the surrounding vegetation. Possible mechanisms are increased mineral (base) cycling and microbial transformations of sulfate. Swank et al. (1984) considered that incorporation of sulfate to organic forms in forest soils could provide a buffer against the impacts of acid precipitation. Increased soil organic matter would be a possible management tool for sulfate removal from soils and for reduced acidity.

The best treatment to offset effects of sulfate input on mined lands and in precipitation may well be to increase ecosystem productivity. This approach recognizes the classic model of soil development and maintenance in which both vegetation and soil are functions of climate, parent material, topography, and biota, all as a function of time (Jenny 1980). Some organic mulches used in reclamation practices not only enhance vegetation establishment on extremely acid sites but have also been shown to increase pH (Slick and Curtis 1985). Production of organic matter by vegetation may be a new solution to perceived problems with acidity on minesoils and on soils impacted by acid precipitation.

LITERATURE CITED

Ashby, W. C., W. C. Hood, and M. L. Guerke. 1979. Geochemical factors affecting plant growth in reclamation. Weeds Trees and Turf 18(4):28,30,34,36,38, 43,61.

Davidson, W. H. 1979. Results of tree and shrub plantings on low pH stripmine banks. USDA For. Serv. Res. Note NE-285, 5 p.

Geyer, W. A., and N. F. Rogers. 1972. Spoils change and tree growth on coalmined spoils in Kansas. J. Soil and Water Conserv. 27(3):114-116.

Jenny, H. 1980. The soil resource origin and behavior. 377 p. Springer-Verlag, New York, NY.

Table 2.--Changes in pH on five mined sites in Pennsylvania over a period of 14 years.

Item	Mosgrove	Burns	Hitchman	Schoonover	Strattanville	Total/ Average
No. Samples	35	17	15	17	17	101
1972 pH	3.2	3.7	3.3	3.3	3.1	3.3
1986 pH	3.6	4.0	3.8	3.5	3.6	3.7

Limstrom, G. A. 1960. Forestation of strip-mined land in the Central States. U.S. Dep. Agric., Agric. Handb. 166. 74 p.

Lindsay, R. E., and J. R. Nawrot. 1981. Evaluation of natural revegetation of problem spoil banks. In Symposium on surface mining hydrology, sedimentology, and reclamation. D. H. Graves (Ed.). Univ. of KY, Lexington, December 7-11, 1981. UKY BU 126. p. 367-375.

Slick, B. M. and W. R. Curtis. 1985. A guide for the use of organic materials as mulches in reclamation of coal minesoils in the Eastern United States. USDA For. Serv. Gen. Tech. Rep. NE-98, 144 p.

Struthers, P. H. 1961. 180,000 stripmine acres: Ohio's largest chemical works. Ohio Farm and Home Res. 46(4):52-53.

Struthers, P. H. 1964. Chemical weathering of strip-mine spoils. Ohio J. Sci. 164(2):125-131.

Swank, W. T., J. W. Fitzgerald, and J. T. Ash. 1984. Microbial transformation of sulfate in forest soils. Science 223:182-184.
http://dx.doi.org/10.1126/science.223.4632.182