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DETERMINING pH OF STRIP-MINE SPOILS

Abstract.—Results with the LaMotte-Morgan method for determining soil pH—or the solution modification of this method—usually agreed fairly well with the results from using a pH meter, the recognized standard. Results obtained with the Soiltex and Hellige-Truog methods often deviated somewhat from the pH meter readings; and the Hydrion papers and the Kelway pH tester often gave results that were considerably different.

Success in establishing various types of vegetation on strip-mine spoils in the Eastern and Central States is often limited by spoil acidity. Thus, for planning revegetation programs on strip-mined areas, a knowledge of the relative spoil acidity is essential. This note contains brief descriptions and evaluations of several methods of determining spoil acidity.

The degree of acidity is measured by the hydrogen ion concentration in solution. If concentrations were given in conventional units, this would result in large unwieldy numbers; however, this can be avoided by using the logarithmic term pH. On the pH scale a value of 7 is neutral: values less than 7 are acid, and acidity increases as the pH value decreases; values greater than 7 are alkaline, and alkalinity increases as the pH value increases.

Certain pines and birches may grow on spoil with pH as low as 3.5; other trees and weeping lovegrass may grow on spoil with pH as low as 4.0. Most commonly used herbaceous species will not grow satisfactorily unless the pH is 4.5 or above. High pH is seldom a problem, but pines may do poorly on alkaline spoils.

Sampling Spoils

Before starting to sample, take a good look at all the spoils on a job. Areas that are obviously different in color or composition should be sampled as separate units if they are big enough to be handled separately in the revegetation program.

The number of samples to take on an area will depend on the homogeneity of the spoils and the objectives of revegetation. Our experience has been that 10 samples are about the minimum needed for revegetation interpretations on several acres of spoil that are uniform in appearance. Heterogeneous spoils and larger areas require more samples, but the question of how many needs further study. Since pH determinations are inexpensive in relation to total revegetation costs, and often inexpensive in relation to travel time to a site, it is better to take too many samples than too few.

When planning revegetation for a spoil area, your first concern should be the proportion of the area that falls into various acidity classes. Therefore, do not combine samples.

A tile spade with a round cutting edge usually works well for sampling. First make a vertical cut to a depth of about 4 inches, and discard the spoil. Then make a second cut, 2 or 3 inches behind the first, to obtain the sample; discard rock fragments larger than about 1/2 inch.

Small paper sacks can be used to hold samples and record information about spoil type and area. However, wet samples should be put in moisture-resistant liners or commercially available soil-test bags.

Several months of exposure after the mining operation are usually required before spoils containing acid-producing materials (sulfides) develop their lowest pH. Thus, in addition to pH measurements, a sulfide test may be desirable on some spoils. Details for making sulfide tests are contained in an article by Neckers and Walker.¹

Methods Used to Determine pH

A pH meter is the standard device for determining soil pH. However, because of the purchase and maintenance costs of these meters, plus the requirements for containers, distilled water, and buffers, other methods are often used to determine spoil pH.

¹ Neckers, J. W., and C. R. Walker. FIELD TEST FOR ACTIVE SULFIDES IN SOIL. *Soil Sci.* 74: 467-470. 1952.

In contacts with revegetation specialists and strip-mine inspectors, we noted that some of the methods did not give results consistent with those that we obtained with a pH meter. To check the methods, we determined pH on 100 representative Kentucky spoils. The samples included spoils from all the major Kentucky strip-mined coal seams. The spoils were air-dried, screened to remove rocks larger than 1/2-inch diameter, and then mixed. The methods used to determine pH were as follows.

pH Meter.—The instrument used was a line-operated Fisher Accumet² pH meter equipped with glass and reference electrodes. The meter was checked with buffer at pH 4.0 and 7.0. Forty milliliters of distilled water were added to 20 grams of spoil. The spoil was allowed to slake in the water a few minutes; next it was mixed and allowed to equilibrate 1 hour; then it was mixed again; finally, the electrodes were inserted into the liquid and the pH was read.

LaMotte-Morgan.—This is a kit that contains several pH indicator dyes. Each dye has a range of about 1.6 pH units. If the color resulting from contact with soil was on either extreme of the range, the next higher or lower range indicator was used. Colors were compared to standard color charts. Directions given by the manufacturer were followed. Because Bromphenol Blue (pH range 3.0 to 4.6) and Meta Cresol Purple (pH range 1.2 to 2.8) were not included in the standard kit, they were ordered extra.

LaMotte-Morgan modification.—This was our modification, using the LaMotte-Morgan pH indicator dyes on the solution from the spoil-distilled water mixtures made up for the pH meter tests. Four drops of the solution were put into the LaMotte-Morgan porcelain test plate, and one drop of indicator was added. The color was read in the shallow groove rather than in the well of the plate.

Soiltex.—The Soiltex kit contains a single liquid-dye indicator that is added to the soil in a small wax-paper “boat”. The color of the liquid after reacting with soil is compared to a color chart. We followed the directions given by the manufacturer.

Hellige-Truog.—This kit contains a single liquid-dye indicator solution that is placed in the cavity of a porcelain test-block; soil is added to absorb all the indicator. The indicator and soil are mixed; then a white powder is sprinkled over the surface. The powder absorbs the

² Mention of product names does not imply endorsement by the U. S. Department of Agriculture or the Forest Service.

color of the indicator, which is then compared to a color chart. The manufacturer's directions were followed.

Hydrion Papers.—These are narrow strips of paper impregnated with pH indicator dyes. The papers are sometimes used on soils and spoils, although they are not made nor advertised for this purpose. The manufacturer recommends that these test papers be used on buffered solutions (buffered solutions have a strong resistance to a change in pH). We dipped these papers into the solution from the spoil-distilled water mixtures made up for the pH meter tests. We also made up a paste of spoil and distilled water; then we pressed one side of the indicator paper against the paste and read the color resulting from the absorbed solution on the other side of the paper. Results of the latter method were nearly the same as the solution method. Wide range (pH 3.0 to 7.5) and short range (pH 3.0 to 5.5) papers were used.

Kelway pH Tester.—This is a probe that is made to be pushed into moist soil, after which the pH is read on a dial at the top of the probe. However, for dry soils the soil can be placed in a container; distilled water is added; and then the probe is inserted into the mixture for a reading. On the test spoils we used this latter procedure, following the manufacturer's directions.

Results and Discussion

Results obtained with the LaMotte-Morgan method, or with our solution modification of the LaMotte-Morgan method, usually agreed fairly well with results from using the pH meter (table 1). Results obtained with the Soiltex and Hellige-Truog methods often deviated more than 0.5 pH unit from the pH meter reading. Hydrion paper and the Kelway pH tester often gave results that were considerably different from those with the pH meter.

Although not strictly comparable because of differences in electrodes and soil materials, the deviations for the LaMotte-Morgan and Soiltex methods were similar but slightly greater than the deviations reported for these methods on soils.³

A pH meter is easy to operate, and battery-operated pH meters can be used readily in the field. However, when many samples are required, the most convenient method is usually to collect the samples and bring them into the laboratory for pH readings (fig. 1).

³ Mason, D. D., and S. S. Obenshain. A COMPARISON OF METHODS FOR THE DETERMINATION OF SOIL REACTION. Soil Sci. Soc. Amer. Proc. 3: 129-137. 1939.

Table 1.—Percentage of readings from six pH determination methods falling within a given deviation of pH meter readings

Method and pH range*	Deviation, in pH units of—				
	0.2	0.5	1.0	2.0	3.0
LaMotte-Morgan:					
2.7-4.5	58	92	100	—	—
4.6-6.0	49	87	100	—	—
6.1-8.3	44	80	100	—	—
LaMotte-Morgan modification:					
2.7-4.5	44	100	—	—	—
4.6-6.0	51	80	100	—	—
6.1-8.3	52	88	100	—	—
Soiltex:					
2.7-4.5	44	83	97	100	—
4.6-6.0	33	59	92	100	—
6.1-8.3	16	44	84	100	—
Hellige-Truog:					
2.7-4.5	42	75	97	100	—
4.6-6.0	23	62	97	100	—
6.1-8.3	12	44	72	100	—
Hydron Papers:					
2.7-4.5	56	97	100	—	—
4.6-6.0	8	31	77	100	—
6.1-8.3	0	0	0	48	100
Kelway pH Tester:					
2.7-4.5	6	33	50	92	100
4.6-6.0	0	3	10	87	100
6.1-8.3	44	68	80	100	—

*Number of spoil samples within the ranges, as determined by pH meter: 2.7 to 4.5—36; 4.6 to 6.0—39; 6.1 to 8.3—25.

The exact ratio of spoil to distilled water makes little difference in routine pH measurements on spoils. Thus the procedure can be simplified by filling small paper cups half full of spoil, then adding distilled water until the cups are nearly full. On more acid spoils (pH 3.5 to 5.0), the time allowed for equilibrium makes little difference (a few minutes will do). To obtain consistent readings on spoils of higher pH, especially in the 6.5 to 8 range, it may be necessary to let the mixture stand an hour or even overnight.

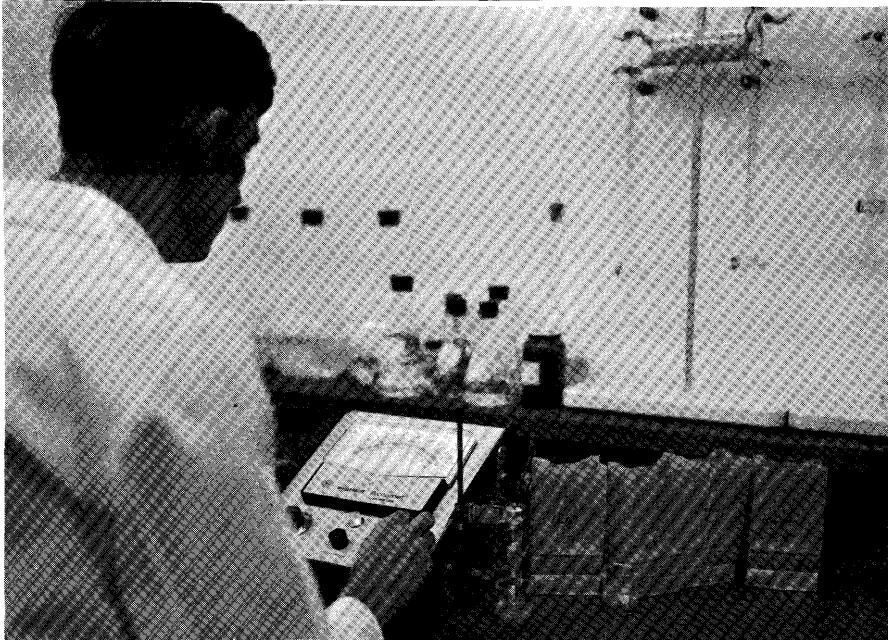


Figure 1.—Determining pH of spoils with a pH meter. Because of its general reliability and ease of operation, the pH meter is the recognized standard for soil pH measurements.

For most spoil materials, about the same readings are obtained with the electrodes in the solution above the settled spoil material as in the material itself. However, in some spoils (and in acid soils) a lower pH is recorded when the electrodes are inserted into the mass of settled particles. This is termed “suspension effect”. The proper electrode placement for best results is still in question. Since electrodes can be broken by sharp contact with coarse particles, we prefer to insert them only into the liquid. The important point is consistency in the technique used.

The LaMotte-Morgan method should give satisfactory results for revegetation interpretations on spoils. The kit is less costly and can take rougher treatment than a pH meter. However, the procedure is more time-consuming because two or more indicators often have to be tried. Advantages of the solution modification method over the normal LaMotte-Morgan method are that spoil does not have to be cleaned from the spot plate, wet sticky spoils are manageable, and coarse fragments (up to about 1/2 inch in diameter) do not have to be removed from the sample. Some spoils will not give a clear solution, but reasonably good results are still obtained by using the slightly cloudy suspension.

The Soiltex and Hellige-Truog methods employ one mixed indicator solution for the pH range 4 to 8.5 or 9. Both of these methods have the disadvantages that readings below 4 cannot be made and that readings

in the pH 4 to 5 range, critical for plant species, cannot be made closer than 0.5 pH unit. An advantage of these methods is that the kits are small and inexpensive. And if carefully used, the Hellige-Truog method can detect components that have different pH levels in a spoil sample. An example is a spoil sample that consists of small gray shale particles (pH 7.0) in a brown loamy matrix (pH 5.0).

The Hydrion papers method is recommended for use only with solutions naturally buffered to resist change in pH. The papers themselves are more strongly buffered than some spoils; thus spoils with a pH of 7 will often read 5.0 or 5.5. Extremely acid spoils are well buffered; therefore, the papers can be used to indicate spoils that have a pH of 4 or less.

The Kelway pH tester usually identified extremely acid spoils (below pH 4), but with spoils in the pH range 4 to 5 this tester often indicated a pH of 7. Thus reliable information on spoil acidity could not be obtained with this device. The Kelway pH tester did not give correct readings when inserted into buffers of pH 4 and 7.

How to Use pH Data

Use a map to delineate spoil types and record pH readings. Recommendations as to species for planting or seeding on spoils are made on the basis of dominant pH range, if that is representative of a large portion of the spoil. If a wide pH range occurs in spoil samples from a given area, and spoil types cannot be delineated by color or texture, select species on the basis of the lower pH readings.

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