hearted manner. Steady drizzle deters insect flight but there would seem to be no serious hazard to echo location. Sound scattering will still be slight and even the finest drizzle droplets will resonate below 10 kHz. In the sudden, heavy rain of thunderstorms there may be large numbers of insects in the air and bats are often seen to continue active and apparently successful hunting, with rapid turns accompanied by ultrasonic "interception buzzes". Drops of 1,000 μm diameter resonate at 350 Hz but scattering may be appreciable, especially at the highest, "blue" frequencies. The problem is then one of distinguishing insect echoes from the "clutter" of echoes returned by raindrops. The critical difference may be that the drops all fall downwards and maintain a constant reflectivity, whereas flying insects do neither. The work of Webster[4] suggests that the processing of echo signals by bats is sufficiently sophisticated to deal with this situation and this is certainly supported by field observation.

This work was sponsored in part by the Air Force Office of Scientific Research through the European Office of Aerospace Research.

J. D. Pye

Department of Zoology,
University of London King's College,
Strand,
London WC2

Received September 10; revised October 26, 1970.

1 Houghton, H. G., and Radford, W. H., *Pap. Phys. Ocean. Meteorol. MIT*, **6**, 5 (1938).
2 George, J. J., in *Compendium of Meteorology* (edit. by Malone, T. F.) (Boston, 1951).
3 Rayleigh, Lord, *The Theory of Sound* (London, 1896).
4 Webster, F. A., *Animal Sonar Systems* (edit. by Busnel, R.-G.), 673 (Jouy-en-Josas, 1967).

*p*H of Very Acid Soils

The purpose of this note is to call attention to the fact that usual methods of measuring soil *p*H[1] seriously underestimate the *p*H of very acid soils, such as those of coal mine spoils[2], cat clays[3] and solfataras[4], in which acidity is due to the presence of free sulphuric acid. Standard methods for measuring soil *p*H involve making a slurry of soil with (usually) distilled water at a 1 : 2, 1 : 5, or 1 : 10 dilution, and reading the *p*H of this slurry. Implicit in this procedure is the assumption that the soil is buffered and hence that *p*H does not change with dilution. This assumption is erroneous in the case of the sulphuric acid soils.

In our work on the microbiology of very acid soils[5] we wanted to know the *p*H values to which the microorganisms were actually subjected; that is, the *p*H of the soil water. To measure this, a slurry of equal parts of soil and water was made and from this slurry a series of dilutions in water were made. The *p*H of each dilution was measured using a Corning combination glass electrode, and a graph was prepared relating hydrogen ion concentration to dilution (Fig. 1). In the case of the sulphuric acid soils, a straight line was generally obtained and this line was then extrapolated back to zero dilution and the hydrogen ion concentration of the soil obtained. If the *p*H of the soil water was desired, the moisture content of the soil was determined and the dilutions then corrected to represent dilutions of the soil. (For example, if the moisture content of the soil were 10% then the initial dilution would be 1 : 20 rather than 1 : 2.) As also shown in Fig. 1, an acidic agricultural soil, being buffered, does not change *p*H significantly with dilution, and hence its *p*H can readily be estimated by the standard procedure.

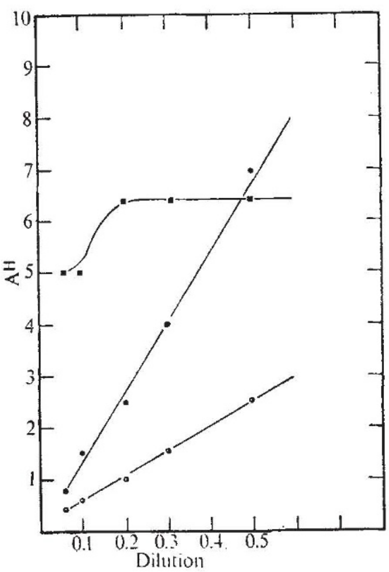

Fig. 1 The dilution curves of three soils. ■, Clay soil, *p*H=5.3; ●, solfatara soil, *p*H=1.90; ○, mine waste soil, *p*H=1.30.

Table 1 *p*H of Coal Mine Refuse from Pike County, Indiana

Diluent	Method 1 : 2 dilution	1 : 10 dilution	Estimated *p*H at zero dilution Soil	Soil water
Distilled water	3.8	4.5	3.5	3.4
1 M KCl	2.3	2.9	—	—
0.01 M $CaCl_2$	2.7	3.2	—	—

Our new procedure was compared with standard procedures for several coal mine spoil and solfatara soils. The results with one representative soil are shown in Table 1. It can be seen that the *p*H value as measured is lower than estimated by standard dilution in distilled water. The *p*H obtained by standard dilution in KCl or $CaCl_2$ is lower than that obtained by our method, but reflects exchange of hydrogen ions by diluent cations[1] and hence does not necessarily represent the *p*H of the soil water. When considering the introduction of plants on coal mine spoils, cat clays, or other very acidic soils, a knowledge of the exact *p*H value, as determined by our new method, should be of significant value.

This work was supported by a research grant from the US National Science Foundation and a training grant from the US Public Health Service.

W. N. Doemel*
T. D. Brock

Department of Microbiology,
Indiana University,
Bloomington,
Indiana 47401

Received October 1, 1970.

* Present address: Biology Department, Wabash College, Crawfordsville, Indiana 47933.

1 Peech, M., in *Methods of Soil Analysis, Part 2*, 914 (Amer. Soc. Agronomy Publ., No. 9, Madison, Wisconsin, 1965).
2 Kohnke, H., *Adv. Agronomy*, **2**, 318 (1950).
3 Moorman, F. R., *Soil Sci.*, **95**, 271 (1963).
4 Schoen, R., *Geol. Soc. Amer. Bull.*, **80**, 643 (1969).
5 Doemel, W. N., and Brock, T. D., *Arch. Mikrobiol.*, **72**, 326 (1970).