THE pH OF FRESH SOILS AND SOIL SOLUTIONS¹

Development of robust glass electrodes in recent years has made possible direct reading of pH on the fresh material of many soils, especially in the rather organic surface horizons characteristic of moist temperate climates, and in aquatic soils. It is well known that such readings, which involve packing moist soil around the electrodes, are often a good deal lower than those made on soil solutions, which may themselves exhibit a marked rise in pH upon stirring and expulsion of excess carbon dioxide. However, the magnitude of the differences has seldom been examined in natural soils, and is sometimes not appreciated by ecologists and others making pH measurements on them.

This communication reports the range of pH values obtained for a series of British soils. Table I presents data from (a) highly organic *mor* humus layers in oak-woods, (b) much less organic *mull* humus layers in mixed hardwoods, and (c) a 4-meter mud core from the deepest part of a fertile lake, Esthwaite Water. All samples were collected in the English Lake District, and the woodland soils have been described previously (Gorham 1953, 1958 a).

It is evident that the lowest pH values were obtained by direct insertion of the electrodes into fresh soil, which exposed them to contact with swarms of adsorbed cations concentrated at the surfaces of soil colloids (the so-called "suspension effect" (Jenny *et al.* 1950). The individual pH readings in this case were 0-1.3 units below those made on fresh soil solutions immediately after expression by a hydraulic press, the differences averaging 1.0 unit in the *mulls*, 0.9 unit in the *mors*, and only 0.4 unit in the much wetter aquatic soils, which did not require so much packing around the electrodes. The freshly collected soil solutions in turn gave readings of 0-1.8 pH units below those obtained after aeration, which reduced carbon dioxide tension to the level of atmospheric equilibration. In this instance the greatest rise on aeration (average 1.3 units) was exhibited by the lake muds, where escape of respired carbon dioxide to the atmosphere is greatly impeded. The average increase in the *mulls* amounted to 0.7 unit, while in the strongly acid *mors* it was negligible.

The extremely low pH values of the expressed *mor* solutions were due to the presence of free sulfuric acid (Gorham 1958 b), while the faint acidity of the fresh solutions from *mulls* and lake muds was obviously due mainly to dissolved carbon dioxide, since the values rose markedly upon aeration, to above the neutral point except in two of the *mulls*. The alkaline pH values in the mud solutions after aeration, and in three of the *mull* solutions, were no doubt due to the presence of bi-

¹ This work was done while the author was on the staff of the Freshwater Biological Association, Ambleside, England.

carbonates, calcium bicarbonate being the chief product of soil weathering in this area (Gorham 1958 a).

In conclusion it may be remarked that the maximum

TABLE I. Three methods of pH measurement on natural soils of the English Lake District

	pH BY GLASS ELECTRODE		
	Direct insertion	Expressed solution	Aerated solution
<i>Mor</i> humus layers	3.5 3.4 3.4 3.5 3.3	3.9 4.1 4.3 4.5 4.6	3.9 4.1 4.3 4.5 4.8
<i>Mull</i> humus layers	4.6 5.3 5.4 5.7 5.4	5.9 6.0 6.2 6.5 6.6	6.5 6.6 7.1 7.3 7.1
Lake muds*			
depth in core (cm.)			
20-40	6.5	6.8	8.1
80-100	6.4	6.8	8.5
100-120	6.3	6.6	8.4
160-180	6.3	6.8	8.0
220-240	6.2	6.7	8.0
250-270	6.2	6.8	8.3
290-310	6.3	7.0	8.4
340-360	6.3	6.8	8.2
385-405**	6.6	6.6	7.1

* pH of water above mud 6.8, rising to 7.6 after aeration.

** Mud less organic and somewhat clayey.

difference, between pH by direct electrode insertion and by measurement on expressed and aerated soil solutions, may reach 1.5 units in the *mors*, 1.9 units in the *mulls*, and 2.1 units in the lake muds; averaging 0.9, 1.6 and 1.8 units respectively.

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