ESTIMATION OF THE SURFACE OF SOILS.

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DURING the last few years a good deal has been heard of the estimation of colloids in soils by means of dye solutions.

The method is described by H. E. Ashley¹ and later by König, Hasenbäumer, and Hassler².

These workers used colorimetric methods of estimating the dye absorbed. R. van der Leeden and F. Schneider³ used a titration method.

B. Sjollema⁴ tried several dye solutions and finally adopted methyl violet dissolved in water as being the most general dye for both basic and acidic constituents of the soil; other dyes such as naphthol yellow, alizarin, and congo red were found to be selective.

König, Hasenbäumer, and Hassler used methyl violet and methyl green but recommend the former as its colour undergoes only a very slight change after being in contact with the soil.

These workers shook up samples of soil in cylinders with solutions of methyl violet and compared the resulting solutions with standard dye solutions of strengths varying from 0.3 mg. to 40 mgs. per 100 c.c.s.

From work described by other workers, particularly Dreaper and Davis⁵, it appears that the dye colours not only colloidal particles but particles of all sizes. Dreaper and Davis used fine sand washed and cleaned with HCl. Their method was to run dilute dye solution from a burette through vertical tubes packed with sand, the end-point being

¹ U.S. Geol. Survey Bull. 1909, 388.

² Landwirtsch. Versuchs Stat. 1911, 75, 377.

³ Inter. Mitt. für Bodenkunde, II. 81.

⁴ Jour. für Landwirtsch. 1905, 67.

⁵ Inter. Congress of Applied Chemistry, 1909, Sect. IV B.

reached when the first coloured drop passed through; this gave a very sharp end-point.

In the work to be described here three soils were used, of which the mechanical analyses were known, and the first method adopted for dyeing them was that used by Dreaper and Davis with methyl violet as the dye.

This method although rapid for sands was found to be unsatisfactory for soils containing any clay, because, even by using a filter pump, it was difficult to get the solution to run through, and also because the soil dyed very unevenly, the colour being much denser at the top of the tube than the bottom when the filtrate first became coloured; moreover the dye solution tended to run in channels amongst the coarser particles.

This led to the adoption of König, Hasenbäumer, and Hassler's method. Glass tube-bottles of about 150 c.c.s capacity with ground-in stoppers were used. Five gms. of air-dried soil were shaken with 100 c.c.s of methyl violet solution and laid on their sides for 24 hours with occasional shaking and then stood upright for another 24 hours to allow the soil to settle. Part of the top solution was then pipetted off, diluted suitably, and the dye estimated colorimetrically by means of Nessler's tubes and standard dye solution. König used different strengths of dye solution for different soils, viz. 1 gm. per litre for sandy soils, 2 gms. per litre for loams and 3 gms. per litre for clays.

If however the weakest solution is used for a clay, the soil does not take up so much dye and yet leaves some in solution. Again if the strongest solution be used for sands the soil takes out far more dye than it will from a weak solution.

It was therefore decided to compare the dye taken out by the soils chosen, from solutions of varying strengths.

The three soils chosen were (1) a sandy loam with 3% clay, (2) a loam with 8% clay, (3) a Rothamsted soil (clay loam) with 20% clay.

The dye solutions were of twelve different strengths varying by 0.25 gm. per litre from 0.25 gm. per litre to 3 gms. per litre and curves were drawn representing the amount of dye absorbed per 100 gms. of soil against the amount of dye left in the solution. The three curves are shown in the accompanying figure. In all cases the dye absorbed increases rapidly with increasing strength of dye solution up to a certain point when the soil appears to become almost saturated.

It is obvious from these curves that if dye solution of one strength be used the three figures obtained cannot be comparable.

The results obtained for the three soils and from which the curves were plotted are given in Table I.

TABLE I.

Dye solution used	Soil No. 519		Soil No. 430		Rothamsted soil	
	Dye per 100 gms. soil		Dye per 100 gms. soil		Dye per 100 gms. soil	
	gms. per litre	Ab-sorbed	Left	Ab-sorbed	Left	Ab-sorbed
0.25	.50	—	.50	—	.50	—
0.50	.97	.03	.98	.02	.99	.01
0.75	1.38	.12	1.46	.04	1.45	.05
1.00	1.75	.25	1.80	.20	1.90	.10
1.25	2.05	.45	2.15	.35	2.25	.25
1.50	2.20	.80	2.45	.55	2.63	.37
1.75	2.30	1.20	2.55	.95	2.86	.64
2.00	2.44	1.56	2.75	1.25	3.05	.95
2.25	2.50	2.00	2.84	1.66	3.20	1.30
2.50	2.60	2.40	3.00	2.00	3.32	1.68
2.75	2.65	2.85	3.05	2.45	3.42	2.08
3.00	—	—	3.10	2.90	3.50	2.50

Curves showing points of equilibrium of dyed soil with dye solution.

To obtain relative values indicating the active surfaces of different soils it is necessary that each soil is brought into equilibrium with a solution of the same strength. For example, for the three soils used the only points by which the soil surfaces can be compared lie on lines parallel with the OX (dye absorbed) axis.

If we use a dye solution of say 1 gm. per litre for all three soils, each dyed soil is in equilibrium with a different solution at the end of the experiment and more dye must be added to the one with 20% clay before the final condition is comparable with that of the soil with 3% clay.

It is necessary to use then not the same strength of dye solution throughout, but such a strength for each soil as will leave it when dyed in equilibrium with the same dye solution.

It is obvious that if the method is to be of use the relative values for different soils ought to be the same whatever the concentration of the final solution.

In Table II the values are taken from the curves for dye absorbed by each soil when in equilibrium with solutions of strengths varying by 0.0125 gm. per 100 c.c.s from 0.0125 to 0.125 gms. per 100 c.c.s.

TABLE II.

Equilibrium solution %	Readings on horizontal axis of curves			Readings reduced to Rothamsted = 1		
	519	430	Rothamsted	519	430	Rothamsted
·0125	7.0	8.0	9.6	·73	·83	1
·025	8.1	9.3	11.0	·74	·85	1
·0375	8.7	10.1	11.8	·74	·86	1
·05	9.1	10.6	12.3	·74	·86	1
·0625	9.4	11.0	12.8	·74	·86	1
·075	9.7	11.3	13.1	·74	·86	1
·0875	9.9	11.6	13.4	·74	·87	1
·1	10.1	11.8	13.6	·74	·87	1
·1125	10.25	12.0	13.8	·74	·87	1
·125	10.4	12.2	13.9	·75	·88	1

In the second part of Table II the same results are expressed in terms of the Rothamsted soil (taken as 1).

It will be seen that the values on the lower parts of the curve where the dye solutions are weak vary considerably, but from .0375% to .1125% they are constant.

The experimental error is also greatest at the extremities of the curve, in the one case the remaining solutions in which the dye is estimated are very weak and in the other case they are concentrated and need considerable dilution.

In the actual experimental work then the equilibrium solution chosen should be one between $\cdot 0375\%$ and $\cdot 1125\%$; the most convenient is $\cdot 05\%$, little dilution is required and the figure is a convenient one for the resulting calculation.

The method adopted for obtaining the requisite equilibrium mixture was to use four solutions for each soil, viz.:

For sands	For loams	For clays
$\cdot 075\%$	$\cdot 1\%$	$\cdot 15\%$
$\cdot 1$	$\cdot 15$	$\cdot 2$
$\cdot 125$	$\cdot 2$	$\cdot 25$
$\cdot 15$	$\cdot 25$	$\cdot 3$

The standard equilibrium solution of $\cdot 05\%$ is treated in the same way as those containing soil. After the 48 hours each solution is diluted 1 in 10, i.e. 10 c.c.s of the top solution is pipetted off and made up to 100 c.c.s, and these solutions are compared with the standard roughly by holding against the light.

The two nearest the standard solution are compared with it accurately by means of Nessler's tubes, and the dye absorbed in equilibrium with a solution containing $\cdot 05\%$ can easily be deduced.

It is intended to continue this work in order to see whether other factors, such as temperature and original amount of water in the soil, influence the percentage of dye taken up by soils; and also to compare the results with values obtained for the 'hygroscopic water' content of soils. In case of some definite relationship existing between the two, the dye absorption method, which is fairly rapid and easy of manipulation, would give a good deal of valuable information regarding the relations between surface and the water content of soils, information that is difficult to obtain at present on account of the very unreliable methods available for its determination.