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A comparative study of the dispersing powers of sodium and ammonium hydroxides with reference to the dispersion of Mysore black cotton soil and the Hebbal soil

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Ammonium hydroxide was advocated for the dispersion of soils by the International Society of Soil Science in 1927, at its meeting in Washington. In 1934, at Versailles, it recommended the use of sodium hydroxide instead. The results obtained with a black cotton soil in this laboratory (*vide infra*) support this change. The factors which contribute towards the higher dispersive power of sodium hydroxide have been investigated by studying (a) dispersion of the soils and the clay fractions, (b) flocculation values of the clays and (c) the sedimentation volumes of the clays.

Experimental

1. Dispersion of black cotton and Hebbal soils.

50 gms. of the black cotton soil (from Mysore) were soaked overnight with (a) 1,000 c. c. of 0·008N sodium hydroxide and (b) 1,000 c. c. of 0·33N ammonium hydroxide and shaken for fifteen minutes. The amounts of silt and clay in the two cases were determined by sedimentation employing the Buoyancy technique. Similar experiments were also tried using the Hebbal soil (red loam). The results are in table I.

TABLE I Percentage of clay

Soil	Shaken with sodium hydroxide (15 minutes)	Shaken with ammonium hydroxide (15 minutes)
Black cotton	35·3	7·3
	35·8	7·7
	35·2	7·8
Hebbal	33·0	23·1
	32·13	23·45
	32·4	24·5

2. **Preparation of pure clay.** 50 gms. lots of the soil were shaken with one litre of 0·008N sodium hydroxide for fifteen minutes on a mechanical shaker and allowed to settle down and the clay portion was removed after appropriate sedimentation (sample removed at a depth of 10 cm. after 7 hours sedimentation at 26°, the laboratory temperature). The clay was then coagulated by addition of dilute hydrochloric acid. The organic matter was next destroyed by first making it definitely alkaline to litmus, using sodium hydroxide and then boiling it with hydrogen peroxide. The black clay changed to a cream colour. The clay was then subjected to hot dialysis using a cellophane tube. The cellophane tube containing the clay was

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closed at both ends and introduced into a conical flask. The flask was closed with a rubber stopper having two holes. Through one of them a long stemmed funnel was introduced so that the tip of the funnel reached the bottom of the flask and the other hole contained a short glass tube connected to the filter pump. Distilled water was continuously fed through the funnel. The filter pump served to maintain a constant level of liquid in the flask and also to suck air through the funnel so that the distilled water was kept stirred up by the air bubbling through the liquid. The flask was kept on a vigorously boiling water bath. It was found that the dialysis was practically complete within about 24 hours.

The hot dialysed sample was next subjected to electrodialysis. The electrodialysis cell of Mattson (1926) with parchment paper membranes was employed. Carbon rods were used for conducting the current. As a convenient direct current source was not available, an electrolytic rectifier giving full wave rectification was constructed, employing aluminum and lead ribbons and ammonium phosphate solution. The maximum current that can be drawn by such a rectifier is 100 ma. If a higher current is drawn, heating effects become considerable and the rectifier gets bad. Since the sparking voltage of aluminium (in ammonium phosphate solution) is about 140 volts, it is desirable to use two elements in series. From an input voltage of about 220 volts one can get an output of 120—130 volts on carrying out the full wave rectification. The rectifier acts practically without any attention. It is only necessary to replace the ammonium phosphate solution once in 3 days. The ammonium phosphate solution was kept in 100 c. c. beakers, about 25 c. c. of 14% solution being used. Aluminium and lead ribbons of about 2—3 mms. in width are used as the electrodes.

The electro-dialysis was carried out until the current remained sensibly constant. About 72 hours were found to be usually sufficient.

3 **Flocculation values** - The electro-dialysed clay was shaken with (a) 0·008N sodium hydroxide and (b) 0·33N ammonium hydroxide. The concentration of clay in the soils was determined by evaporation to a constant weight at 105°, of an aliquot in a glass evaporating dish. The sol. was then diluted with the respective solvents to a concentration of about 1·03 gm. of clay per litre. The proportion of alkali to clay is so large under these conditions that the clay would be completely saturated and the pH values of the soils would be nearly those of the pure respective media. A known volume of the soil was mixed with an equal volume of water, containing different quantities of the coagulating electrolytes, the coagulating electrolytes being ammonium chloride, calcium chloride, hydrochloric acid and sodium chloride. It was shaken well, allowed to stand for five minutes and then filtered through an ordinary filter paper. The clarity of the filtrate gave an idea of the extent of coagulation. Some experiments were also tried using an ordinary centrifuge. A known volume of soil was mixed with the electrolyte as before and centrifuged for 2 minutes with a

force 35·5 times that of gravity, coagulation values were thus obtained using the 4 electrolytes given above. The results obtained by the two methods are found to be very nearly the same and are given in table II.

TABLE II Black cotton clay.

Electrolyte used	Flocculation values by filtration (in milli-equivalents per litre)		Flocculation values by centrifuge (in milli-equivalents per litre)	
	dispersed in NaOH	dispersed in ammonia	dispersed in NaOH	dispersed in ammonia
Ammonium chloride	150	200	150	200
Sodium chloride	400	400	300	400
Calcium chloride	4	4	4	4
*Hydrochloric acid	0·8	40	0·8	40

Hebbal clay.

Electrolyte used	Flocculation values in milli-equivalents per litre Filtration method		Flocculation values in milli-equivalents per litre Centrifuge method	
	NaOH	ammonia	NaOH	ammonia
Ammonium chloride	100	100	100	100
Sodium chloride	300	300	300	300
Calcium chloride	4	4	4	4
*Hydrochloric acid	2	...	2	...

* HCl acts by removing OH. This was tried just with the idea of investigating the effect of residual acid left after washing in the International method of carrying out the dispersion of soils.

4. **Sedimentation volumes.** The clay suspension dispersed in different media behaved differently with regard to sedimentation. Hence a systematic study of the sedimentation volumes was undertaken. Preliminary experiments showed that the diameter of the vessel used did not have any appreciable influence on the sedimentation volumes obtained. So the experiments were carried out in test tubes (6" × ¾"). 10 c. c. of the clay soil and 10 c. c. of the electrolyte were mixed together and allowed to sediment for 72 hours in the test tube and the length of the sedimenting column was measured with a millimetre scale. The sedimentation volume per gram was calculated. The mixture was next shaken again and centrifuged for about 5 minutes using graduated centrifuge tubes and the volumes measured. The experiments were tried with dispersions of clay from black cotton soil (soil 2) got by employing (a) 0·008N sodium hydroxide, (b) ammonium hydroxide (13·4N), (c) lithium hydroxide (0·008N), for dispersion and using different concentrations of calcium chloride as the coagulating electrolyte. In the sodium clay, effect of addition of different amounts of sodium hydroxide was also tried. It was found that the volume corresponding to 0·008N

alkali (i. e. the usual concentration used for dispersing the soil) was small compared to the rest. In each of the above cases six experiments were tried and the average taken. The results are given in table III.

TABLE III

Sedimentation volume in c. c. per gm. of clay.

Quantity of calcium chloride in m. e. litre	Sodium clay	Ammonium clay	Lithium clay
16	641	207	155
1	448	194	155

Discussion. From the results recorded in table I it is clear that sodium hydroxide disperses the soil much better than ammonium hydroxide does. This difference may at first sight be attributed to a higher stability of suspension dispersed by sodium hydroxide. The results on the flocculation values (table II) however, indicate that with sodium chloride and calcium chloride as coagulants the flocculation values are not very different in dispersions with the two reagents. A notable difference in the sedimentation volumes is however observed (table III). The sedimentation volumes were found to be the largest with sodium hydroxide dispersed clays. The large sedimentation volumes are to be attributed to the formation of ramifying aggregates, containing a great deal of dispersion medium. The aggregates once formed are sufficiently rigid as not to break down under the influence of gravity. The higher sedimentation volume (*vide* table III) obtained in presence of a high concentration of the coagulating electrolyte is of great interest. It may at first sight appear that with a high concentration of the coagulating electrolyte larger clusters would be formed and hence would sediment quickly and thus would give rise to small sedimentation volumes. But an examination of table II shows just the reverse effect. The observed effect can however be explained on the basis of ideas put forth to explain the behaviour of quartz suspensions (Buzagh, 1930). The exhibition of large sedimentation volumes is due to the formation of ramifying clusters on coagulation. The stability of the ramifications is determined by the strength of binding between the particles. With a high concentration of the coagulating electrolyte, the electrical repulsion between the particles is reduced; the adhesion consequently increases, leading to the formation of stable ramifying clusters having large sedimentation volume.

The difference in the behaviour of sodium, lithium and ammonium clays cannot however be interpreted on the basis of electrical forces. The phenomenon is presumably caused by the specific influence of the Li^+, NH_4^+ and Na^+ ions modifying the adhesive properties of the clays.

It is of interest to note that the sediment from the ammonia dispersion of black cotton clay after long standing with half the flocculation concentration of calcium chloride, is easily redispersed on shaking and does not sediment within 2 minutes of centrifuging whereas the dispersion of sodium clay subjected to an identical treatment gets completely sedimented. If the two suspensions are allowed to settle down under gravity, the sodium hydroxide dispersion sediments more slowly than the other dispersion. This difference in the behaviour of the two dispersions can again be explained on the basis of the ideas put forth above.

The sediment from ammonium clay is made of particles bound together by weak forces (they do not therefore give rise to ramifying clusters and consequently the sedimentation volumes are small). On shaking, such a sediment redisperses quite easily giving rise to particles of very small size. Such particles are not brought down under the influence of centrifuge. In time however, there is slow coagulation to form compact flocs which settle down easily even under the influence of gravity. The sediment from sodium clay on the other hand is made up of particles bound together by strong forces. On shaking, the sediment is no doubt dispersed; but the dispersion contains comparatively large clusters of particles. These come down easily in the centrifuge. In time however, much larger ramifying aggregates are formed which settle down only very slowly under the influence of gravity.

Similar experiments have been carried out employing pure clay dispersions obtained from the Hebbal soil (the red soil). But the Hebbal clay dispersions have been found to give small sedimentation volumes irrespective of the reagent originally used for dispersion and the concentration of the coagulant employed. This is presumably due to the low adhesion exhibited by this clay irrespective of the nature of the saturating ion. In this case therefore, the cause of the difference in dispersing powers of sodium and ammonium hydroxides is not clear.

Summary. The difference in clay fraction noticed when sodium hydroxide and ammonia are used for dispersion of the black cotton soils is not due to the greater stability of the suspension in sodium hydroxide since the suspensions obtained with both the reagents give practically the same flocculation values. Settling in the suspension of sodium clay is a slow process owing to the formation of ramifying clusters.

References

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