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Effect of Dispersion Techniques On Mechanical Analysis Of Oregon Soils



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Effect of Dispersion Techniques on Mechanical Analysis of Oregon Soils

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SUMMARY

The following factors in the mechanical analysis of soils were examined for a number of Oregon soils: (a) pH adjustment of soil suspensions prior to organic matter removal, (b) HCl leaching during the salt removal step, (c) chemical dispersing reagents, (d) iron removal prior to dispersion, (e) air- and oven-drying of samples, and (f) type of mechanical agitation. The samples used were from Reddish Brown Lateritic, Sol Brun Acide, Gray-Brown Podzolic or Brunizem, Grumusol, and Chestnut profiles.

The greatest differences in percent clay among treatments were obtained for the Sol Brun Acide and Reddish Brown Lateritic samples; however, some differences were obtained for all soils. In general the results showed the following: (a) Adjusting the soil suspension to pH 3.5 prior to organic matter removal increased clay percentages in some cases, (b) Boiling Na_2CO_3 as the dispersing reagent yielded the highest clay percentage for the soils most difficult to disperse, (c) Calgon was next to boiling Na_2CO_3 in terms of clay percentage, particularly when the soil samples were previously leached with HCl, (d) The effect of iron removal on clay percentage depended upon the soil and the dispersing agent, with both increases and decreases being obtained due to iron removal, (e) Neither air- nor oven-drying of soil samples prior to analysis or during analysis depressed clay yields significantly, (f) Air-jet stirring for five minutes was fully as effective as mixing with a reciprocating shaker for 12 hours.

INTRODUCTION

Ever since the general acceptance of size limits for soil particles and the adoption of analysis techniques, the mechanical analysis of soils has been regarded as an important soil characterization. The two general methods in use are the pipette method (1) and the hydrometer method (4). An excellent review of the subject is to be found in the reference text *Soil Physics* by Baver (3). Dispersion techniques have varied considerably, but the procedure presented by Kilmer and Alexander (10) is regarded as giving good dispersion for a range of

soils. However, certain aspects of the procedure as well as recently proposed modifications have not been thoroughly evaluated, particularly for soils difficult to disperse. These aspects are: (a) pH adjustment prior to organic matter removal; (b) HCl leaching during the salt removal step; (c) chemical dispersing reagents; (d) iron removal for soils high in iron content; (e) air-drying and oven-drying during the analysis, and (f) type of mechanical agitation.

Furthermore, soil mineralogists wishing to segregate different size fractions prior to mineralogical analyses have adopted certain modifications in dispersion techniques different from those commonly used for mechanical analysis. To varying degrees, Na_2CO_3 or boiling Na_2CO_3 (8, 9) are used by soil mineralogists. For reasons of "purification" of soils prior to analysis, iron removal treatments are frequently employed (1, 6, 7, 11, 13). Although the procedures depend to a large extent upon the objective of the study, it seemed desirable to evaluate the effect of some of these pretreatments on mechanical analysis of soils of the Pacific Northwest. It was also thought of interest to examine the effects of treatments normally used for mineralogical analyses.

Observations made locally on some Oregon soils showed unusually high exchange capacity values for the amounts of organic matter and clay measured in these soils. Microscopical examination of the silt fractions revealed appreciable amounts of clay mineral aggregates. Apparently Calgon dispersion and conventional reciprocating shaking did not adequately disperse these soils.

Therefore, it seemed advisable to study the six aspects of soil dispersion listed above alone and in combination, using samples of soil from five different series with a wide range of characteristics.

METHODS

The pipette method presented by Kilmer and Alexander (10) for mechanical analysis was generally followed, except for steps of the procedure in which variables were imposed. However, two modifications of the Kilmer and Alexander method were introduced, except where they themselves were evaluated: (a) all samples were adjusted to pH 3.5 prior to organic matter removal, and (b) an air-jet apparatus instead of a reciprocal shaker was used to mix the soil suspensions.

A discussion of the specific steps employed that differ from those described by Kilmer and Alexander follows.

pH adjustment

Jackson reports (8) that the presence of excess Ca salts causes formation of resistant gel-like humates which retard the action of hy-

drogen peroxide when removing organic matter. Instead of using pH 5 NaOAc buffer (8), the soils were adjusted to pH 3.5 (soil to water ratio 1:10) with 1 N HCl prior to the digestion of organic matter with hydrogen peroxide. This treatment was applied to part of the samples in the evaluation of pH 3.5 adjustment and to all samples in all other evaluations.

HCl leaching

In order to avoid formation of insoluble Ca or Mg hydroxides when Na or Li hydroxide was used as the dispersing agent, samples were leached with dilute HCl to remove exchangeable Ca and/or Mg. It also was considered of interest to evaluate the effect of HCl leaching in connection with dispersing agents such as Calgon and Calgon plus NaOH. Two hundred and fifty ml. of 0.5 N HCl were passed through each sample, using Pasteur-Chamberland filters during the salt removal step. Subsequently, the samples were washed free of Cl ions with distilled H₂O.

Dispersing reagents

Several chemicals have been recommended at one time or another for dispersing soils in suspension. The following were selected for comparison:

1. Sodium oxalate has been evaluated and recommended by Olmstead and others (12) and Alexander (2) for soils with relatively high exchangeable and carbonate calcium. Ten ml. of 0.5 N Na₂C₂O₄ were added to each sample.

2. Sodium carbonate is frequently used in sample preparation for mineralogical analysis (9). Each sample in dilute suspension was titrated to pH 10 with 1 N Na₂CO₃.

- 3 and 4. Lithium carbonate and lithium hydroxide should have excellent dispersing properties because of the small ion size and the large shell of hydration and the consequently high potential (3). Each sample was titrated to pH 10 with 1 N Li₂CO₃ or 1 N LiOH.

5. Calgon has perhaps been used most widely ever since the recommendations of Kilmer and Alexander (10). Ten ml. of 5% Calgon solution were added to each sample.

6. Calgon plus sodium hydroxide was found very efficient by Youngberg (15) for the dispersion of "latosolic soils" of Oregon. Three ml. of 1 N NaOH plus 10 ml. of 5% Calgon were added to each sample.

7. Boiling sodium carbonate was found most useful for the dispersion of soils where silica and aluminum cause cementation of clay

particles (8). Four grams of anhydrous Na_2CO_3 were added to the soil suspensions prior to boiling for five minutes.

8. Trisodium phosphate gave very good results for the dispersion of "laterite soils" (14). Ten ml. of a 0.4 *N* solution of trisodium phosphate were added to each soil sample.

9. Sodium hydroxide has been widely used in the past as a dispersing reagent (3). Each sample was titrated to pH 10 with a 1 *N* solution of NaOH.

Iron removal

Iron removal treatments are believed to facilitate dispersion of soils prior to mineralogical as well as chemical analysis (1, 11).

The dithionite method (11, Method A) was used in the evaluation of the effect of iron removal and in conjunction with the evaluation of air-drying. When boiling Na_2CO_3 was used as the chemical dispersing agent, the dithionite-citrate method (1) was used. The iron removal treatments were carried out following soluble salt removal but prior to the addition of the dispersing agent.

Air-drying

Since soil constituents, such as amorphous materials, certain clay minerals, and organic matter, may be irreversibly changed by drying, it was believed that laboratory air-drying could adversely influence dispersion of soil particles. In order to evaluate this, samples of two soils were kept in a moist condition from the time of field sampling until analysis; parallel samples were allowed to air-dry.

Oven-drying

The procedure presented by Kilmer and Alexander calls for oven-drying soil samples after removal of organic matter and soluble salts. Clay mineral data indicate irreversible changes as a result of temperatures in excess of 100° C with such minerals as halloysite, and some lattice collapse with minerals such as vermiculite. It was felt that oven-drying might thus influence aggregation and ultimately result in inaccurate mechanical analyses. Half of the samples were oven-dried during the course of the procedure and half were always kept in suspension. In all other evaluations, parallel samples were oven-dried to ascertain weight losses due to organic matter and soluble salt removal.

Mechanical agitation

Chu and Davidson (5) proposed the use of an air-jet stirrer for mechanical analysis and showed data that compared very favorably

with other methods of mechanical agitation. Half of the samples were subjected to air-jet stirring for either 2.5, 5, or 10 minutes and half of the samples were agitated by the reciprocating shaker for either 6, 12, or 24 hours.

Statistical analysis of results

All determinations were made in duplicate and, based on the variation between clay percentages of all duplicates, least significant differences were calculated for specific comparisons.

SOILS

Soil samples were taken from A and B horizons of profiles designated as Astoria and Aiken and from A horizons only of profiles designated as Willamette, Walla Walla, and Climax. Chemical data for these soil profiles are given in the appendix of this bulletin. During the course of the experiments the stock of original Astoria A horizon soil (referred to in the text as Site I) was depleted and a new sample was obtained from a different site (referred to in the text as Site II).

The Astoria profiles were sampled at the John Jacob Astor Experiment Station near Astoria, Oregon, within a delineated area identified with the Astoria series in the Astoria Soil Survey Report published in 1959. The Astoria series is placed in the Sol Brun Acide great soil group in the Tillamook Area Soil Survey Report of 1964. The soil is developed from colluvium derived from sedimentary rock.

The Aiken profile was sampled in Douglas County, Oregon. Identification of the Aiken series is based upon a previous broad concept used in an unpublished map of the area. The profile is in or very close to the range of the tentative Jory series as used in the Marion County Soil Survey Report (in preparation). The soil is within the Reddish Brown Lateritic great soil group and is developed from colluvium derived from basalt.

The Willamette profile was sampled on the Hyslop Experimental Farm near Corvallis, Oregon, within a delineated area identified with the Willamette series in the Benton County Soil Survey Report published in 1924. The soil is intermediate with respect to the Gray-Brown Podzolic and Brunizem (Prairie) great soil groups and is developed from water-deposited silts in the Willamette Valley.

The Walla Walla profile was sampled in Sherman County, Oregon. The soil is within the Walla Walla series as used in the Sherman County Soil Survey Report of 1964. It is within the Chestnut great soil group and is developed from loess.

The Climax profile was sampled in the McDonald Forest near Corvallis, Oregon. Identification with the Climax series is based on the series description dated September 21, 1939. The soil is within or closely related to the Grumusol great soil group and is derived from colluvium.

RESULTS AND DISCUSSION

Although the mechanical analysis results from each of the several methods include percent sand, silt, and clay determined in duplicate, the main emphasis was placed on the clay percentages since they are considered the best single measure of the dispersion obtained. The average clay percentages for duplicates are presented in the following tables with the appropriate LSDs derived from the variation among duplicates. The results are arranged according to the various factors studied.

Effect of pH 3.5 adjustment

Adjustment of the soil pH to 3.5 prior to organic matter removal resulted in a significantly higher clay percentage mean for the seven soils and two dispersing reagents (Table 1). The difference in means is primarily due to the influence of pH adjustments with Na_2CO_3 as the dispersing reagent. With Na_2CO_3 both horizons of the Astoria (Site I) soil showed significant clay increases (11.4 and 3.7% clay) as a result of pH adjustment. With Calgon as the dispersing reagent, only the Walla Walla showed a significant increase (3.2%) in clay as a result of the treatment.

Table 1. EFFECT OF pH ADJUSTMENT TO 3.5 PRIOR TO H_2O_2 TREATMENT ON CLAY PERCENTAGES USING TWO DISPERSING REAGENTS

Soils	Calgon		Na_2CO_3		LSD 5%
	Not pH adjusted I	pH adjusted II	Not pH adjusted III	pH adjusted IV	
	%	%	%	%	
Astoria A (Site I)	19.0	19.6	8.5	19.9	2.9
Astoria B (Site I)	31.5	30.9	26.2	29.9	2.9
Aiken A	45.9	46.6	45.1	44.4	2.9
Aiken B	60.7	61.1	52.3	54.8	2.9
Climax A	39.8	39.2	37.9	36.2	2.9
Willamette A	22.6	22.3	20.6	20.9	2.9
Walla Walla A ..	9.0	12.2	9.6	9.9	2.9
Means	32.6	33.1	28.6	30.9	1.1
	Mean of I and III	30.6	Mean of II and IV	32.0	0.8

With Calgon, pH adjustment appears important only for soils high in Ca. With Na_2CO_3 and the Astoria A and B horizons, factors other than Ca concentrations must be responsible for clay percentage increases since these two soils are low in Ca.

Because significantly higher clay percentages were obtained in some cases and significantly lower clay percentages were never obtained with pH 3.5 adjustment, all subsequent samples were brought to pH 3.5 prior to organic matter removal.

Effect of dispersing reagents and HCl leaching

Of the five dispersion reagents— $\text{Na}_2\text{C}_2\text{O}_4$, Na_2CO_3 , Li_2CO_3 , Calgon plus NaOH, and Calgon used without an HCl leaching treatment (Table 2), Calgon gave as good or better dispersion than any other reagent. The overall clay percentage mean for Calgon was significantly higher than the means for the other four reagents. Li_2CO_3 and Calgon plus NaOH gave significantly low means.

When the soils are considered individually, the effect of dispersing reagents is particularly marked for the Astoria A (Site I) soil, where a low of 2.4% clay with $\text{Na}_2\text{C}_2\text{O}_4$ and highs of 19.9 and 19.6% clay with Na_2CO_3 and Calgon, respectively, were obtained. However, there is no significant difference between $\text{Na}_2\text{C}_2\text{O}_4$ and Calgon for any of the other soils. Na_2CO_3 , on the other hand, gave significantly lower percentages in some cases. The addition of NaOH to Calgon yielded significantly lower clay percentages than Calgon alone for six of the seven soils. Li_2CO_3 , against all expectations, yielded significantly lower clay percentages than Calgon for three of the seven soils; a particularly low clay percentage (5.4%) was obtained for the Astoria A (Site I) soil.

Only partial data are available for comparison of effects of boiling Na_2CO_3 and $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$. Boiling Na_2CO_3 resulted in the highest yield of clay for all reagents tested.

When an HCl leaching treatment was imposed on the soils prior to the addition of the dispersing reagent, the dispersion using Calgon and Calgon plus NaOH was almost the same, as shown by the mean for the four soils: Astoria A (Site I), Aiken A, Willamette A, and Walla Walla A. On consideration of individual soils it is apparent that Calgon, Calgon plus NaOH, and LiOH gave no significantly different clay percentage. Calgon preceded by an HCl leaching treatment caused a marked and significant increase in clay percentages, as reflected in the overall mean of 28.3 versus 25.2 when the HCl leaching treatment was omitted. This increase is particularly evident with the Astoria A (Site I) soil, where a clay content of 19.6% was recorded for Calgon not preceded by the leaching treatment versus a clay content of 28.4% when an HCl leaching treatment was included.

Table 2. EFFECT OF DISPERSING REAGENTS AND HCl LEACHING ON CLAY PERCENTAGES

Soils	Not HCl leached						HCl leached					LSD 5%
	Na ₂ C ₂ O ₄	Na ₂ CO ₃	Li ₂ CO ₃	Calgon		Boiling Na ₂ CO ₃	Na ₂ PO ₄ • 12H ₂ O	Calgon	Calgon			
				and NaOH	Calgon				and NaOH	NaOH	LiOH	
%	%	%	%	%	%	%	%	%	%	%		
1. Astoria A (Site I)	2.4	19.9	5.4	17.0	19.6	.....	.....	28.4	28.0	25.0	28.3	2.9
2. Astoria A (Site II)	.....	.....	.....	.....	24.9	31.9	24.9	.....	.....	.....	.....	2.9
3. Astoria B (Site I)	32.1	29.9	26.2	27.9	30.9	.....	.....	.....	.....	.....	.....	2.9
4. Aiken A	46.0	44.4	47.6	41.1	46.6	52.2	50.4	48.3	48.7	47.3	46.0	2.9
5. Aiken B	58.2	54.8	57.2	55.9	61.1	.....	.....	.....	.....	.....	.....	2.9
6. Climax A	39.3	32.2	36.5	29.5	39.2	.....	.....	.....	.....	.....	.....	2.9
7. Willamette A	22.0	20.9	21.1	17.6	22.3	24.7	22.8	23.2	23.2	20.7	21.5	2.9
8. Walla Walla A	12.3	9.9	8.4	8.5	12.2	.....	.....	13.4	13.6	10.8	11.3	2.9
						Means						
All except 2	30.3	30.9	28.9	28.2	33.1	.....	.....	.....	.....	.....	.....	1.1
2, 4, and 7	.....	.....	.....	.....	31.3	36.3	32.7	.....	.....	.....	.....	1.7
1, 4, 7, and 8	20.7	23.8	20.6	21.1	25.2	.....	.....	28.3	28.4	26.0	26.8	1.5

Effect of iron removal

When evaluating the effect of iron removal with three soils and four dispersion treatments (Table 3), it must be realized that the effect of dispersing reagents is partially confounded with the effect of methods of Fe removal. Boiling Na_2CO_3 was the only dispersing reagent used with the dithionite-citrate method and was not used with the dithionite method.

The change in clay percentage due to iron removal depended on the dispersing treatment and the soil (Table 3). Consequently, overall treatment means have little significance and for purposes of comparison individual soil clay percentages only are relied upon. For the Willamette A soil, no significant differences were observed for any dispersion treatment as a result of iron removal. In the case of the Aiken A soil, significant decreases were observed for all four dispersion treatments. For the Astoria A soil (Site I and Site II), the change in clay percentages as a result of iron removal treatments depended on the efficiency of the dispersion treatment. The treatments that gave the best dispersion in previous evaluations, i.e., boiling Na_2CO_3 and Calgon preceded by an HCl leaching treatment (Table 2), resulted in decreases of clay percentages, while inferior dispersion treatments, i.e., Na_2CO_3 and Calgon (Table 2), resulted in increases of clay percentages following iron removal.

The Willamette soil, being low in iron and easily dispersed by most dispersing reagents, showed little response to an iron removal treatment. The Aiken soil, however, with a relatively high iron content, in spite of the differing response to dispersion reagents, reacted markedly to an iron removal treatment. In all cases a decrease in clay content was measured.

Table 4 shows the percentages of sand, silt, and clay with and without the iron removal treatment. The change in percent of each size fraction as a result of the iron removal treatment is given also. Table 5 shows the percentages of matter removed by the dithionite iron removal treatment and by the HCl leaching treatment.

The silt percentages decrease for all soils and dispersing reagents, while the sand percentages increase except in one case. The increase in the sand fraction is surprising; however, it was observed that following the Fe removal treatment, the isolated sand fractions contained relatively soft aggregates of finer particles. These aggregates were not observed when iron was not removed. It must be stated, however, that it is impossible in general to ascertain the effects on percent sand, silt, and clay resulting a) from a dissolution and removal from the soil suspension of iron compounds, and b) from the elimination of cementing forces that these same iron compounds may have exerted on soil particles. It seems that the removal of iron compounds over-

Table 3. EFFECT OF IRON REMOVAL BY TWO DIFFERENT METHODS USING DIFFERENT DISPERSING AGENTS ON CLAY PERCENTAGES¹

Soils	Dithionite method of iron removal						Dithionite-citrate method		LSD 5%
	Na ₂ CO ₃		HCl leached Calgon		Calgon		Boiling Na ₂ CO ₃		
	Fe in	Fe out	Fe in	Fe out	Fe in	Fe out	Fe in	Fe out	
	%	%	%	%	%	%	%	%	
Astoria A (Site I)	19.9	23.4	28.4	24.5	19.6	26.2	.....	.....	2.9
Astoria A (Site II) .....	.....	.....	.....	.....	24.9	29.4	31.9	29.2	2.9
Aiken A	44.4	38.8	48.3	43.0	46.6	41.5	52.2	48.4	2.9
Willamette A	20.9	19.6	23.2	20.8	22.3	22.5	24.7	24.7	2.9

¹ Results expressed on an oven-dry basis for Fe in, and on an oven-dry, iron-free basis for Fe out.

Table 4. SAND, SILT, AND CLAY PERCENTAGES AS INFLUENCED BY IRON REMOVAL¹

Soils	Size fraction	Na ₂ CO ₃			HCl leached-Calgon			Calgon		
		I	II	II - I	I	II	II - I	I	II	II - I
		Fe in	Fe out		Fe in	Fe out		Fe in	Fe out	
		%	%	%	%	%	%	%	%	%
Astoria A (Site I)	Sand	20.9	23.4	2.5	19.1	25.2	6.1	23.3	23.4	0.1
	Silt	59.2	47.4	-11.8	52.5	44.6	-7.9	57.1	44.8	-12.3
	Clay	19.9	21.7	1.8	28.4	22.7	-5.7	19.6	24.3	4.7
Aiken A	Sand	10.0	16.8	6.8	9.7	18.7	9.0	11.3	16.5	5.2
	Silt	45.6	37.7	-7.9	42.0	32.0	-10.0	42.1	35.5	-6.6
	Clay	44.4	34.9	-9.5	48.3	38.7	-9.6	46.6	37.4	-9.2
Willamette A	Sand	10.6	9.1	-1.5	7.1	9.1	2.0	8.1	9.6	1.5
	Silt	68.5	67.3	-1.2	69.7	66.2	-3.5	69.6	65.1	-4.5
	Clay	20.9	18.7	-2.2	23.2	19.8	-3.4	22.3	21.4	-0.9

¹ All percentages based on oven-dry weight prior to the removal of iron.

Table 5. WEIGHT LOSS DUE TO REMOVAL OF Fe BY DITHIONITE AND DUE TO HCl LEACHING

Soil	Percent weight loss due to:	
	dithionite	HCl leaching
	%	%
Astoria A (Site I)	7.5	4.7
Aiken A	10.6	2.4
Willamette A	4.9	1.7

rides the effects of increased dispersion where a reduction in clay and silt percentages takes place as a result of Fe removal. On the other hand, where an increase in clay percentages takes place, better dispersion overrides the effects of the removal of Fe compounds.

Thus for the Astoria A horizon, a soil relatively low in iron compounds (Table 5), increased dispersion was more important than the removal of Fe compounds; the clay percentages with Na_2CO_3 and Calgon as the dispersing agents increased significantly. For the Aiken A horizon, a soil relatively high in iron compounds (Table 5), loss of these overrides increased dispersion; clay percentages with all dispersing reagents decreased. The effects on the Willamette A soil may be considered intermediate.

Effect of air-drying and oven-drying

For the two soils most difficult to disperse, Astoria A (Site I) and Aiken A, air-drying soils prior to mechanical analysis did not adversely affect clay percentages (Table 6). The only significant increase due to leaving samples moist after field sampling was measured for the Astoria A (Site I) soil with Calgon as the dispersing agent. When Calgon was preceded by an HCl leaching treatment, a dispersion treatment previously shown to be superior, no significant effect of air-drying was observed. In all other cases air-drying resulted in either no change or in a nonsignificant or slightly significant increase in percent clay.

It is obvious from the data presented in Table 7 that oven-drying soil samples during the course of the mechanical analysis procedure also has no effect on clay percentages.

Effect of mechanical agitation

The air-jet method presented by Chu and Davidson (5) seems fully as efficient as the reciprocating shaker method for the Astoria A (Site I) soil, the one most difficult to disperse (Table 8). The recommended time of five minutes seems adequate since no significant dif-

ference in percent clay was measured between 2.5, 5, and 10 minutes. There was also no difference for 6, 12, and 24 hours of shaking the soil samples with the reciprocating shaker. Either method of mechanical agitation thus seems to yield good mechanical analysis results.

Table 6. INFLUENCE OF AIR-DRYING SOIL SAMPLES PRIOR TO ANALYSIS ON CLAY PERCENTAGES

Soils and dispersing reagents	Air-dried	Undried	Air-dried	Undried	LSD 5%
	%	%	%	%	
Astoria A (Site I)					
Calgon	19.6	22.8	26.2	25.7	2.9
HCl leached - Calgon	28.4	28.2	24.5	24.3	2.9
Means	24.0	25.5	25.4	25.0	2.1
Aiken A					
Calgon	46.0	43.9	41.5	39.2	2.9
HCl leached - Calgon	48.3	45.3	43.0	41.6	2.9
Means	47.4	44.6	42.2	40.4	2.1

Table 7. INFLUENCE OF OVEN-DRYING DURING ANALYSIS ON CLAY PERCENTAGES WITH CALGON AS THE DISPERSING REAGENT

Soil	Air-dried	Oven-dried	LSD 5%
	%	%	
Astoria A (Site I)	19.6	18.4	2.9
Aiken A	44.6	45.6	2.9
Means	32.1	32.2	2.1

Table 8. EFFECT OF MECHANICAL AGITATION BY AIR-JET AND BY RECIPROCATING SHAKER ON CLAY PERCENTAGES OF ASTORIA A (SITE I) SOIL

Dispersing reagents	Air-jet			Shaker			LSD 5%
	2.5 min.	5 min.	10 min.	6 hrs.	12 hrs.	24 hrs.	
	%	%	%	%	%	%	
Calgon	19.4	21.4	18.6	19.7	19.6	21.2	2.9
HCl leaching Calgon ..	28.0	27.9	28.2	28.6	28.4	28.2	2.9
Means	23.2	24.6	23.4	24.2	24.0	24.7	2.1

CONCLUSIONS

The eight samples of Oregon soils used in the previously described experiments cover a wide range of characteristics. Thus the results obtained should be applicable to many soils in other regions. Large differences among dispersion methods were found for soils high in organic matter and iron compounds. However, differences were measured for every soil used. A procedure is desirable which is applicable to all soils and which is fast enough for routine analysis.

The adjustment of pH prior to organic matter removal caused an increase in clay percentages for only one soil when Calgon was used as the dispersing reagent. However, particularly when a mineralogical analysis is to be made, the use of pH 3.5 adjustment is not recommended because of the destructive influence of this treatment on aluminosilicates.

The highest clay percentages for all soils were obtained by use of boiling Na_2CO_3 as the dispersing reagent. It was superior to Calgon, which is commonly used for soils difficult to disperse. HCl leaching combined with Calgon gave nearly as high clay percentages as boiling Na_2CO_3 . Which procedure is used should depend upon the relative time involved in each procedure. It appears that Calgon alone is not adequate for soils difficult to disperse.

The removal of iron resulted in most cases in a reduction in the clay and silt percentages and an increase in the sand percentages. The iron removal technique tended to form rather stable aggregates of sand size which were not dispersed during the remainder of the procedure. These effects tend to discredit iron removal as a step in routine mechanical analysis.

Since air- or oven-drying of the soil prior to or during the course of the analysis had no adverse effects on the resulting clay percentages, the inclusion of these techniques is justified.

The use of air-jet mixing of the soil suspension, as recommended by Chu and Davidson (5), gave no significant difference in clay yields from those obtained using a reciprocal shaker. Because of its simplicity and economy of time, air-jet mixing is preferred.

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APPENDIX

ASTORIA SILT LOAM

John Jacob Astor Experiment Station, Astoria, Oregon

Horizon	Depth	pH	K	Ca	Mg	CEC
	<i>in.</i>			<i>mc/100g</i>		
A ₁₁	0-9	4.8	.2	.4	.2	25.9
A ₁₂	9-23	5.0	.2	.4	.2	20.4
B ₁₁	23-33	5.2	.2	.2	.2	17.8
B ₁₂	33-43	5.2	.1	.2	.3	18.5
B ₂	43-60+	4.6	.1	.4	.8	17.2

Reference: Ernest H. Gardner, 1960. Potassium release from several western Oregon soils and its relationship to crop growth and soil mineralogy. Ph.D. thesis, Oregon State University.

JORY (AIKEN) SILTY CLAY LOAM Langdon Farm, Douglas County, Oregon

Horizon	Depth	pH	P	K	Ca	Mg	CEC
	<i>in.</i>		<i>ppm</i>		<i>mc/100g</i>		
A _p	0-6	5.5	2.0	.9	4.6	2.1	25.8
B ₁	6-17	5.6	1.3	.2	4.5	2.1	21.0
B ₂	17-38	5.5	2.2	.1	2.0	1.6	17.1
B ₃	38+	5.9	3.2	.1	1.7	1.4	16.7

Reference: R57—Oregon—10-3-(1-4).

WILLAMETTE SILT LOAM Hyslop Farm, Benton County, Oregon

Horizon	Depth	pH	P	K	Ca	Mg	CEC	N	O.M.
	<i>in.</i>		<i>ppm</i>		<i>mc/100g</i>			<i>%</i>	<i>%</i>
A _p	0-7	5.4	50.0	0.6	6.2	1.3	15.5	.1	3.0
A ₂	7-13	5.7	65.5	0.6	7.4	1.6	16.8	.2	1.9
B ₁	13-19	5.8	44.5	0.5	8.5	2.1	17.0	....	....
B ₂₁	19-26	5.9	43.8	0.7	12.0	4.1	23.3	....	....
B ₂₂	26-34	5.9	41.5	0.6	11.4	3.9	22.2	....	....
B ₃₁	34-41	6.0	45.3	0.7	15.6	5.7	25.7	....	....
B ₃₂	41-55	6.2	32.3	0.6	15.9	5.5	27.7	....	....
C ₁	55+	6.4	17.3	0.6	17.6	5.7	25.5	....	....

Reference: J. L. Andersen, 1963. Response of field corn to irrigation, plant population, and nitrogen on soils of the Willamette catena. M.S. thesis, Oregon State University.

WALLA WALLA SILT LOAM
Sherman County, Oregon

Horizon	Depth	pH	K	Ca	Mg	Na	CEC	N	O.M.
	<i>in.</i>				<i>mc/100g</i>			<i>%</i>	<i>%</i>
A _{1p}	0-7	5.9	1.5	8.3	2.2	.2	17.3	.1	2.0
A ₁₂	7-17	6.4	1.3	8.6	2.5	.2	16.9	.1	1.2
B ₂₁	17-25	6.7	1.0	8.4	2.9	.3	15.3	.1	.8
B ₂₂	25-34	7.1	.7	8.1	3.4	.3	14.6	.1	.6
C ₁	34-50	7.3	1.4	7.2	3.8	.8	13.8	....	.4
C ₂	50-66	7.4	1.4	6.4	4.3	.6	13.9	....	.3

Reference: Soil Survey Report No. 37, 1959.

CLIMAX SILTY CLAY
McDonald Forest, Benton County, Oregon

Horizon	Depth	pH	P	K	Ca	Mg	CEC	N	O.M.
	<i>in.</i>		<i>ppm</i>			<i>mc/100g</i>		<i>%</i>	<i>%</i>
A ₃₁	0-4	6.3	2.5	.2	23.0	21.1	53.4	.3	7.7
A ₃₂	4-20	6.2	2.4	.2	24.5	21.5	51.1	.2	4.9
C ₁	20-32	6.2	3.8	.2	24.0	21.5	47.9	.1	2.3
C ₂	32+	6.4	3.6	.1	20.5	15.0	44.9	.1	0.9

Reference: C. T. Youngberg and C. T. Dyrness. Soils of McDonald Forest. Unpublished report. Department of Soils, Oregon State University.