Med. Fac. Landbouww. Rijksuniv. Gent 50/1/1985

INTER-RELATIONSHIPS AMONG IMPORTANT SOIL PROPERTIES BASED ON DATA OF SOME TYPIC PALEUDULTS

by

*LOPULISA, C.F. and B.M. *MSANYA

ABSTRACT

A study of inter-relationships among important soil characterization physico-chemical data was made. These data were extracted from thirty soil profile descriptions representing soils developed on different parent materials and classified as Typic Paleudults according to the USDA Soil Taxonomy (1975).

Correlation studies indicate that most of these parameters are highly correlated.

INTRODUCTION

Characterization of soils involves various analyses which may include both field and laboratory work to generate the required data. Most laboratory analyses of soils are known to be expensive and in many cases require sophisticated equipment. This could be a big burden to many developing countries which need to know their soils in order to be able to make sound programmes of land use.

Systematic correlation studies on soils data can easen the mentioned problem. When two soil variables are well correlated, this means that using their correlation equation one variable can be determined using the measured value of the other. Establishment of such correlations would be very useful in those areas where they can be applicable. Time and money would definitely be saved when one can estimate the value of some parameters using the measured values of few other parameters. Correlated data are also very useful in the case where analytical methods do not give reliable data, for example 15-bar water content is used to estimate the clay content of soils with silt- and sand-size aggregates of clay which do not disperse with the routine dispersion in sodium hexametaphosphate solution (USDA-SSS, 1975). Some soil parameters determined by different methods have also been correlated. An example in this case is the cation exchange capacity determined by NH_4OAc at pH 7 and the one by sum of cations (Moormann, 1978, and Buurman and Rochimah, 1980).

The present study is aimed at expanding the knowledge on the relationships existing between various important soil parameters based on characterization data of some Typic Paleudults developed on different parent materials.

---

* Present address: State University Ghent, International Training Centre for Post-Graduate Soil Scientists, Department of General Pedology, Krijgslaan 281 B-9000 Ghent-Belgium.

MATERIALS AND METHODS

The study involved characterization data of thirty profile descriptions from seven countries ie Brazil, Cameroon, Indonesia, Malaysia, Phillipines, Thailand and the United States. These descriptions represented soils belonging to "Typic Paleudults" according to the USDA Soil Taxonomy (1975). Table 1 gives the types of parent material of the represented soils.

Table 1. TYPE OF PARENT MATERIALS OF REPRESENTED SOILS AND THE FREQUENCY DISTRIBUTION OF PROFILE DESCRIPTIONS

Parent material	No.of profile descriptions	Maximum no. of samples (no.of horizons)
Granite	17	136
Marine sediments	6	43
Unconsolidated sediments	7	56

The mean values of the various parameters were calculated for cation exchange capacity (CEC), clay content, organic carbon (OC), silt/clay ratio, free iron oxide (Fe_2O_3), extractable aluminium (Al), extractable acidity (EA), base saturation (BS), and soil reaction (H_2O ratio 1:1)(pH).

Regression and correlation analyses of the data were run using Graphical Computer Model Tektronix 4051 with BASIC language.

RESULTS AND DISCUSSION

The results of the study are presented in tables 2 and 3.

1. Cation exchange capacity (CEC) and other soil parameters

CEC is one of the standard parameters measured in the analysis of mineral soils, where for the most part the exchange sites are provided by the clay particles (Everett, 1983). This property is a measure of the exchange capacity or negative charges of the soil colloidal fraction. CEC is a good index of soil fertility especially when interpreted in conjuction with other soil properties. Correlation between CEC and other parameters should be of interest.

The correlation studies (cf table 2) indicate that CEC is well correlated with clay content, organic carbon and silt/clay ratio of different parent materials, namely granite, marine sediments and unconsolidated sediments. This is illustrated by the relatively high values of correlation coefficients ($r > .60$). Dumanski et al. (1970) had similar experience of high correlation between organic carbon and CEC and associated this with the fact that OC contributes to CEC. It is worthwhile to note that for the three soil properties correlated with CEC, the correlation was lowest on soils developed from marine sediments, probably reflecting differences that might have occured during different cycles of marine depositions.

The high correlations between CEC and other soil properties in all the cases investigated imply that statistically the

Table 2. RELATIONSHIPS BETWEEN CATION EXCHANGE CAPACITY AND OTHER SELECTED SOIL PROPERTIES

*Selected soil properties	Parent materials	Number of samples	Correlation equation	Correlation coefficient(r)
Clay content	1. Granite	136	CEC = 37.01+ 5.29 log (clay)	0.79**
	2. Marine sediments	43	CEC = 74.24 – 11.27 log (clay)	-0.66**
	3. Unconsolidated sediments	56	CEC = 169.4 – $(Clay)^{0.6}$	-0.94**
Organic carbon	1. Granite	136	CEC = 11.87 + 6.74 (OC)	0.89**
	2. Marine sediments	43	CEC = 39.06 $(OC)^{0.10}$	0.67**
	3. Unconsolidated sediments	56	CEC = 39.02 + 123.0(OC)	0.85**
Silt/Clay ratio	1. Marine sediments	43	CEC = 42.88 + 7.72 log(Silt/Clay)	0.67**
	2. Unconsolidated	56	CEC = 37.44 + 18.91 log(Silt/Clay)	0.89**

* Units of measurements: CEC, meq/100 g clay (calculated from meq/100 g soil-NH_4OAc, uncorrected OC)
Clay, %
Organic carbon, %

** Significant at 1 % level

difference in nature of parent material cannot be traced in the values of the correlation coefficient. However, for marine sediments and unconsolidated sediments, CEC was negatively correlated with clay content. This means that large values of CEC are associated with small values of clay in these materials.

The reason why the correlation of CEC and clay is positive in soils on granite and negative in soils on marine sediments and unconsolidated sediments is that the soils on granite had more clay than the other two soil types and since the CEC is calculated on the basis of clay content naturally it will be high when the clay content is low and low when the clay content is high. This means that in the granite soils the CEC is mostly contributed by the clay. In the correlation of CEC and organic carbon, it can be seen from the correlation equations that for soils on marine sediments and unconsolidated sediments, CEC is more contributed by organic carbon, unlike in the soils on granite.

2. Other important properties

Apart from CEC, clay, organic carbon and silt/clay ratio, there are other important properties used to characterize soils. These include free iron oxides, pH, extractable aluminium, extractable acidity and base saturation etc. Table 3 presents the results of the correlation analysis on different pairs of these attributes. Most correlations are highly significant meaning that the attributes are well associated. In general it can be said that for the pairs of attributes under consideration, the coefficients of correlation are highest for soils developed on granite and lowest for soils developed on marine sediments.

Clay and Fe_2O_3 are highly and positively correlated for soils on granite, meaning that increase in clay content is associated with increase in free iron oxides. On the other hand, the correlation was not significant for soils developed on marine sediments.

Al and pH are highly correlated in a negative manner for soils on granite indicating that increase in Al is associated with decrease in pH. This was expected as solubility of Al increases with increasing acidity (decreasing pH). However, the data for soils on unconsolidated sediments is not conclusive as the correlation equation was not appropriate for the data used (Lopulisa, 1982).

pH is highly and negatively correlated with extractable acidity (extractable H^+) for soils on granite, marine sediments and unconsolidated sediments. However, it is highly and positively correlated with base saturation. This means that increase in pH is associated with decrease in extractable acidity, while on the other hand it is associated with increase in base saturation.

CONCLUSIONS

The following major conclusions can be made from the results of this study

(a) highly significant relationships exist among most of the

Table 3. RELATIONSHIPS AMONG OTHER IMPORTANT SOIL PROPERTIES

* Soil properties	Parent materials	Number of samples	Correlation equation	Correlation coefficient (r)
Clay and Fe_2O_3	1. Granite	80	$Fe_2O_3 = 0.68\ e^{0.03\ Clay}$	0.68**
	2. Marine sediments	42	$Fe_2O_3 = 4.27 - (27.47/Clay)$	0.33
pH and Al	1. Granite	136	$Al = 92.37\ e^{-0.94pH}$	-0.95**
	2. Unconsolidated sediments	56	$Al = 0.27\ (pH)^{+}$	
pH and EA	1. Granite	120	$EA = 15.25 - 1.93\ (pH)$	-0.61**
	2. Marine sediments	42	$EA = 101.79/pH - 8.93$	-0.46**
	3. Unconsolidated sediments	56	$EA = 22.43 - 3.48\ (pH)$	-0.72**
pH and BS	1. Granite	136	$BS = \frac{1}{0.61 - 0.09pH}$	0.99**
	2. Marine sediments	46	$BS = 11.42(pH) - 46.92$	0.53**
	3. Unconsolidated	56	$BS = 31.6(pH) - 129.2$	0.62**

* Units of measurement : Clay,%
Fe_2O_3,%
Base saturation (NH_4OAc),%
Aluminium, meq/100 g soil
Extractable acidity, meq/100 g soil

** Significant at 1% level

\+ The equation is not appropriate for the data used.

important soil parameters.

(b) for some correlations especially CEC and clay, CEC and OC, and CEC and Silt/clay ratio, difference in nature of parent material does not affect the level of significance.

(c) in most correlations soils developed on marine sediments had the lowest coefficients of correlation and in one case being insignificant; while those developed on granite tended to have the highest coefficients.

(d) for few parameters, the difference in parent material was expressed only by difference in the sign of coefficient of correlation.

REFERENCES

Buurman,P. and L.Rochimah (1980). Mathematical correlations between exchange characteristics of soil and clay samples. In Red Soils in Indonesia pp. 141-152.

Dumanski,J., R.Newton and J.D.Lindsay (1970). Geographic zonation in selected characteristics of surface mineral horizons in Alberta soils. Can.J.Soil Sci. 50:131-139.

Everett,K.R. (1983). Histosols. In Pedogenesis and Soil Taxonomy, II The Soil Orders pp. 1 - 53. Editors: L.P. Wilding, N.E.Smeck and G.F.Hall.

Lopulisa,C.F.(1982). Properties and classification problems of Typic Paleudults. MSc (Soil Sci) thesis pp.104. State University Ghent, International Training Centre for Post-Graduate Soil Scientists.

Moormann,F.R.(1978). Calculated cation exchange capacities for some Brazilian soils. In Proceedings of first International Soil Classification Workshop in Rio de Janeiro, Brazil pp. 354-362. Editors: M.N.Camargo and F.H.Beinroth.

USDA-Soil Survey Staff.(1975). Soil Taxonomy. A Basic System of Soil Classification for Making and Interpreting Soil Surveys. Agriculture Handbook No.436. pp 754.

RESUME

Inter-relations entre les importantes propriétés du sol basées sur les données de quelques Typic Paleudults.

Une étude des inter-relations entre les donneés importantes des caracteristiques physico-chimiques du sol à été faite. Ces données ont été extraites de trente descriptions de profil representant des sols developpés sur differents materiaux parentaux et classés comme Typic Paleudults selon "USDA Soil Taxonomy (1975)".

Les études de correlation indiquent que la plupart de ces paramètres sont hautement correlés.