

Effect of dolomite dust on some soil properties in selected agricultural areas of Igbeti, Oyo State

Olatunji, O.O., Adebayo, K.K. and Emmanuel, O.C.

Department of Crop Production and Soil Science, Ladoke Akintola University of Technology,
P.M.B. 4000, Ogbomoso, Oyo State, Nigeria. oolatunji@lautech.edu.ng +2348062577474

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Abstract

Dolomite mining and processing has become a major activity competing with agricultural in and around Igbeti. The accumulation of the resultant dusts from the dolomite processing sites and its effects on the soil physical and chemical properties on farm lands in Igbeti, Olorunsogo Local Government Area of Oyo State in Nigeria were assessed in relation to farm land proximity to the processing sites. Four processing sites were selected for this study and two profile pits were dug at 100 m and 300 m away from each processing site. A control site was located 5 km away from any point of processing site. A total of nine standard profile pits were dug and sampled according to genetic horizons. Soil samples were collected and processed for laboratory analysis as pH, exchangeable cations, organic matters and heavy metals contents were analyzed geochemically. Data collected were subjected to descriptive statistics and Coefficient of variation. The results of the analysis showed that, there was moderate variability of some soil morphological properties across the five locations. Soil chemical properties such as pH, sodium and magnesium were consistently least variable irrespective of the locations (CV<15%). However, calcium, iron, zinc, cobalt, cadmium, clay and silt were moderately variable across the nine profile pits (15 - 34% CV). Potassium, manganese, copper, cadmium, lead and nickel were extremely variable (CV>35%). The pH ranged from moderately acidic to slightly acidic (6.0-6.7) in all the soils. pH was highly and directly correlated with K ($r=0.86$, $p<0.01$), iron ($p<0.01$), nickel ($p<0.01$), Clay ($p<0.01$), Silt ($r=0.70$ $p<0.01$) and Sand ($r=0.75$, $p<0.01$).

High calcium content was observed in the soils and the values were higher at 100 m distance away from processing sites. Chromium, Cobalt, Lead and Nickel were high in many of the profiles but higher at 100 m away from the processing sites. The accumulation of dolomite dust increased the quantity of heavy metal contents in the soil of farmlands close to the processing sites

INTRODUCTION

Nigeria is endowed with abundant mineral resources, which have contributed to the national wealth with associated socio-economic benefits. Mineral resources are important source of wealth for a nation but before they are harnessed, they have to pass through the stages of exploration, mining and processing (Ajakaiye, 1985; Adekoya, 2003). Mining operations may completely alter a site's ecosystems by disrupting the ecological balance, natural landscapes, agricultural lands, forests, plantations and vegetation as well as the economic food and tree crops. Other impacts of mining include alteration of the soil structure, loss and overturning of the fertile top soil, air, soil and water pollution, instability of soil and rock masses, destruction of flora and fauna and noise pollution, and displace many of species of animals within the ecosystem (Aigbedion and Iyayi, 2007; Adegboye 2012).

The dominant effect of the process of mining activities is that soil formation processes and development is interrupted and soil properties

physically and detrimentally modified. In the southwestern part of Nigeria especially Igbeti Township and the environs that domiciled significant deposit of dolomite, the assumption is that this exploration and mining activities will be enhance to the socio-economic activities of the town, but contrary was the case as it has been observed the agricultural productivity of the town as one of the food basket of Oyo State is reducing. In recent time, processing and crushing of dolomite rocks into smaller particles is now done within living and farming areas of Igbeti and in as much as dust particles that originate from the processes have been reported to be harmless its nuisance value have been reported to reach a threshold limit of 10 mg m^{-3} (Fukaya *et al.*, 1993). There is a clear indication that the dolomite dust of the respiratory system, but the evidence for associations between exposure and either symptoms or functional impairments of the lungs is lacking (Fukaya *et al.*, 1993 and Selden *et al.*, 2001). Also there is evident competition between agricultural and industrial (mining) land uses to

the detriment of agricultural bot in size and effects. The major mineral contents of dolomite are calcium and magnesium and these are not easily soluble in water and their accumulation in form of dust tend emasculate the soil and prevents the normal functioning of the soil as a living and dynamic system. Additionally, apart from the calcium and magnesium contents, dolomites equally contain other impurities in as much as they exist in trace quantifies their presence in the dust could equally be detrimental to human health. These constitute a significant form of environmental pollution that originates from dolomite exploration and exploitation to the detriment of the inhabitants of the area and their livelihood activities.

In as much as dolomite exploration and processing is a major activity in Igbeti, the mining and processing significantly contributes to the economic development of the country. Yet this activity still have some manifest detrimental effects through the dust particles that emanate from the exploitation process settle on the soil surface and interfere with the dynamic of the soil as a natural system. The objectives of this work are to evaluate the Extent to which dolomite dust affect the soil physical and chemical properties in relation to proximity to processing sites, and investigate the possible accumulation of undesirable elements through dolomite dust on the surrounding soils under dolomite exploitation.

MATERIALS AND METHODS

Description of the study area

The study areas were located at Igbeti in Olorunsogo Local Government Area of Oyo State, Nigeria. It lies within latitude 8°40' and 9° 05' N longitude 3° 45' and 4° 15' E, and falls within the Northern Guinea Savanna of South Western Nigeria (LRS, 1976). The rainfall pattern is bimodal and falls from late February to late October each year. The population of the town was approximately 81,000 at the 2006 census. Igbeti is popularly known as marble city for its rich marble deposit. Igbeti is one of the dolomite mining and processing towns in Oyo State. Several agricultural activities were going on around the processing sites especially crop production. Crops cultivated at most of the location were maize and cassava and as at the time of this experiment, the maize is fully grown and ready for harvest. Four processing sites were purposively selected in the study area among the different processing sites in view of their proximity to agricultural activities and living areas

and one location was cited outside the processing environment at about 5 km away from any mining sites which served as the control. Nine standard profile pits were dug altogether. Two profile pits were dug at each location, one at 100 m and the other at 300 m away from the processing site. One pit was dug at the last location 5 km away from all the mining sites which serves as the control. The profile pits will be described (not included in this report) using FAO (2010) and sampled according genetic horizons. The soil samples were preserved in sampling Bags, properly labeled and taken to the laboratory for processing.

Laboratory analysis

The soil samples were air dried, pulverized and made to pass through 2.0 mm aperture sieve. The processed soil samples were used for laboratory analysis. Particle size analysis was conducted using the hydrometer method (Bouyoucos, 1962), soil pH was determined in 0.01 M CaCl₂ extracts using a glass electrode. Organic carbon was determined by wet oxidation method (Walkley-Black, 1934). Total nitrogen (N) was determined using micro Kjeldahl procedure followed by steam distillation (Bremner and Keeney, 1966). Available phosphorus (P) was extracted using the Bray 1 method (Bray and Kurtz, 1945). Exchangeable cations (Ca, Mg, K and Na) were determined in neutral 0.01 M NH₄OAc extracting solution. The concentrations of potassium (K⁺) and sodium (Na⁺) were determined using a Gallen kamp model FH 500 Flame Photometer. Magnesium (Mg²⁺), calcium (Ca²⁺), and heavy metals (Cd⁺, Cu²⁺, Pb²⁺, As⁺ and Fe²⁺) were extracted using 0.1 N HCl solution and determined using a Perkin Elmer model 703 Atomic Absorption Spectrophotometer. Data generated was summarized using means, standard deviation and coefficient of variation to evaluate dispersion.;

RESULTS AND DISCUSSIONS

The range of the pH of the soils studied ranged between 6.2 and approximately 6.5 indicating that the soils are moderately acidic. Most humid tropical soils are generally slightly acidic (Akinifesi *et al.*, 2005) if uncontaminated. The moderately acidic reaction of the soils within the mining site was as a result of accumulation of dust particulates on the topsoil. The highest value was recorded at location 5 (control) with mean of 6.64. This could be as a result of the dolomite dust traveling away from the processing site and getting deposited as far as 5 km away from processing site. Total nitrogen in all the location showed medium availability ranging between

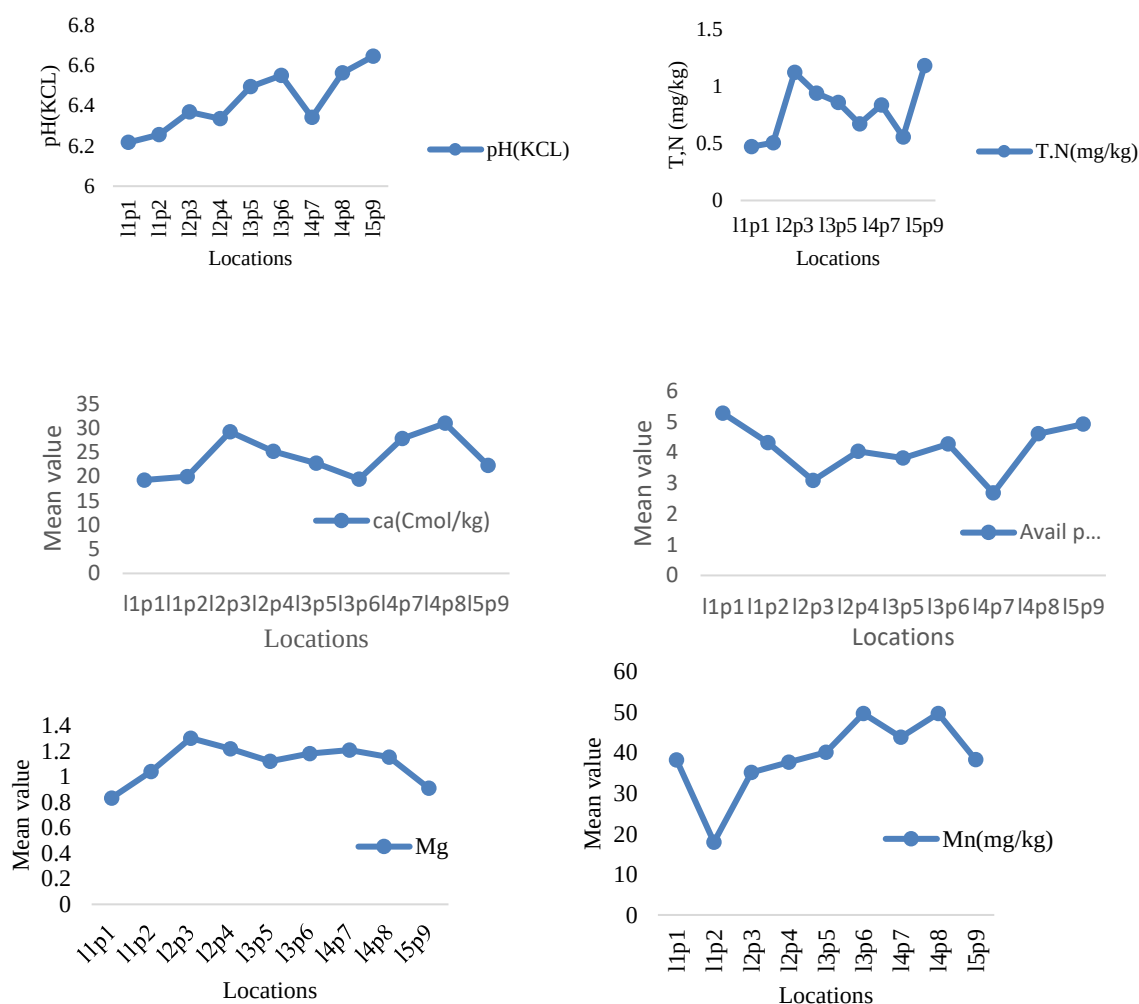


Fig 1: Distribution of exchangeable cations (cmol kg^{-1}), total nitrogen (%) and available phosphorus (mg kg^{-1}) across the nine profile pits.

approximately between 0.47 mg kg^{-1} to 1.18 mg kg^{-1} corroborating previous reported by Sobolu and Osiname (1985). Total nitrogen present at the location closer (100 m away) to the processing site recorded the range of 0.47-1.12 while at locations 300 m away from the processing site recorded the range of 0.50-0.94. This shows that the dust do not have a significant effect on the soil nitrogen contents in the study area both in the control site and the locations at the processing site. The range of exchangeable calcium was from mean of 30.96 g kg^{-1} , to 19.27 g kg^{-1} . The result also showed that there was variation between the soils closer to the processing site compared to those up to 300 m away as shown in location 2 and 3. Also there was variation between profiles that are 300 m away from the processing site showing lower values than those pits closer to the processing site as shown in location 1 and 4. The variation could be the result of the deposition of the dust from the

processing site to the farm land, since Ca^{2+} and Mg^{2+} are the two constituent of Igbeiti dolomitic marble and these are deposited with mine dust. Available phosphorus (P) was highly variable in the location far away from the processing site with the CV of 70.8%, mean of 4.92 and the range of 4.0-4.9 g kg^{-1} . In the location closer to the processing site, it has a CV of 58.6%, mean of 5.27 g kg^{-1} and the range of 2.6-5.2 g kg^{-1} . Locations 300 m away from the processing site showed a high degree of variability for available P. Exchangeable magnesium content of the soils was a slight variable on all the location both the close and the 300 m away from the processing site with CV of 36.1%, mean of 1.15 g kg^{-1} , and the range of 0.8-1.20 g kg^{-1} . The variation could be the result of the activity of the dolomite processing in the area since it is a major constituent of Igbeiti marble, and the accumulation of the dust from the processing site to the farm.

Table 1: Descriptive statistics of the heavy metals observed in the experimental locations

Location 1	Mean	P1 SD	CV%	Mean	P2 SD	CV%
Fe (mg kg ⁻¹)	56.50	3.40	6.02	55.66	7.21	12.95
Cu (mg kg ⁻¹)	1.09	1.08	99.46	1.70	0.24	14.19
Zn (mg kg ⁻¹)	2.12	0.86	40.45	2.22	0.13	5.76
Co (mg kg ⁻¹)	18.08	3.29	18.19	15.38	4.38	28.48
Cr (mg kg ⁻¹)	45.50	22.54	49.55	20.30	16.39	80.71
Cd (mg kg ⁻¹)	7.02	1.64	23.41	7.16	0.42	5.85
Pb (mg kg ⁻¹)	31.77	20.11	63.30	38.56	18.87	48.94
Ni (mg kg ⁻¹)	30.21	13.54	44.80	20.71	8.57	41.38
Location 2:						
Fe (mg kg ⁻¹)	50.03	1.64	3.27	64.04	7.54	11.77
Cu (mg kg ⁻¹)	2.78	1.25	45.06	2.68	1.27	47.30
Zn (mg kg ⁻¹)	3.62	1.50	41.27	2.62	0.71	27.11
Co (mg kg ⁻¹)	13.68	4.97	36.38	11.24	4.07	36.18
Cr (mg kg ⁻¹)	31.08	18.64	59.98	34.50	22.91	66.42
Cd (mg kg ⁻¹)	8.07	1.70	21.03	7.89	1.24	15.75
Pb (mg kg ⁻¹)	28.22	13.00	46.07	25.20	16.77	66.55
Ni (mg kg ⁻¹)	29.67	17.19	57.94	28.45	17.32	60.86
Location 3						
Fe (mg kg ⁻¹)	72.65	19.02	26.18	62.90	23.58	37.48
Cu (mg kg ⁻¹)	1.26	0.54	43.38	2.93	1.60	54.56
Zn (mg kg ⁻¹)	2.11	1.60	75.74	2.46	0.80	32.44
Co (mg kg ⁻¹)	13.25	7.85	59.24	12.81	1.86	14.49
Cr (mg kg ⁻¹)	36.43	31.64	86.87	43.68	16.27	37.24
Cd (mg kg ⁻¹)	5.69	1.12	19.63	7.71	1.62	21.01
Pb (mg kg ⁻¹)	46.73	0.67	1.44	26.52	12.05	45.45
Ni (mg kg ⁻¹)	26.75	12.52	46.79	32.74	10.67	32.59
Location 4:						
Fe (mg kg ⁻¹)	61.95	5.00	8.08	67.00	24.40	36.42
Cu (mg kg ⁻¹)	2.68	1.48	55.45	3.38	0.53	15.75
Zn (mg kg ⁻¹)	2.60	0.96	36.78	3.14	0.25	7.87
Co (mg kg ⁻¹)	11.03	4.39	39.83	13.52	3.14	23.26
Cr (mg kg ⁻¹)	32.96	28.55	86.61	43.42	18.54	42.71
Cd (mg kg ⁻¹)	7.66	1.61	21.08	8.77	0.32	3.66
Pb (mg kg ⁻¹)	35.61	22.44	63.03	26.86	7.92	29.48
Ni (mg kg ⁻¹)	32.43	18.82	58.02	36.98	12.23	33.07
Location 5:						
Fe (mg kg ⁻¹)	67.03	2.01	3.00			
Cu (mg kg ⁻¹)	2.25	1.56	69.24			
Zn (mg kg ⁻¹)	2.33	0.62	26.61			
Co (mg kg ⁻¹)	11.29	1.91	16.90			
Cr (mg kg ⁻¹)	31.87	21.91	68.75			
Cd (mg kg ⁻¹)	6.75	3.08	45.58			
Pb (mg kg ⁻¹)	57.61	18.96	32.91			
Ni (mg kg ⁻¹)	34.90	8.78	25.16			

Fe = iron, Cu = copper, Zn = zinc, Co = cobalt, Cr = chromium, Cd = cadmium, Pb = lead, Ni = nickel, P1 = pit 1 (100 m away), P2 = (300 m away from processing site).

Table 2: Grouping of soil properties using CV % values

Group of properties	Range of CV value	Soil properties
Least variable	<15%	pH, Na, Mg
Moderately variable	15-35%	Cu, Fe, Zn, Co, Cd, clay, silt.
Extremely variable	>35%	K, Mn, Cu, Cr, Pb, Ni, TN, TOC, avail p, sand.

Manganese (Mn) shows variation according to each location whereby high variability was recorded at locations 300 m away from the

processing site in all location except at location 1 where the pit is closer to the processing site. This could be as a result of high concentration of Mn

present in the dust settling close to the processing sites. Fe = iron, Cu = copper, Zn = zinc, Co = cobalt, Cr = chromium, Cd = cadmium, Pb = lead, Ni = nickel, pH has a highly significant correlation with K ($r = 0.86$, $p < 0.01$), Fe ($r = 0.64$, $p < 0.01$), Ni ($r = 0.64$, $p < 0.01$), clay ($r = -0.75$, $p < 0.01$), silt ($r = -0.7$, $p < 0.01$) and sand ($r = 0.75$, $p < 0.01$). Equally, the pH of the soils of the study area had significant correlation with some micro nutrients such as Mn ($r = 0.56$, $p < 0.01$) and Cu ($r = 0.43$, $p < 0.01$) and the cations. It has been reported that the pH of the soil has significant effect on the dynamics of heavy metals (Williams, 1990). It was equally observed that Ca and Mg contents of the dolomite affected soils has a negative significant correlation with available P ($r = -0.53$, $p < 0.01$), and ($r = -0.80$, $p < 0.01$). This may be due to the concentration of the dolomite dust which constituents are calcium and magnesium around the mining and processing site in Igbeti since acidic soils tends to be deficient in P. expectedly exchangeable Mg showed significant correlation with Ca ($r = 0.63$, $p < 0.01$).

CONCLUSIONS

High calcium content was observed in the soils and the values were higher at 100 m distance away from processing sites. Chromium, Cobalt, Lead and Nickel were high in many of the profiles but higher at 100 m away from the processing sites. The accumulation of dolomite dust increased the quantity of heavy metal contents in the soil of farmlands close to the processing sites.

REFERENCES

Adegboye, M.A. 2012. Effect of mining on farming in Jos South Local Government Area of Plateau State. *Journal of Soil Sci. Environ. Mgt.* 3:77–83.

Adekoya, J.A., Kehinde-Phillips, O.O. and Odukoya, A.M. 2003. Geological distribution of mineral resources in Southwestern Nigeria. In: Elueze A.A. (ed.) *Prospects for Investment in Mineral Resources of Southwestern Nigeria. Nig. Mining and Geosci. Soc. (NMGS)*, pp.1- 13.

Adekoya, J.A. 2003. Environmental Effect of Solid Minerals Mining. *J.Phys. Sci. Kenya*. Pp.625-640.

Adetoro, J.G. 1986. "History and Ownership Structure of Nigerian Marble Mining Company (NMMC) Ltd., Igbeti," Oyo State, pp. 1-8.

Aigbedion, I. and Iyayi, S.E. 2007. Environmental effect of mineral exploitation in Nigeria. *Int. J. Phys. Sci.* 2:33–38.

Aigbedion, I.N. 2005. Environmental Pollution in the Niger-Delta, Nigeria. *Inter-Disciplinary J. Enugu-Nigeria*: 3(4):205–210.

Ajakaiye, D.E. 1985. Environmental Problems associated with Mineral Exploitation in Nigeria. A Paper Presented at the 21st Annual Conference of the Nigeria Mining and Geosciences Society held at Jos: pp. 140–148.

Boynton, R.S. 1980. Chemistry and Technology of lime and limestone. Second edition John Wiley USA, 578p.

Aigbedion, I. and Iyayi, S.E. 2007. Environmental effect of mineral exploitation in Nigeria, *International Journal of Physical Sciences*, 2(2):33-38.

Bremner, J.M. and Mulvaney, C.S. 1982. Total nitrogen. In: *Methods of soil analysis*. 2nd ed. Part 2 ed., Page, A. L. Miller, R. H. and Keeney, D. R.. eds. *Agronomy Monograph No. 9*. Madison, WI: American Society of Agronomy. pp 595-624.

Fukaya, Y., Matsumoto, T., Gotoh, M., Ohno, Y. and Okutani, H. 1993. Lead exposure of workers in the ceramics industry and relevant factors. *Nihon Eiseigaku Zasshi*. 48(5): 980-910.

Lal, R. 1985. Mechanical tillage system effects on properties of a tropical alfisol in watersheds cropped to maize. *Soil and tillage research*, 6:149-161.

LRS (Land Resource Study). 1976, *Soils of the Western State Savanna in Nigeria*. Volume 1. The Environment. Land Resources Division, Ministry of Overseas Development, Tolworth Tower, England.185 pp.

Odu, C.T.I., Babalola, O., Udo, E.J., Ogunkunle, A.O., Bakare, T.A. and Adeoye, G.O. 1986, *Laboratory manual for agronomic studies in soil, plant and microbiology*. 1st edition. Published by the Department of Agronomy, University of Ibadan, Ibadan, Nigeria. 83 pp.

Selden, A., Berg, N., Lundgren, E., Hillerdal, G., Wik, N., Ohlson, C. and Bodin, L. 2001. Exposure to tremolite asbestos and respiratory health in Swedish dolomite workers. *Occup Environ Med* 58 (10):670-677.

Table 4: Pearson correlation coefficient of soil properties in Igbeti area Oyo state.

	T.O.C(	T.N	Avail p	Exch Acidity	Ca	K	Mg	Na	Mn	Fe	Cu	Zn	Co	Cr	Cd	pb	Ni	CLAY	SILT	SAND
T.N	-0.9																			
Avail P	-0.56	-0.39																		
Exch Acidity	-0.21	-0.3	-0.52																	
Ca	0.47	0.31	-0.53	0.16																
K	0.08	0.23	0.37	-0.28	-0.02															
Mg	0.52	0.3	-0.8	0.14	0.63	-0.18														
Na	0.4	0.44	-0.1	0.26	0.23	0.41	-0.16													
Mn	0.04	0.05	-0.02	0.00	0.33	0.39	0.22	-0.22												
Fe	-0.07	0.09	0.17	0.02	0.00	0.67	-0.08	0.12	0.48											
Cu	0.4	0.22	-0.3	-0.06	0.66	0.37	0.65	0.14	0.5	0.00										
Zn	0.53	0.33	-0.04	-0.18	0.82	-0.16	0.67	-0.03	0.21	-0.39	0.72									
Co	-0.7	-0.67	0.49	-0.09	-0.41	-0.54	-0.53	-51	-0.34	-0.46	-0.58	-0.21								
Cr	-0.33	-0.28	0.35	-0.17	0.01	0.13	-0.13	-0.53	0.82	0.29	0.13	0.03	0.19							
Cd	0.11	-0.12	-0.14	-0.02	0.61	0.005	0.48	-0.05	-0.29	-0.36	0.83	0.74	-0.13	0.17						
Pb	0.13	0.38	0.18	-0.01	-0.03	0.43	-0.52	0.56	-0.25	0.4	-0.47	-0.49	-0.17	-0.36	-0.74					
Ni	0.17	0.2	0.13	-0.13	0.43	0.55	0.01	0.16	0.84	0.32	0.58	0.34	-0.34	0.64	0.42	-0.05				
CLAY	0.34	-0.34	0.21	-0.12	-0.43	-0.77	-0.31	-0.55	-0.41	-0.49	-0.68	-0.23	0.78	0.09	-0.27	-0.25	-56			
SILT	-0.56	-0.57	0.29	0.03	-0.51	-0.73	-0.42	0.53	-0.37	-0.55	-0.65	-0.3	0.89	0.14	-0.19	-0.27	-0.84	0.93		
SAND	0.61	0.62	-0.27	-0.22	0.53	0.31	0.46	0.01	0.78	0.36	0.52	0.46	-0.6	0.49	0.21	-0.07	0.74	-0.42	-0.56	
pH (KCL)	0.25	0.39	0.15	-0.37	0.16	0.86	0.06	0.51	0.56	0.64	0.43	0.11	-0.54	0.25	-0.01	0.37	0.64	-0.75	-0.76	0.57