CHARACTERIZATION OF SOILS IN THE GEOTHERMAL ZONE OF ACOCULCO, PUEBLA, MEX.

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1 Abstract

Soil is one of the dynamic and living natural entities that plays a very important role in terrestrial ecosystems. The problem of soil pollution is not only specific to rural areas of the world or industrialized or densely populated areas, sometimes due to natural phenomena or human impacts. Evaluating the physicochemical characteristics and chemical composition of soils allows us to identify processes that are affecting their quality. In the case of areas where there are natural hydrothermal activity, it is of great importance to characterize the soils. This, due to the potential presence of chemical elements that can be transported or inserted in the food chain, without losing sight of the human impacts of the region. To characterize the soil, texture is a parameter to know the distribution of particle sizes and classify the soils. Together with this, pH, electrical conductivity and the amount of organic matter give an idea of the possible processes that follow the chemical elements. The geothermal zone studied is located in Acoculco, Puebla, where the hydrothermal activity is characterized by temperatures of 25 °C and acid pH with bubbling hydrogen sulfide. The calculations of the enrichment factor, the geoaccumulation index and the anthropogenic factor allowed the identification of elements of geothermal origin (As, Ba, Fe, Mn and S), geological origin (Nb, Rb, Y) and anthropogenic origin (Br, Cl, Cr, V and K). Concentrations of trace elements such as Ho, Mo, Sb, Sc and Se were notable. Rain plays a very important role, as the concentrations of most of the chemical elements in the soil increased and a greater number of correlations were identified. Barium was detected in an order of thousands of parts per million, Cl, Mn, Rb, Sr, V and Zn in hundreds of parts per million. The site studied, as said before, shows specific characteristics of low-temperature hydrothermalism on the surface, with acidic conditions that can promote the mobility of trace elements. Having sandy loam soils, it promotes water infiltration and chemical reactions in the deep fraction (40 and 50 cm).

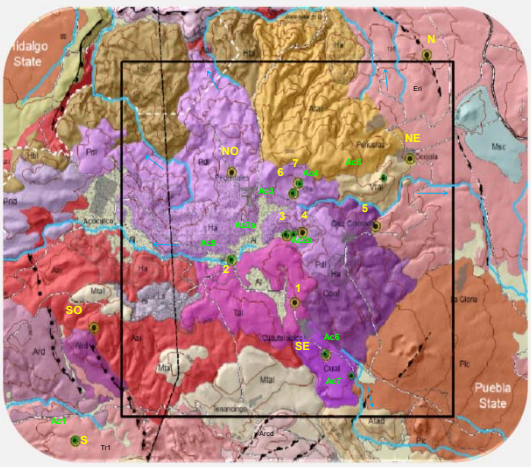
2 Study site

Climate: temperate sub-humid, semi-cold and temperate humid

Precipitation
700 -1000 mm/year

T_{env} - 12 - 14 °C
$T_{hydrothermal}$ - 25 °C

3 Sampling



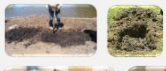
Soil Cores sampling
Simple soil samples

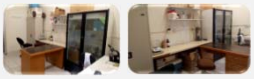
Aai - Acoculco andesitic ignimbrite
Ahrc – Ahuacatla rhyolitic coulee dome
Al - Alluvium
Aird - Altamira rhyolitic dome
Amrc – Amolo rhyolitic coulee dome
Arcd - Alilita rhyolitic coulée dome
Ard - Arco rhyolitic dome
Atad - Ajolotla trachyandesitic dome
Atal – Aguila basaltic trachyandesite lava
Coal - Colorada andesitic lava
Crd – Canoas rhyolitic dome
Cred – Chica rhyolitic coulée dome
Crl – Cabezas rhyolitic ignimbrite
Cual - Cuautelolulco trachy-andesitic lava
Erl - Encimada rhyolitic ignimbrite
Ha - Hydrothermal alteration
Hbl – Huistongo basaltic andesite lava
Lrd – Lobera rhyolitic dome
Ls - Lacustrine sediments
Mrcd – Mirilla rhyolitic coulée dome
Msf – Maguey surges/fall rhyolitic pyroclastic
Msc - Moxhuite basaltic andesite scoria cone
Mtal - Manzanito basaltic trachyandesite lava
Pald – Puente andesitic lava domes
Pdd – Peñuela dacitic domes
Pdl – Pedemal rhyolitic lava
Plc - Palla basaltic trachyandesite scoria cone
Prld - Pintada rhyolitic lava dome
Srl – Sayula rhyolitic lava
Tal – Terrerillos andesitic lava and scoria cone
Tdld – Terrerillos dacitic lava domes
Tr1, Tr2 – Tecoloquillo rhyolitic ignimbrite
Trcd – Togo rhyolitic coulée dome
Vtal - Viejo basaltic trachyandesite lava

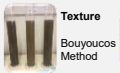
**Special thanks to Dr, Macías for the geology base map., published as: Avellán, D. R., Macías, J. L., Layer, P. W., Cisneros, G., Sánchez-Núñez, J. M., Gómez-Vasconcelos, M. G., ... & Osorio-Ocampo, S. (2019). Geology of the late Pliocene–Pleistocene Acoculco caldera complex, eastern Trans-Mexican Volcanic Belt (México). Journal of Maps, 15(2), 8-18.*

4 Methodology

4.1 GRANULOMETRY


1 m³


OM
Ignition


Texture
Bouyoucos Method


pH, EC
Soil extract

$$EF = \left[\frac{(C_n/C_l)_{sample}}{(C_n/C_l)_{Earth\ crust}}\right]$$

EF – Enrichment factor
C_n – Concentration of the element
C_l – Concentration of the lithogenic element

4.2 ELEMENTAL CHEMISTRY


Coring 50 cm depth, divided each 10 cm, diameter 10 cm


Freeze Dry
24 hrs


Milling
Agate container


Press
40 ton


Analysis
XRF, Na-U
> 2 mg/kg

$$I_{geo} = Log_2\left[\frac{C_n}{(1.5 * C_{n\ Earth\ crust})}\right]$$

Igeo – Geoaccumulation Index

$$AF = \left[\frac{(C_n)_{surface}}{(C_n)_{deep}}\right]$$

AF – Anthropogenic Factor

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5 Results and Discussion

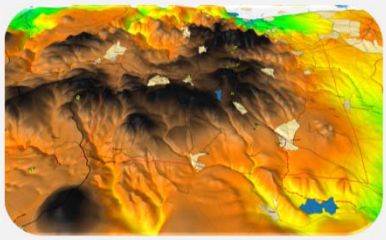
5.1 GRANULOMETRY, PHYSICOCHEMICAL PARAMETERS

Site	Sampling ID	Texture	OM %	EC µS/cm²	pH
Control	Ac1	Sandy loam	3.7	202	6.3
Los Azufres	Ac2a	Sandy loam	2.9	8.4	2.7
Los Azufres	Ac2b	Loam	24.6	53.1	5.5
E Jonuco Pedernales	Ac3	Sandy loam	7.9	714	4.4
Alcaparrosa	Ac4	Sandy loam	12.8	28.4	2.2
Stream	Ac5	Clay loam	10.9	102.6	4.8
Dam	Ac6	Clay	16.6	890	5.5
Capulaque	Ac7	Clay loam	10.6	98.2	5.1
Ocojala	Ac8	Loam	10.9	74.3	5.7

5.2 SUMMARY OF SOIL QUALITY INDEXES

SAMPLING SITES		ENRICHMENT FACTOR		GEOACCUMULATION INDEX		ANTHROPOGENIC FACTOR	
		Dry	Wet	Dry	Wet	Dry	Wet
N	Tehuacán	Zr, Nb, Zn, Br, As		Zr, Zn, Br, As			
NO	600 m NO Jonuco	Zr, Nb, As		Zr, As		Mg, S, Si, Pb, Zn, Sr, Cl, Ba, Ni, Mn, Nb, Rb, As	
NE	Stream Ocojala	Zr, As		Zr, As		Si, Fe, Ca, Mg, Na, V, Rb, Y	
S	Control	Cu, Nb, Rb, Zr, As		Zr, As		Si, Fe, K, Ti, Mg, Ni, Cl, Zn, Sr, Ca, Cr	
SO	Well Cerro	Zr, Nb		Br		Mg, Mn, Ni, Sr, Zn, Nb, Cl, Rb, P, Cr, Br	
SE	Dam San Fco.	Zr, As		Zr, As		Si, Al, Mg, Na, Ca, Zn, Ba, Sr, Y	
1	500 m N Cuautelolulco	Zr, As	Br, Pb, Y, As	Zr, As	Zr, Y, As, Br	Ti, Si, Ca, Mn, Sr, Nb, Ba, S, P, As	Si, Al, Zr, Na, V, Cu, Cr, Pb, As, P, Mg, S, Ca, Sr, Br, Y
2	San Fco. Terrerillos	S, As	Zr, As	As	Zr, Rb, Mn, As	Si, Ca, Fe, Ti, S, P, Sr, V, Nb, Ba, Cr, Cl, Mn, Mg, Na	Si, Fe, Al, P, Ca, S, Zr, Ni, V, Pb, Cl, Sr, y, Mn, As
3	Los Azufres	Rb, Ba, Nb, Zr, S, As	Nb, Zr, As, S	Zr, S, As	Zr, Nb, Rb, Mn, As, S	P, Si, Na, Pb, Rb, Nb, Zn, Ni, Ba	Zr, Ca, K, Ti, Mg, Nb, Ni, Pb, Cu, Ga, Sr, As, S, Fe, Mn, V
4	500 m E Los Azufres	Nb, Rb	Zr, As	Pb	Rb, Nb, As, Zr	Zn, Cu, Sr, V, Si, Al, Ca, Mg, Na, S, P, Rb, Cl	Ti, Al, Fe, Cr, Rb, Nb, Y, Ga, V, As
5	1 km NE Cruz Colorada	S, Zr, Ga, Nb, Pb, Br	Nb, As, Zr	Zr, S, Nb, Br	Zr, Nb, As, Rb, Mn	Si, Na, Ti, Zr, Pb, Zn, V, Al, Ba, Rb, Nb	Zr, Sr, Cl, Nb, Rb
6	300 m S Alcaparrosa	Nb, As		As, Mn, As, Zr	Zr, Mn	Si, K, S, Al, Ni, Rb, Zn, Fe, Na, As	P, Si, Ca, Na, Mg, Ni, C, Sr
7	Alcaparrosa	S, Nb, Zr	Nb, As, Zn, Zr	Zr	Zr, S, As, Mn, Nb, Rb	Mg, Ti, V, Nb, Si, K, Zr, Y	Ca, P, Na, Al, Rb, Mn, Pb, S, K, Fe, As, Zn
		moderated significant	very high extreme	medium/high high	very high extraordinary	1 to 1.5 - moderated 1.5 to 2 - significant	2 to 3 - very high > 3 - extraordinary

5.3 SPEARMAN CORRELATIONS


3D Elevation model of Acoculco. 2,200 a 3,300 mosl.

CaFe
Highly correlated in all site

AlCa, AlFe, AlMg, CaFe, CaNa, KNa, PS, PZr, TiZr
Associated to geology

AlP, CaFe, FeMg, KNa
Fertilizer use

BaCr, CrNb, CrV, CuSr, CuV, CuY, GaNb, NbV, RbV, VY
Correlation wet season both fractions

KNa, CaMg
Only in deep samples

BaCr, CuV, NiSr
Correlation both seasons surface fraction

CuGa
Correlation both seasons deep fraction

BaCr, CrNb, NbV, RbV
Negative correlations

CrV
Negative correlation surface
Positive correlation deep

GaNb
Positive correlation surface
Negative correlation deep

PZr
Positive correlation dry deep
Negative correlation wet surface

6 Conclusions

According to the results, rain plays a very important role in the site, as the concentrations of most of the trace elements in the soil increased in wet season. A greater number of correlations were identified in wet season. In sandy loam soils, water infiltration is promoted and chemical reactions in the deep fraction (40 and 50 cm) is occurring. In addition the studied site, shows specific characteristics of low-temperature hydrothermalism on the surface, with acidic conditions that can promote the mobility of trace elements through hydrological and or erosion processes.

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