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Background Geochemistry of Soil in Part of Girei District, Upper Benue Trough, N. E. Nigeria

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Abstract

Soil geochemical study aimed at determining the background levels of trace and major elements in soils of a relatively small part (MAUTECH Campus) of Girei District has been carried out. The results show that the contents of trace and major elements in the area are generally low and vary by factors ranging from about 3 times (As, V), about 4 times (Ni, W), about 6 times (Cd, Rb, Be), about 10 times (Cr, Ba, Br), about 7 times (Se), about 18 times (Mo), about 30 times (Co) and about 45 times (Pb). The low contents reflect the granites and migmatite gneisses bordering the study area and suggest that the soil was derived from these granites with little contribution from the mafic gneisses. Correlations amongst elements are significant at the probability level of 0.01. Among the major elements; Mg has a strong positive relationship with Ca (0.88), and Al (0.74) while Fe is also strongly related to Al (0.69). Several trace elements have very strong positive relationship with one another: Ba-As (0.91), Be-As (0.93), Be-Ba (0.91), Cs-Ba (0.91), As-Cs (0.85), Cr-Ba (0.85), Cr-Be (0.85), Cs-Be (0.88), As-Ce (0.94) and Cs-Cr (0.86). Mn and Mo are poorly related with most of the trace elements. Among the rare earth elements, Eu is strongly related to Dy (0.98), Gd (0.99) and Lu (0.96) just as Dy is strongly related to Er (0.99), Eu (0.98), Gd (0.98) and Lu (0.98). These strong positive correlations among elements suggest that chemical and physical factors control elements associations in parent materials and soil forming processes. Consequently, the data may serve as a reference standard in the assessment and monitoring of possible future environmental issues related to trace and/or major element contamination.

Keywords

Background Geochemistry, Girei, Benue Trough, Nigeria

1. Introduction

The term "trace element" is loosely used in scientific literature to refer to a number of elements that occur in natural systems in small concentrations [1]. Other terms such as "trace metals", "heavy metals" etc. have been considered synonyms to the term "trace elements". The term "heavy metals", is the most commonly used and widely recognised term for a large group of elements with density greater than 5.0 g/cm^3. The trace elements are defined as those elements having less than 0.1% average abundance in the earth's crust [2]. Using this definition, the elements Al, Ca, Fe, Mg, K, and Na with average abundances over 1.0%, are considered "major elements" in this work.

Trace elements are ubiquitous in the earth crust. Their natural levels in soil vary widely, as a function of the geology (nature of parent materials from which soil form) and soil-forming processes [3] [4] [5] [6]. These natural levels in soils have, in many areas, been affected by anthropogenic activities such as mineral exploration, mining and smelting, agriculture, manufacturing, waste disposal and transportation [1] [3] [7]. Industrial effects are relatively well-documented and are usually largely concentrated around the mine site or form dispersion trains along drainage basins. This explains why whenever there are environmental problems related to high trace elements levels in soils or groundwater, there is always a tendency for the public to blame the most visible industry first without proper technical assessment of other possible unnatural or natural causes [8].

Girei District is situated within the Yola Arm of the Upper Benue Trough (**Figure 1**). In recent years, MAUTECH (Modibbo Adama University of Technology) Campus, (a relatively small area within the district), has experienced and is still experiencing rapid infrastructural expansion/development including construction of students' hostels, faculty complexes, laboratories, etc. Similarly, the renewed interest in food production has also led to increased agricultural activities on the university land. All these activities have the potentials to affect the natural trace elements levels in soil. Such effects can only be properly determined if there exist a reference data of background trace elements distribution in the area. However, the general lack of background data on natural trace elements distribution patterns in soils makes the determination, monitoring and management of such anthropogenic influences very difficult if not impossible.

This work provides the first comprehensive, reliable scientific database on background levels of trace elements in soils of MAUTECH Campus. Such reliable reference data are essential to any systematic monitoring and accurate assessment of trace elements effects when environmental issues related to elevated or reduced trace and major elements levels in MAUTECH soils are being considered.

2. Geological Setting

MAUTECH Campus is situated within the northern part of the Benue Trough

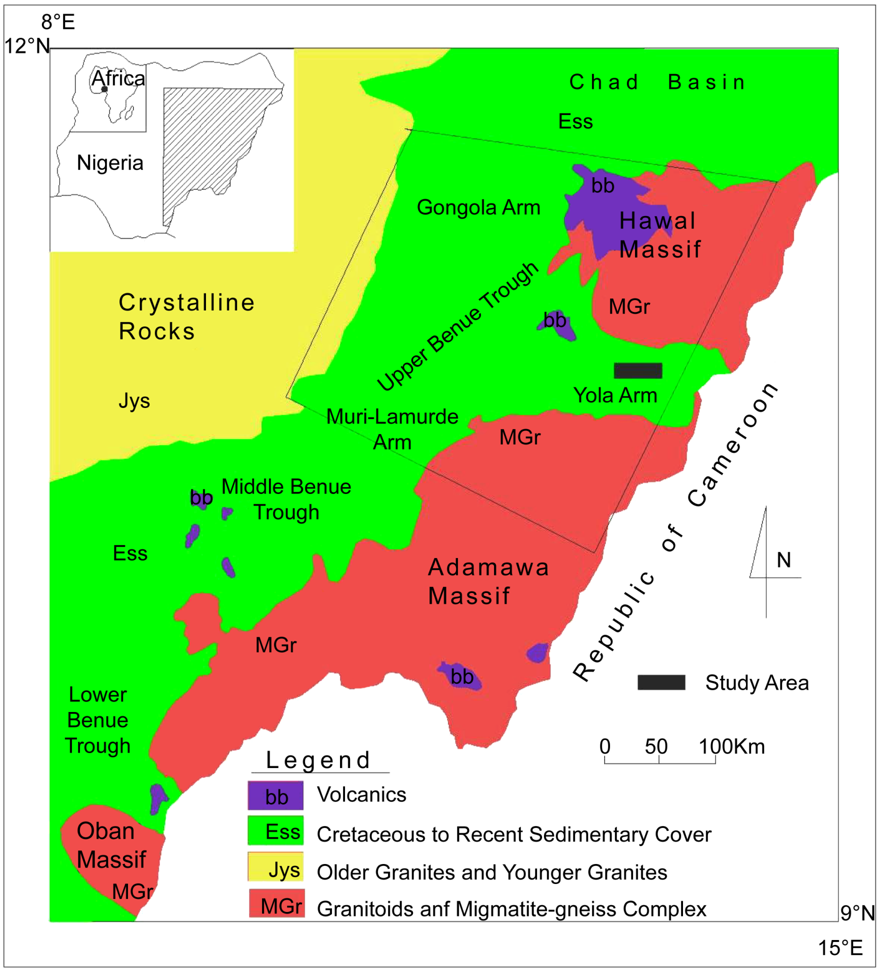

Figure 1. Regional geologic map of Northeastern Nigeria [16].

(**Figure 1**). The Trough is a NE - SW trending rift depression filled with continental and marine sediments. Different models have been proposed for the evolution of this megastructure. [9] presented the structure as a basin which has experienced deformation (aulacogen). [10] and [11] interpreted the Benue Trough as a set of juxtaposed pull-apart basins initiated in the Early Cretaceaous, and formed by sinistral movement along a NE - SW transcurrent fault inherited from the Atlantic oceanic crest. [12] and [13] suggested that the Benue Trough is genetically related to the opening of the equatorial domain of the South Atlantic. All the models imply an intraplate rifting for the genesis of Benue Trough.

The northern part of the Benue Trough is subdivided into three sub-basins: the N-E trending domain to the south, the N-S Gongola Arm to the north and the E-W trending Yola Arm to the east (**Figure 1**). MAUTECH Campus lies within this Yola Arm. The arm is bounded to the northeast by the basement rocks of the Hawal Massif and to the south, by the Adamawa Massif.

In the Yola Arm, the Precambrian basement is unconformably overlain by the Aptian-Albian Bima sandstone which is the oldest and most extensively outcropping formation in the sub-basin [14] [15]. The Bima sandstone is overlain by transitional Yolde Formation (interbeds of shale, siltstone and calcareous mudstone) and followed upward by the Dukul Formation (mainly of gray shales and thin silty beds), and the Jessu and Numanha Formations. These sequences are overlain and capped by poorly to moderately sorted sandstone of Lamja Formation.

3. Materials and Methods

3.1. Sample Collection

Sixteen (16) representative soil samples were analysed for this work. The samples were collected over a period of four months from July to October 2016. The sampling sites were mostly from agricultural fields distant from known areas of contamination on campus. Here, the fear of trace elements input from agro-ecosystem (fertilisers, pesticides etc.) may arise. However, such input is balanced by output represented by losses of trace elements through plant tissue removal for food, erosion etc [17]. Therefore the background concentrations of trace elements in soils are probably not significantly altered by short-term agricultural use. Harmason and de [17] calculated that it would take three centuries of phosphate fertiliser at 100 kg P_2O_5 per hectare per year to enrich the top 20 cm of soil by 1 mg/kg U, if the P_2O_5 fertiliser contained 100 mg/kg U. Consequently, the trace element contents should be representative of background levels.

At each sample site, approximately 20 g of soil was collected from a depth of about 20 cm or termite mounds (where they exist) in plastic sample bags to avoid the effects of both surface and metallic contaminations. The samples were later air-dried and screened for large rock particles in the laboratory. The locations of these samples and other samples (for other studies) are indicated in **Figure 2**.

3.2. Sample Preparation and Analyses

The samples were prepared in the geochemistry laboratory of the Ashaka Cement Company, Gombe. The preparation involved grinding, pulverisation and quartering to obtained representative samples. The samples so prepared were later shipped to Activation Laboratories, Canada for both trace and major elements determinations. The trace and major elements in soil were determined by BioLeach-MS methods. It is within ActLabs standards to ensure that analyses are conducted with adequate control on precision and accuracy of the results obtained. The quality control is usually done through analysis of standards, blanks and duplicate samples, done under the same conditions with the samples submitted. All these were done by ActLabs, Canada and submitted along with the analytical results. The standard comparison is excellent, making the results to be reliable and in conformity with highest industry standards.

4. Results and Discussion

Table 1 shows total contents of 49 trace and major elements in soils of MAUTECH Campus.

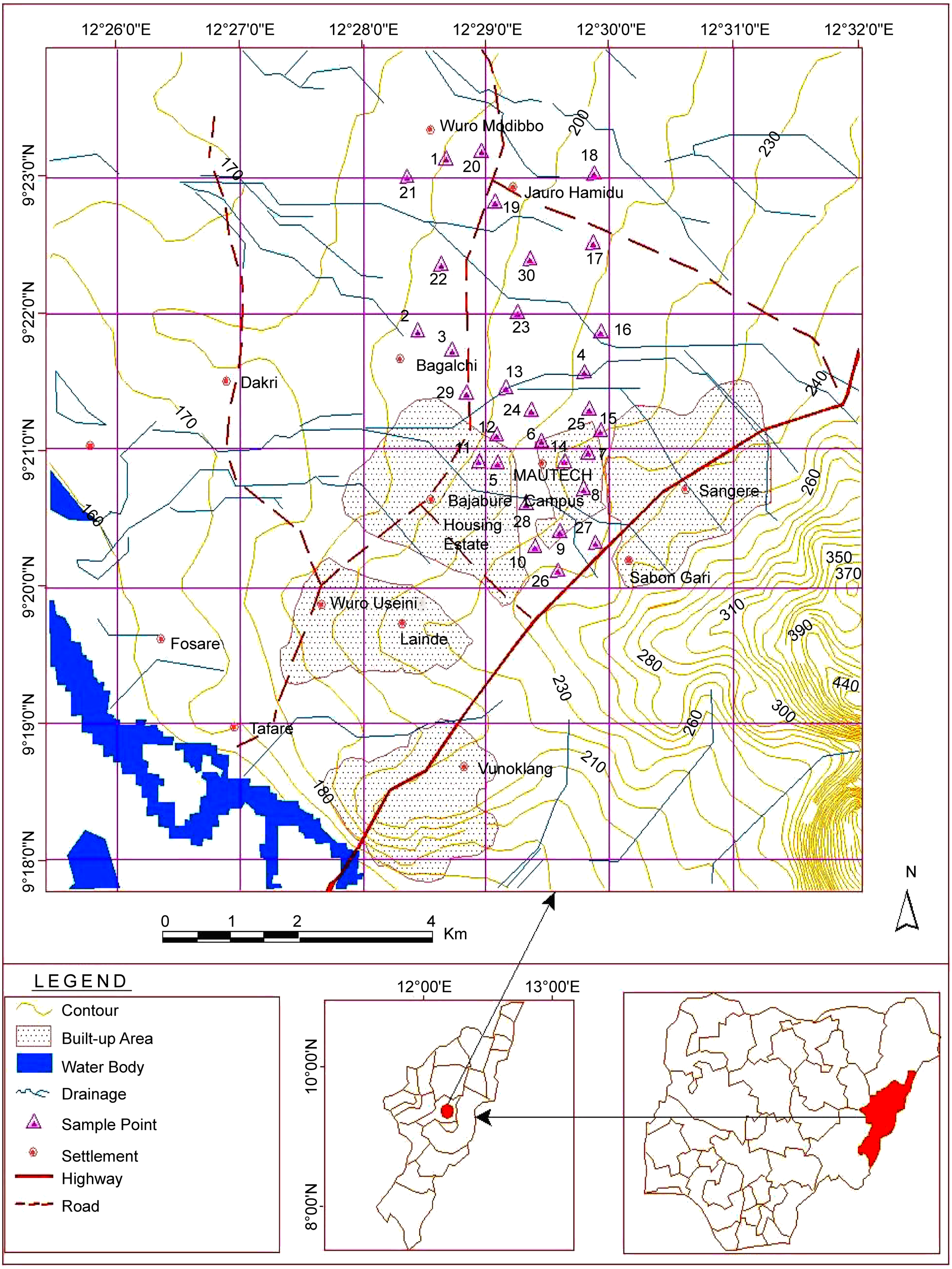

Figure 2. Map of MAUTECH Campus and the neighbouring villages [18].

Table 1. Trace and major elements content in soils of MAUTECH campus.

	Element (ppm)												
Sample	Al	Ca	Fe	K	Mg	Ag	As	Au	Ba	Be	Bi	Br	Cd
15	84.7	1060	61	140	271	1.4	68.1	0.16	3430	64.1	0.4	373	1.33
16	110	1300	78	130	225	1.1	61.7	<0.05	2890	88.7	0.3	516	2.28
17	109	1270	79	449	308	1.1	51.1	<0.05	3710	60.7	0.2	558	1.55
18	159	1410	105	139	252	0.9	60.3	<0.05	4700	66.7	<0.1	463	1.25
19	52.1	1530	57	720	333	1	57.7	<0.05	3440	46.2	<0.1	1140	2.69
20	152	1320	104	273	362	1.1	62.2	0.1	4610	96.5	<0.1	584	1.83
21	107	1290	77	167	236	0.9	56	0.13	2160	53.2	<0.1	441	1.79
22	84.7	1410	134	485	358	0.5	59.2	<0.05	5080	72.6	<0.1	1280	3.44
23	152	602	96	76	82	1.2	67.5	<0.05	3850	74.3	<0.1	207	1.16
24	604	753	254	186	171	1.3	119	<0.05	9550	233	0.2	381	1.29
25	79.6	1130	54	188	222	0.6	47.7	<0.05	1310	34.2	<0.1	656	2.07
26	149	1110	110	113	189	1.2	72.5	0.17	5660	176	<0.1	427	3.58
27	1460	258	163	134	84	0.5	94.7	<0.05	8300	240	<0.1	301	0.53
28	1640	435	204	162	156	1.1	110	<0.05	13200	245	0.3	400	0.73
29	304	303	120	110	59	1.7	65.9	<0.05	3200	74.7	<0.1	125	0.71
30	233	655	103	109	127	1.5	62.4	<0.05	3850	69.1	<0.1	201	0.9
	Summary												
Min.	52.1	258	54	76	59	0.5	47.7	0.1	1310	34.2	0.2	125	0.53
Max.	1640	1530	254	720	362	1.7	119	0.17	13200	245	0.4	1280	3.58
Ave.	342.51	989.75	112.44	223.81	214.69	1.07	69.75	0.14	4933.75	105.94	0.28	503.31	1.70

	Element (ppb)												
Sample	Ce	Co	Cr	Cs	Cu	Dy	Er	Eu	Ga	Gd	Ge	Hf	Hg
15	1610	704	84	2.33	403	316	155	120	169	437	10.3	4.15	1.74
16	1590	1340	99	3.55	600	346	174	111	152	416	7.65	3.39	0.96
17	1100	1600	108	1.72	653	107	55.3	36.1	176	141	3.13	2.61	1.62
18	1630	1400	135	3.3	509	213	111	71.6	239	258	5.17	3.16	2.38
19	1360	1600	100	1.9	699	101	51	33	150	133	2.92	2.02	1.25
20	1970	1220	142	3.61	692	173	88.4	59.8	229	229	4.79	3.52	1.17
21	2050	766	129	3.69	605	418	218	136	119	484	7.84	3.46	1.07
22	1710	555	123	2.9	999	135	68.5	47.6	237	183	4.64	1.1	0.66
23	5740	7850	220	4.32	362	568	265	230	211	814	19.5	5.85	7.32
24	14700	3010	330	7.01	796	756	360	334	528	1210	29.6	7.09	0.9
25	1020	434	74	2.74	535	119	61.2	38	73.4	147	3.32	1.12	0.61
26	3860	823	148	5.7	987	651	333	217	290	791	15.3	6.75	1.05
27	8240	8570	743	6.92	613	434	219	167	609	624	15.6	0.26	0.8
28	8520	10500	718	12.4	623	436	215	170	772	643	15.9	3.11	0.93
29	4110	14300	195	4.6	179	309	149	120	198	456	12.1	5.76	8.8
30	3070	5860	143	4.97	222	241	120	94.6	214	346	8.84	6.1	6.42
	Summary												
Min.	1020	434	74	1.72	179	101	51	33	73.4	133	2.92	0.26	0.61
Max.	14700	14300	743	12.4	999	756	360	334	772	1210	29.6	7.09	8.8
Ave.	3892.50	3783.25	218.19	4.48	592.31	332.69	165.21	124.11	272.90	457.00	10.41	3.72	2.36

Continued

	Element (ppb)												
Sample	Ho	I	In	La	Li	Lu	Mn	Mo	Nb	Nd	Ni	Os	Pb
15	56.1	114	0.1	1710	16.8	15.6	10700	6	<0.2	2380	194	<1	18.7
16	62.2	261	0.2	1350	16.1	16.9	14000	14	<0.2	1880	373	<1	22.3
17	20	270	0.1	761	21.3	5.8	17100	11	<0.2	717	502	<1	28.8
18	39.1	189	0.2	984	22	11.4	12300	12	<0.2	1250	391	<1	52
19	18.7	284	<0.1	741	15.3	5.59	18500	14	<0.2	688	611	<1	21.9
20	31.1	232	0.2	1160	22.5	9.91	22100	15	<0.2	1230	502	<1	70.9
21	79.4	137	0.2	1460	9.8	22.9	11900	24	<0.2	2100	336	<1	68.7
22	24.6	470	0.2	856	8.4	6.87	18300	38	<0.2	967	731	<1	105
23	99.3	87	0.4	3340	24.4	23.8	14200	14	<0.2	4490	211	<1	143
24	127	200	0.8	5620	91.6	35.3	18900	17	<0.2	7560	524	<1	464
25	21.6	256	0.2	616	5	6.65	12100	18	<0.2	725	272	<1	18
26	118	464	0.3	2540	16.7	32.4	18800	20	<0.2	3690	596	<1	86.5
27	76	109	1.4	3230	296	24.5	4890	2	<0.2	3880	584	<1	434
28	74.6	127	1.3	3570	348	23.5	5970	12	<0.2	3960	635	<1	833
29	54.5	83	0.5	2120	55.9	14.3	12200	14	<0.2	2680	180	<1	139
30	42.5	165	0.4	1580	36.7	12.4	9490	18	<0.2	2050	174	<1	78.5
	Summary												
Min.	18.7	83	0.1	616	5	5.59	4890	2		688	174		18
Max.	127	470	1.4	5620	348	35.3	22100	38		7560	731		833
Ave.	59.04	215.50	0.43	1977.38	62.91	16.74	13840.63	15.56		2515.44	426.00		161.52

	Element (ppb)												
Sample	Pd	Pr	Pt	Rb	Re	Ru	Sb	Sc	Se	Sm	Sr	Ta	Tb
15	<0.5	560	<0.5	274	0.03	0.28	1.5	74.6	108	511	3700	<0.01	64.5
16	<0.5	435	<0.5	333	0.03	0.58	1.3	77.7	114	453	3620	<0.01	66.1
17	<0.5	184	<0.5	367	0.08	0.51	0.9	65.2	45	151	6010	<0.01	21.7
18	<0.5	295	<0.5	352	0.03	0.62	1.2	92.5	68	286	5690	<0.01	41.8
19	<0.5	177	<0.5	518	0.07	0.58	1.8	47	49	138	10700	<0.01	20.3
20	<0.5	305	<0.5	359	0.04	0.64	1	92.5	58	255	6610	<0.01	34.9
21	<0.5	478	<0.5	291	0.06	0.36	1.4	81.2	115	498	3200	<0.01	81.6
22	<0.5	236	<0.5	447	0.04	0.23	2.3	75	58	195	5740	<0.01	27.6
23	<0.5	1090	<0.5	326	0.05	2.99	1	189	204	936	1980	<0.01	120
24	<0.5	1940	<0.5	782	0.02	1.66	2	506	326	1500	3540	<0.01	169
25	<0.5	172	<0.5	278	0.01	0.23	1.1	62.2	44	157	3270	<0.01	23.2
26	<0.5	837	<0.5	372	0.07	0.47	1.6	133	204	863	2880	<0.01	124
27	<0.5	995	<0.5	1270	0.03	2.74	<0.2	525	177	758	1560	<0.01	92.3
28	<0.5	1030	<0.5	1620	0.02	4.29	0.9	420	179	773	3470	<0.01	92.2
29	<0.5	677	<0.5	556	0.05	6.23	1.4	304	124	537	1230	<0.01	66.8
30	<0.5	508	<0.5	490	0.04	2.65	1.1	216	99	415	2700	<0.01	51.3
	Summary												
Min.		172		274	0.01	0.23	0.9	47	44	138	1230		20.3
Max.		1940		1620	0.08	6.23	2.3	525	326	1500	10700		169
Ave.		619.94		539.69	0.04	1.57	1.37	185.06	123.25	526.63	4118.75		68.58

Continued

	Element (ppb)										
Sample	Te	Th	Tl	Tm	U	V	W	Y	Yb	Zn	Zr
15	<1	134	2.6	19	89.6	960	500	1700	118	87	121
16	<1	133	2.9	22.1	183	1080	352	1930	134	117	54.3
17	<1	87.4	2.2	6.8	97.4	717	223	558	43.3	576	84.1
18	<1	167	2.5	14.1	166	938	605	1140	85.5	246	72.6
19	<1	81.2	2.6	6.49	155	804	195	511	40.2	404	69.1
20	<1	144	2.8	11.5	264	903	155	860	73.8	378	92.5
21	<1	166	2.6	27.5	208	840	259	2280	168	305	39.2
22	<1	106	4	8.24	108	850	53.7	703	50.9	656	29.4
23	<1	402	3.2	30	118	607	1900	2880	176	157	107
24	<1	449	5.4	42.1	474	940	266	3570	265	703	99.8
25	<1	67.4	2.6	7.9	118	470	167	685	50.1	149	26.4
26	<1	219	4.8	41.7	370	1350	281	3630	253	208	85.2
27	<1	298	7	28.2	298	803	227	2090	188	271	1.8
28	<1	221	9	26.9	259	1300	200	1830	175	446	45.4
29	<1	921	4.7	17.1	85	715	2320	1390	107	99	155
30	<1	607	4.6	14.6	95.6	623	1820	1170	90.8	108	148
						Summary					
Min.		67.4	2.2	6.49	85	470	53.7	511	40.2	87	1.8
Max.		921	9	42.1	474	1350	2320	3630	265	703	155
Ave.		262.69	3.97	20.26	193.04	868.75	595.23	1682.94	126.16	306.88	76.93

In general, background elemental contents for the soil vary by factors ranging from about 3 times (As, V), about 4 times (Ni, W), about 6 times (Cd, Rb, Be), about 10 times (Cr, Ba, Br), about 7 times (Se), about 18 times (Mo), about 30 times (Co) and about 45 times (Pb) (**Table 1**).

An examination of geologic map of the region (**Figure 1**) shows a predominance of granites over migmatite-gneisses with isolated areas of basalts (ultramafic volcanics) in the region. While the gneisses are mostly ferromagnesian silicates with minerals such as olivine ($MgSiO_4$-$FeSiO_4$), pyroxenes ($MgSiO_3$-$FeSiO_3$-$CaSiO_3$) and the amphiboles, the granites are mostly non-ferromagnesian silicates composing predominantly of plagioclase (a solid solution between anorthite, $CaAl_2Si_2O_8$, and albite, $NaAlSi_3O_8$) and potassium feldspars (solid solution between albite, $NaAlSi_3O_8$ and orthoclase, $KAlSi_3O_8$) with quartz (SiO_2) and associated Ni, Co, Pb etc.

Soils formed from predominantly granitic rocks would likely have low values of Ni, Co, Pb, etc. The average values of Ni (426 ppb), Co (3783.25 ppb) and Pb (161.52 ppb) (**Table 1**) in soil of the study area are far less than their average background values of 17 ppm (Ni), 10 ppm (Co) and 17 ppm (Pb) in uncultivated soils [19] [20].

The low values of these elements can therefore be explained in terms of the source materials and their chemical behaviours. Ni has intermediate ionic radii and is abundant in the earlier members of differentiation sequence as a result of ready substitution for Fe and Mg, with some strongly enriched with magnesium in ultramafic rocks [21]. Ni is concentrated in magnesium and olivine (in ultrabasic and basic rocks) and to a lesser extent in biotite in intermediate and acid rocks [22]. The low values of Ni can be attributed to the paucity of basic and ultrabasic rocks in the area and the predominance of acid granites. In granites, almost all the Ni is contained in biotite, and in an environment such as the study area that is flanked by acid granites, the value of Ni can hardly be any higher. Co is one of the elements occurring in the transitional group of the elements, and like Ni, has an intermediate ionic radii and substitute readily for Fe and Mg and hence its abundance in the earlier members of differentiation sequence. The low content of Co can therefore be explained in terms of the paucity of both the basic and ultrabasic rocks and its chemical behavior during transportation. Co has relatively high mobility but readily scavenged and held by Fe-Mn oxides [23]. Pb is one of the elements belonging to "large-ion lithophile" group (LIL). It has cations with large radii and low electric charge, which tend to substitute for K; hence its concentration in felsic rather than mafic rocks [21]. Pb is concentrated in orthoclase, which is the mineral indicator of the geochemical characteristic of acid and intermediate rocks. Maximum concentrations are found in zircon and in some other accessory minerals [22]. However, as a result of weathering, Pb is released from the various Pb-bearing minerals in the acidic environment and passed into water phase with little, getting co-precipitated or absorbed by clay minerals and organic matter. All these suggest that soil in the study area was derived principally from these sub-adjacent granites with little contribution from the mafic rocks. The processes involved in such derivation are probably weathering, erosion, transportation and deposition. In other words, the soil does not appear to have been significantly sourced from ultramafic rocks as such soil would contain appreciably high content of Ni, Cr, etc resulting from serpentine, a magnesium silicates which dominate the mineral composition of ultramafic rocks [24]. The above results underline the significance of material composition and soil forming processes on background contents of trace and major elements in soil.

Correlations among elements are shown in **Table 2** and summary of their statistics in **Table 3**. Correlations are significant at the probability level of 0.01. Among the major elements; Mg has a strong positive relationship with Ca (0.88), and Al (0.74) while Fe is also strongly related to Al (0.69). Several trace elements have very strong positive relationship with one another. These include: Ba-As (0.91), Be-As (0.93), Be-Ba (0.91), Cs-Ba (0.91), As-Cs (0.85), Cr-Ba (0.85), Cr-Be (0.85), Cs-Be (0.88), As-Ce (0.94) and Cs-Cr (0.86). Mn and Mo are poorly related with most of the trace elements. Among the rare earth elements, Eu is strongly related to Dy (0.98), Gd (0.99) and Lu (0.96) just as Dy is strongly

Table 2. Correlation between elements in soils of MAUTECH campus.

	Al	Ca	Fe	K	Mg
Al	1				
Ca	−0.83	1			
Fe	0.69	−0.62	1		
K	−0.33	0.59	−0.32	1	
Mg	−0.58	0.88	−0.41	0.74	1
Ag	−0.10	−0.05	0.22	−0.13	−0.11

	As	Ba	Be	Br	Cd	Ce	Co	Cr	Cs
As	1								
Ba	0.912483	1							
Be	0.928649	0.907837	1						
Br	−0.40642	−0.24623	−0.40955	1					
Cd	−0.46582	−0.40403	−0.35092	0.672138	1				
Ce	0.94354	0.790068	0.850453	−0.4316	−0.45758	1			
Co	0.651296	0.7131	0.652642	−0.44915	−0.65263	0.609583	1		
Cr	0.787342	0.848058	0.849114	−0.37472	−0.60248	0.693215	0.883105	1	
Cs	0.853764	0.912344	0.879488	−0.41455	−0.41482	0.74014	0.772786	0.858595	1
Cu	0.141857	0.246413	0.296226	0.52429	0.698457	0.12266	−0.27746	−0.02177	0.114131

	Mn	Mo	Ni	Pb	Rb	Sr	Th	U	Zn
Mn	1								
Mo	0.481065	1							
Ni	0.210373	0.316607	1						
Pb	−0.488	−0.20803	0.411569	1					
Rb	−0.56975	−0.31429	0.520259	0.944351	1				
Sr	0.538248	0.153108	0.356052	−0.34347	−0.21933	1			
Th	−0.10669	−0.18714	−0.04475	0.540131	0.367571	−0.54395	1		
U	0.122168	−0.05963	0.394234	0.532161	0.436625	−0.26722	0.625634	1	
Zn	0.38357	0.409479	0.69224	0.355992	0.304885	0.360311	0.134593	0.299134	1
Zr	0.476976	−0.20018	−0.36986	−0.23342	−0.40052	0.148913	0.245982	0.031763	−0.05573

	Dy	Er	Eu	Ga	Gd	Hf	Hg	I	La	Li
Dy	1									
Er	0.997577	1								
Eu	0.981714	0.968127	1							
Ga	0.494031	0.489538	0.543945	1						
Gd	0.980695	0.967535	0.999409	0.566942	1					
Hf	0.75673	0.745503	0.741697	0.063628	0.730556	1				
Hg	0.235076	0.197344	0.259879	−0.16129	0.237575	0.373809	1			
I	−0.20961	−0.18727	−0.26807	−0.27074	−0.26339	−0.02107	−0.39104	1		
La	0.884325	0.861712	0.945922	0.740478	0.952633	0.576677	0.180194	−0.35144	1	
Li	0.297089	0.298252	0.329998	0.924788	0.354354	−0.21439	−0.17421	−0.41368	0.548062	1
Lu	0.985911	0.992389	0.955268	0.558873	0.957462	0.682789	0.11778	−0.21883	0.870414	0.385875

Continued

	Nd	Sc	Se	Sm	Tb	Tl	Tm	V	W	Y
Nd	1									
Sc	0.810976	1								
Se	0.990278	0.771752	1							
Sm	0.994341	0.763229	0.997067	1						
Tb	0.962579	0.688828	0.984838	0.984925	1					
Tl	0.597945	0.845339	0.589357	0.561856	0.51789	1				
Tm	0.885279	0.622757	0.932268	0.924842	0.971717	0.520386	1			
V	0.295874	0.223507	0.360218	0.33426	0.377923	0.508215	0.496258	1		
W	0.289256	−0.01002	0.280708	0.309326	0.338075	−0.16636	0.251548	−0.26891	1	
Y	0.863006	0.521766	0.914719	0.910799	0.965755	0.392585	0.985373	0.425888	0.349622	1
Yb	0.896614	0.671105	0.938846	0.930721	0.970142	0.567108	0.997286	0.50272	0.208592	0.971878

Table 3. Summary content of selected elements.

S/N	Element	Mean	Standard Deviation	S/N	Element	Mean	Standard Deviation
1	Al	395.70	559.25	26	Zr	66.27	34.65
2	Ca	1043.17	423.44	27	Dy	340.93	213.54
3	Fe	119.75	60.35	28	Er	169.60	103.13
4	K	257.67	193.75	29	Eu	126.51	89.57
5	Mg	229.42	97.67	30	Ga	282.46	205.27
6	Ag	0.95	0.28	31	Gd	465.00	320.82
7	As	70.55	21.78	32	Hf	3.40	2.05
8	Ba	5135.00	3201.93	33	Hg	1.60	1.71
9	Be	110.80	77.14	34	I	228.57	120.53
10	Br	551.93	302.70	35	La	1995.57	1468.90
11	Cd	1.82	0.92	36	Li	65.28	111.20
12	Ce	3935.71	4023.51	37	Lu	17.22	10.00
13	Co	2883.71	3403.35	38	Nd	2536.93	1974.73
14	Cr	225.21	223.75	39	Pr	623.86	505.07
15	Cs	4.44	2.84	40	Sc	174.35	172.57
16	Cu	648.29	184.91	41	Se	124.93	83.19
17	Mn	14268.57	5033.07	42	Sm	533.86	394.05
18	Mo	15.50	8.46	43	Tb	69.94	45.75
19	Ni	461.57	167.36	44	Tl	3.87	2.02
20	Pb	169.06	240.40	45	Tm	20.90	12.32
21	Rb	542.07	409.81	46	V	897.29	237.04
22	Sr	4426.43	2357.77	47	W	384.55	458.30
23	Th	191.07	117.52	48	Y	1740.50	1070.98
24	U	207.71	113.84	49	Yb	130.06	76.37
25	Zn	335.93	199.97				

related to Er (0.99), Eu (0.98), Gd (0.98) and Lu (0.98). Others with strong positive correlations include Tb-Sm (0.99), Yb-Sm (0.93) and Lu-Er (0.99). These strong positive correlations among elements suggest that chemical and physical factors control elements associations in parent materials and soil forming processes [25].

5. Conclusion

Soil geochemical studies to determine the background levels of trace and major elements in soils of MAUTECH Campus have been carried out. Based on trace and major element data, parent material and soil forming processes have a major influence on the chemical composition of the soil. The low content of trace and major elements in the soil corresponds with granite migmatites gneisses bordering the study area thus suggesting that the soil was derived from these granites with little contribution from the mafic gneisses. The data may have application to the identification of areas of trace elements deficiencies and trace elements toxicity for plant growth and may also be useful in soil genesis studies. Most importantly, the data may serve as a reference data in the assessment and monitoring of possible future environmental issues related to trace and/or major element contamination.

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