as the fact that the intensity of the heavy emissions in the areas is minimal compared to the other zones in Kaduna state. Fe was recorded as the element with exceptionally high concentrations (in thousands) in all the samples analyzed, this was not surprising since it is a ubiquitous element and a macro nutrient. Therefore, the iron levels found in this study may be an additive outcome of lithological or crustal origin and human influences. Iron could also be responsible for the deterioration of car bodies and the wear on crankshafts. The waste produced in the research area's auto workshops, which includes solvent, hydraulic fluid, used lubricants, metal construction work, metal welding, and iron bending, may be the cause of the soil's increased iron concentration. Ni, Ta, Au, Ga, Sn, U, and As were elements that were found in relatively low concentrations, which was to be expected given that several of them are rare earth elements. Leachates from used motor oils include high copper concentrations, lead, and antimony.

The average concentrations of the selected heavy metals in Kaduna north zone-V, Fe, Co, Ni and Zr had their maximum concentrations Kudan school; whilst, Cr, Mn, Cu, Ga and As maximum concentrations were recorded in Makarfi mechanical workshops. Th was detected only in Kudan and Soba schools while U, Ir, Pt and Au were detected only Kudan School.

Table 1.0: Heavy metals concentrations (ppm) for samples from Kaduna north zone

	KUDAN SCH	SOBA SCH	MKRF MECH	LERE MECH	BGRD
HM	**Aver± S.D**	**Aver± S.D**	**Aver± S.D**	**Aver± S.D**	**Aver± S.D**
V	170.7±12.6	67.0±4.5	106.6±22.0	61.0±8.1	124.7±2.5
Cr	77.3±18.4	56.5±1.7	104.0±38.2	67.0±11.2	18.7±5.2
Mn	735.7±64.8	1110.0±146.4	2809.5±793.6	1230.2±73.4	4998.0±24.6
Fe	367638.8±232.4	25433.6±132.7	51317.5±287.2	156.3±108.6	440.5±32.8
Co	250.6±63.0	BDL	BDL	BDL	BDL
Ni	185.0±17.0	BDL	13.7±23.7	BDL	0.0
Cu	0.2±0.0	13.1±2.9	105.4±49.1	100.4±23.0	0.4±0.1
Zn	99.3±11.9	205.5±13.7	307.2±124.3	563.0±184.6	80.1±8.2
Ga	27.7±11.0	7.6±1.6	23.1±23.1	9.1±2.3	2.7±0.6
As	26.4±1.8	BDL	90.0±60.0	BDL	9.5±1.8
Sn	19.4±5.8	BDL	BDL	BDL	BDL
Hf	50.4±42.9	BDL	BDL	BDL	BDL
Ta	BDL	36.4±3.0	78.5±47.0	36.0±5.9	0.0±0.0
Ir	0.2±0.0	BDL	BDL	BDL	BDL
Pt	7.9±10.9	BDL	BDL	BDL	BDL
Au	8.3±7.3	BDL	BDL	BDL	BDL
Pb	47.9±27.0	124.8±22.4	1641.9±2363.7	BDL	20.4±2.7
Th	35.8±11.3	2.0±3.5	BDL	BDL	0.0
U	15.2±5.2	BDL	BDL	BDL	BDL
Zr	4608.8±601.1	2520.6±75.8	1407.7±717.6	BDL	7194.5±21.9

Ni was only detected in Kaduna north and Kaduna south schools in Kaduna central zone as 0.2ppm throughout. As was not detected in Kaduna north school. Co, Ir, Pt and Au were not detected in all the Giwa and Igabi mechanical workshops samples. Fe, Zr, Mn and Zn were noted to have comparatively higher concentrations compared to the other heavy metals considered in this work. Sn, Hf, V, Fe, Co, Ni, Ga, Th and Zr were observed to be maximum in samples from Chikun schools; Cr, As and T in Giwa mechanical workshop; Mn, Cu, Zn and Pb in Igabi mechanical garage. The least concentrations of the heavy metals were found to occur in: Cu and Ta in Kaduna north school, Mn, Zn, Pb in Chikun school, V in Kaduna south school, Cr, Hf, Co, Ni, As, Sn and Th in Igabi mechanical workshop. Similarly, Fe was recorded as the element with exceptionally high concentrations (in thousands) in all the samples analyzed, this was not surprising since it is a ubiquitous element and a macro nutrient. Elements observed to be of relatively low concentrations were Ni, Ga, Ta, Au, Sn, U, As which was expected since some of them are rare earth elements.

In the Kaduna south zone, Co, As, Sn, Hf, Ir, Pt, Au and U were not detected in all the Kachia local government

school samples. The average concentration of the selected heavy metals in the sampling area under this zone was found to have the highest values thus- V, Cu, U in Kachia Mechanical workshop; Cr, Mn, Pb in Kachia school; Fe, Ga, As, Hf, Co, Ni, Zn, Ta, Th in Kauro school and Pt, Au and Zr in Kagarko school. V, Cr, As, Co, Ni, Cu, Zn, Sn, Hf, Ta, Pt, Au and Za had their least concentrations in Kagarko school while Mn, Ir, Pt, Au, Pb had theirs in Kauro school.

The world health organization (WHO) and the food and agriculture organization (FAO) have stipulated the thresholds limits of heavy metals concentration in soil thus: Zn-300 ppm, As-20 ppm, Pb-100 ppm, Cu-100 ppm, Cd-3 ppm, Cr-100 ppm,Co-50 ppm and Ni-50 ppm. The average concentrations obtained in this work for each heavy metal in both the schools and the auto mechanic workshops were compared in the form of ratio (quotient) with the threshold limits recommended by WHO/FAO. It was observed that As, Pb, Cd, Co, Ni were of serious health concern because in almost all the zones, there average concentrations replicates the threshold provided by WHO/FAO. The high levels of Pb in these locations proved to the overall high degree of environmental pollution with this metal and were easily linked in large part to the activities in these locations. The quantity of waste oil increases these levels of Pb, the presence of automobile fumes, and the outdated motor batteries that are carelessly abandoned by nearby battery chargers and auto mechanics. The amount of heavy metals in the soil at the auto-mechanic workplace in the research region varies according to how long the workshop has been operating there. The quantity of waste oil may increase these levels of Pb, the presence of automotive fumes, and the indiscriminate disposal of old motor batteries by battery chargers and auto mechanics in these areas. The studied auto-mechanic workshop could also be identified as a playground or close to residential areas where children play freely, and for children, ingestion of contaminated soil is the most significant pathway to Pb exposure. As a result, concern about Pb concentrations in auto-mechanic workshop soils may arise primarily due to this. Additionally, schools and auto repair shops had higher concentrations of heavy metals than the surrounding area did, including Cr, Cu, Zn, As, Pb, V, Mn, Fe, Ga, and Ta.

Table 2.0: Heavy metals concentrations (ppm) for samples from Kaduna central zone.

	K/NORTH SCH	CHIKUN SCH	K/SOUTH SCH	GIWA MECH	IGABI MECH	
HM	**Aver± S.D**	**Aver± S.D**	**Aver± S.D**	**Aver± S.D**	**Aver ±S.D**	**BGRD**
V	60.8±9.9	174.8±78.3	47.0±8.9	59.3±15.4	75.7±34.3	32.8±2.8
Cr	63.6±6.1	68.6±2.0	70.1±26.8	88.5±9.8	33.5±4.8	12.3±4.2
Mn	320.4±8.9	260.4±50.2	283.4±58.1	1845.8±334.6	2061.4±445.2	808.5±20.7
Fe	38718.8±6205.2	60178.8±202184	30478.8±7950.5	29978.8±2714.8	34353.4±4889.3	8645.5±212
Co	113.6±16.0	177.2±34.3	101.8±7.6	BDL	0.2±0.0	BDL
Ni	0.2±0.0	41.0±15.6	0.2±0.0	BDL	0.1±0.1	12.3±3.6
Cu	10.5±5.0	23.8±1.6	17.5±14.6	32.4±10.9	42.9±14.9	4.1±2.3
Zn	168.2±74.5	84.1±57.1	148.2±41.4	224.2±24.9	234.8±62.8	56.3±4.8
Ga	13.0±3.1	31.2±13.8	12.4±1.4	4.1±2.6	10.4±2.3	6.4±1.6
As	ND	5.1±4.2	2.5±3.3	10.6±16.6	0.1±0.1	0.0±0.0
Sn	15.3±2.9	17.2±1.6	14.3±1.3	0.2±0.0	0.2±0.0	BDL
Hf	41.1±11.9	50.3±8.0	33.8±2.4	0.2±0.0	0.2±0.0	BDL
Ta	0.2±0.0	7.9±10.8	0.2±0.0	147.9±195.6	25.3±16.3	23.7±2.2
Ir	8.3±2.5	8.2±1.7	6.2±5.3	BDL	BDL	BDL
Pt	6.1±8.3	11.2±1.8	4.9±6.6	BDL	BDL	BDL
Au	5.5±7.5	8.0±1.5	6.1±5.2	BDL	BDL	BDL
Pb	67.1±2.9	42.9±7.7	67.5±6.1	133.4±53.3	577.8±352.7	73.5±8.8
Th	20.8±5.7	31.3±8.1	14.3±2.6	BDL	0.0±0.0	0.0±0.0
U	10.7±2.5	10.1±2.2	10.7±1.5	ND	ND	ND
Zr	3112.8±171.7	3270.8±180.4	2872.8±185.6	351.4±144.1	2741.0±1413.1	3882.8±86.4

Key: HM-heavy metal, BDL-Blow detection Limit, sch-school vicinity, K/North- Kaduna north L.G, K/south- Kaduna south L.G, mech-mechanic workshop and BGRD-background.

Table 3.0: Heavy metals concentrations (ppm) for samples from Kaduna south zone

	KACHIA MECH	KACHIA SCH	KAURO SCH	KGARKO SCH	
HM	**Aver± S.D**	**Aver± S.D**	**Aver± S.D**	**Aver± S.D**	**BGRD**
V	103.5±20.6	89.9±29.3	76.4±52.5	43.7±1.8	24.0±2.8
Cr	80.0±22.4	94.1±19.8	85.9±44.5	42.4±13.0	23.0±8.6
Mn	434.3±182.3	2150.9±640.9	353.3±122.7	569.4±40.0	709.2±82.6
Fe	58059.9±21449.4	35058.9±8692.0	671798.8±273511.9	31178.8±7556.0	7373.0±122.
Co	181.9±78.1	BDL	191.0±37.4	115.7±22.2	BDL
Ni	13.3±16.9	8.4±14.5	18.6±4.1	0.2±0.0	15.2±3.2
Cu	28.9±14.1	39.1±5.9	14.9±6.7	12.9±2.3	1.9±0.6
Zn	204.9±49.8	169.8±87.3	247.0±49.1	162.0±21.6	33.1±2.8
Ga	22.4±15.5	10.4±5.3	29.8±7.5	14.6±4.5	2.7±0.3
As	11.2±1.9	BDL	301.8±129.4	3.6±4.8	2.5±0.6
Sn	21.3±10.7	BDL	37.0±15.3	14.5±2.9	BDL
Hf	47.5±11.6	BDL	301.0±92.1	40.0±3.8	BDL
Ta	30.8±2.6	57.3±24.6	369.9±1.8	0.2±0.0	3.4±0.8
Ir	18.6±13.2	BDL	0.2±0.0	7.7±2.1	BDL
Pt	7.3±4.4	BDL	0.2±0.0	7.3±1.6	BDL
Au	8.7±8.7	BDL	0.2±0.0	7.9±1.5	BDL
Pb	65.8±47.9	102.8±47.4	41.2±1.2	60.9±8.2	62.2±10.3
Th	23.3±13.9	8.8±12.4	952.2±651.4	15.5±1.3	BDL
U	27.6±6..6	BDL	7.5±6.4	6.3±1.9	BDL
Zr	2835.9±228.9	781.2±112.6	2167.8±1386.7	3132.8±54.4	BDL

Key: HM-heavy metal, BDL-Blow detection Limit, sch-school vicinity, mech-mechanic workshop and BGRD-background.

Correlation coefficients for heavy metals concentrations in the vicinity of schools and auto mechanic workshops

Table 4 presented the Pearson correlation coefficients between different pair of heavy metals in Kaduna north zone. Where positive correlation exists, it is an indication that the elements are from the same source and, negative correlation indicates the element are from different sources. Some of the heavy metals detected in this Zone were observed to have strong positively correlation with each other thus; Cr/Cu (0.75), Cr/Zn (0.84), Cr/Ga (0.93), Cr/As (0.84), Cr/Ta (1.00), Fe/Co (1.00), Fe/Ni (0.99), Cu/Zn (0.99), Cu/As (0.81), Cu/Pb (1.00), Zn/As (1.00), Zn, /Ta (0.88), Ga/As (1.00), Ga/Ta (0.88), Ga/Pb (0.99) and As/Ta (0.90). On the other hand, there was significantly strong negative relationship between: V/Cr (-0.8), Cr/Mn (-0.86), Mn/Co (-0.71), Mn/Ni (-0.75), Mn/Ta (-0.81), V/Cu (-1.00), V/Zn (-1.00), V/As (-1.00) and V/Pb (-1.00). The correlation coefficients clearly indicated that increase in Cr is associated with the increase Cu, Zn, Ga, As and Ta; increase in Fe is associated with the increase in Co and Ni; increase in Cu is associated with increase in Zn, As and Pb. On the other hand, increase in V concentration is associated with decrease in As, Pb, Zn, Cu and Cr and increase in Mn concentration is associated with decrease in Co, Ni and Ta.

Pearson correlation coefficients among the heavy metals in Kaduna central zone were presented in table 5. Some of the heavy metals detected in this Zone were observed to have strong positively correlation with each other thus; Cr/Fe (0.98), Cr/Cu (0.73), Cr/Zn (0.77), Cr/As (0.93), V/Cr (0.94), V/Fe (0.99), V/Ga (0.86), V/As (0.75), Mn/Cu (0.76), Mn/Zn (0.72), Mn/Pb (0.96), Fe/Co (0.75), Fe/Ga (0.79), Fe/As (0.83), Cu/As (0.93), Cu/Ta (0.80), Cu/Pb (0.90), Zn/As (0.95), Zn/Ta (0.76), Zn/Pb (0.88) and Ta/Pb (0.98). On the other hand, there was significantly strong negative relationship between: Mn/Co (-0.74), Mn/Ni (-0.98), Mn/Ga (-0.70), Ni/Cu (-0.88), Ni/Zn (-0.85) and Ni/Ta (-0.99). The correlation coefficients clearly indicated that increase in Cr is associated with the increase Fe, Cu, Zn and As ; increase in Fe is associated with the increase in Co, Ga and As; increase in Cu and Zn are associated with increase in Ta, As and Pb. On the other hand, increase in Mn concentration is associated with decrease in Co, Ni, Ga and increase in Ni concentration is associated with decrease in Zn and Ta.

Pearson correlation coefficients among the heavy metals in Kaduna south zone were presented in table 6. Some of the heavy metals detected in this Zone were observed to have a strong positively correlation with each other thus; V/Cr (0.94), V/Co (0.96), V/Cu (0.98), V/Zn (0.93), V/Ga (0.97),Cr/Cu (0.99),Cr/Ga (0.99), Cr/Pb 90.87), Mn/Fe (0.77), Mn/As (0.86), Mn/Ta (0.78), Fe/As

(0.99), Fe/Pb (0.91),Co/Pb (0.84), Cu/Zn (0.98),Cu/Pb (0.79), Zn/Ga (0.99), Zn/Pb (0.89), Ga/Pb (0.81), As/Ta (0.99), As/Pb (0.84) and Ta/Pb (0.91) On the other hand, there was significantly strong negative relationship between: Mn/Ni (-0.71), Ni/As (-0.97), Ni/Ta (-0.99) and Ni/Pb (-0.95). The correlation coefficients clearly indicated that increase in V is associated with the increase Cr, Co, Cu, Zn and Ga ; increase in Cr is associated with an increase in Cu, Ga and Pb; increase in Fe is associated with increase in As and Pb and, increase in Cu is associated with increase in Zn and Pb. On the other hand, increase in Mn concentration is associated with decrease in Ni and increase in Ni concentration is associated with decrease in As, Ta and Pb.

Table 4.0: Pearson correlation matrix for Kaduna north zone.

	V	Cr	Mn	Fe	Ni	Cu	Zn	Ga	As	Ta	Pb
V	1.00										
Cr	**-0.80**	1.00									
Mn	0.38	**-0.86**	1.00								
Fe	0.44	0.19	-0.66	1.00							
Co	0.38	0.25	**-0.71**	**1.00**							
Ni	0.32	0.31	**-0.75**	**0.99**	1.00						
Cu	**-1.00**	**0.75**	-0.31	-0.51	-0.39	1.00					
Zn	**-1.00**	**0.84**	-0.44	-0.38	-0.26	**0.99**	1.00				
Ga	-0.53	**0.93**	-0.99	0.53	0.63	0.47	0.58	1.00			
As	**-1.00**	**0.84**	-0.45	-0.37	-0.25	**0.99**	**1.00**	0.59	1.00		
Ta	-0.85	**1.00**	**-0.81**	0.09	0.22	**0.81**	**0.88**	**0.90**	**0.89**	1.00	
Pb	**-1.00**	0.74	-0.29	-0.52	-0.41	**1.00**	**0.99**	0.45	**0.99**	0.80	1.00

Table 5.0: Pearson correlation matrix for Kaduna central zone.

	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	As	Ta	Pb
V	1											
Cr	**0.94**	1.00										
Mn	-0.23	0.11	1.00									
Fe	**0.99**	**0.98**	-0.10	1.00								
Co	**0.83**	0.59	**-0.74**	**0.75**	1.00							
Ni	0.02	-0.31	**-0.98**	-0.11	0.58	1.00						
Cu	0.46	**0.73**	**0.76**	0.57	-0.12	**-0.88**	1.00					
Zn	0.51	**0.77**	**0.72**	0.62	-0.06	**-0.85**	**1.00**	1.00				
Ga	**0.86**	0.64	-0.70	**0.79**	**1.00**	0.53	-0.06	0.00	1.00			
As	**0.75**	**0.93**	0.47	**0.83**	0.24	-0.65	**0.93**	**0.95**	0.30	1.00		
Ta	-0.17	0.17	**1.00**	-0.03	-0.69	**-0.99**	**0.80**	**0.76**	-0.65	0.53	1.00	
Pb	0.03	0.37	**0.96**	0.16	-0.54	**-1.00**	**0.90**	**0.88**	-0.48	0.69	**0.98**	1.00

Table 6.0: Pearson correlation matrix for Kaduna south zone.

	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	As	Ta	Pb
V	1.00											
Cr	**0.94**	1.00										
Mn	-0.38	-0.05	1.00									
Fe	0.29	0.59	**0.77**	1.00								
Co	**0.96**	**1.00**	-0.11	0.55	1.00							
Ni	-0.38	-0.67	**-0.71**	-1.00	-0.63	1.00						
Cu	**0.98**	**0.99**	-0.20	0.47	**1.00**	-0.55	1.00					
Zn	**0.93**	**1.00**	-0.02	0.62	**1.00**	-0.69	**0.98**	1.00				
Ga	**0.97**	**0.99**	-0.16	0.50	**1.00**	-0.58	**1.00**	**0.99**	1.00			
As	0.14	0.46	**0.86**	**0.99**	0.42	**-0.97**	0.33	0.49	0.37	1.00		
Ta	0.27	0.58	**0.78**	**1.00**	0.53	**-0.99**	0.46	0.60	0.49	**0.99**	1.00	
Pb	0.66	**0.87**	0.44	**0.91**	**0.84**	**-0.95**	**0.79**	**0.89**	**0.81**	**0.84**	**0.91**	1.00

Clustering analysis for heavy metals concentrations in the vicinity of schools and auto mechanic workshops

The cluster analysis was applied to detect spatial similarity for grouping of the heavy metals concentrations in the premises of schools and auto mechanic workshops. The concentration of the various heavy metals in each of the samples studied were treated using cluster analysis (Ward's Method). The result of this treatment is presented in figure 1 in the form of a dendrogram consisting of four (4) different groups with an outlier clearly indicated.

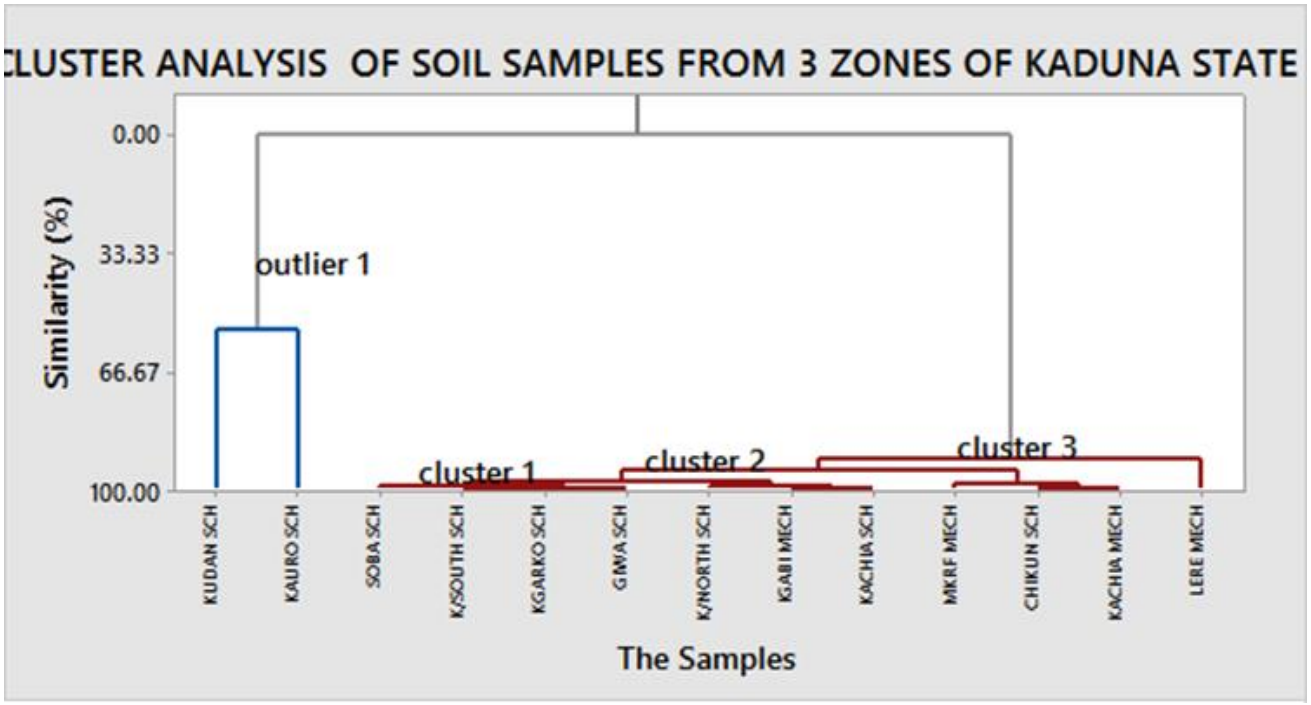

Fig 2.0: Cluster analysis with outliers

Because this outlier 1 has clearly affected proximity in measurement and has created obscure clustering tendencies, it was removed. The removal of this outlier has yielded a better grouping as shown in the next dendrogram in figure 2.

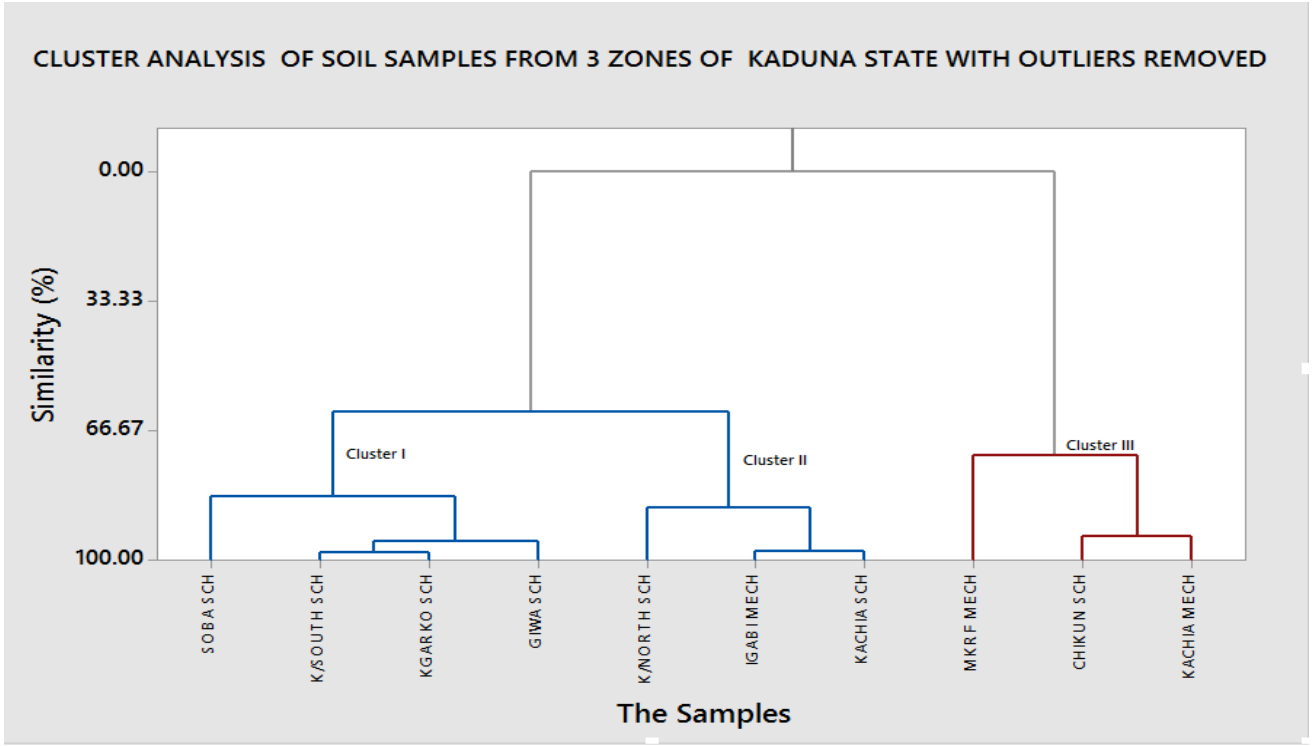

Fig 3.0: Cluster analysis without outliers

Three distinctive clusters exist, each containing samples with closely similar elemental composition which reflects similarity in the samples from those sites. Cluster I consists of samples from Soba, Kaduna South, Kagarko, and Giwa schools. It is worthy to note that Cluster I consists of samples from Kaduna North; South; and Central Zone. This suggest that soil from this location shows homogeneity.

Cluster II on the other hand consists of samples from Kaduna central and south zone, It consist samples from Kaduna north schools, Igabi mechanics and Kachia schools. while Cluster III consists of samples from Kaduna North; South; and Central Zone, consisting of samples from Makarfi mechanics, Chikun schools and Kachia mechanics. It can be seen from the dendrogram that the cluster analysis results were in agreement with the reported heavy metals pollution levels.

CONCLUSION

Heavy metals from soil samples around schools and auto mechanic workshops in Kaduna state at varying concentrations were determined. Majority of the elements (>80%) detected and analysed are not of interest in toxicity assessment and some are rare earth elements. These heavy metals levels may be attributed to the natural composition of the soil as well as the fact that the intensity of the heavy emissions is variable. The concentrations of As, Pb, Cd, Co, Ni were of serious health concern considering that in almost all the zones in Kaduna state, the average concentrations replicate the threshold provided by WHO/FAO. It is therefore concluded that it is not safe for children to be playing around the vicinity of schools located around auto-mechanic workshops and highways.

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