

Trace Elements Composition of *Achatina achatina* Samples from the Madina Market in Accra, Ghana

¹A.K. Anim, ¹M. Ackah, ¹J.R. Fianko, ¹L. Kpattah, ¹J. Osei, ²Y. Serfor-Armah and ¹E.T. Gyamfi

¹Nuclear Chemistry and Environmental Research Center, National Nuclear Research Institute, Ghana Atomic Energy Commission, P.O. Box LG 80, Legon, Accra, Ghana

²Graduate School of Nuclear and Allied Sciences, University of Ghana, Box AE 1, Legon, Accra, Ghana

Abstract: This research was carried out to assess the composition and sources of trace elements in seventeen *Achatina achatina* samples obtained from the Madina Market. The trace elements were analyzed using Atomic Absorption Spectrophotometer (VARIAN AA 240 FS) and Instrumental Neutron Activation Analysis (INAA). The highest mean Concentration, 2240.5 mg/kg was measured for chlorine while the least mean concentration, 0.13 mg/kg was measured for Magnesium. The mean elemental Concentrations were in the order Cl>Ca>Na>Al>Fe>Cu>Zn>Ni>Mn>K>V>Mg. Pearson Correlation matrix, Principal Component(PC) Analysis and Hierarchical Cluster Analysis (CA) shows varying sources of the trace elements, however there is great interrelationships regarding their sources. The correlation matrix at 99% confidence level loaded the components Al-Fe-Mn, Ca-Cl-Mg, Cl-Mg-Na, Fe-V, and Ni-V. PC1 which loaded Ca, Cl, Mg, Na, Ni, and V agrees very well with CA1. A similar trend is shown in CA2 and PC2 with Al, Fe and Mn loadings. The geology of the original habitat of the samples which is characterized by Shales, Quartzite and Feldspathic sandstone together with anthropogenic inputs from fertilizers, pesticides, and herbicides have been identified as the possible sources of the elements. All the elements analysed in the samples were essential elements.

Key words: Anthropogenic, cluster analysis, concentration, correlation, geology and principal component

INTRODUCTION

Snails belong to the class of animal kingdom called mollusk and they can be found both in water and on land. *Achatina achatina*, common name the giant Ghana snail, also known as the giant tiger land snail, is a species of very large, air-breathing land snail, or more technically a terrestrial pulmonate gastropod mollusk in the family Achatinidae. *Achatina achatina* are the largest land snails in the world and are a widely sought after species, due to their size, distinct markings and lack of availability. They are more difficult to breed than other African snails. Average adult shell length is 18 cm, with an average diameter of 9 cm. In exceptional cases the shell can grow to be 30 cm long but this is very unlikely, especially in captivity. Large ones may achieve a shell length of 22 cm.

Snails constitute an important source of protein for most people in Africa and elsewhere in the world. Apart from serving as a source of protein, they are used for medicinal purposes especially, their shell in many parts of the world. Ghana consumes over 15,000 ton of snails a year. Figures available indicate that Ghana exported 620 kg of snails in 1994 to the Netherlands and 1,050 kg to the USA (Ghana web.com).

According to Tsu-Chang *et al.* (2001), mollusks can accumulate numerous pollutants from natural environment in quantities that are orders of magnitude higher than the background levels. In addition to that the levels of heavy metals in mollusks and other invertebrates are often considerably higher than in other constituents of the marine environment (Hamed and Emara, 2006). Compared to sediments, mollusk exhibit greater spatial sensitivity and therefore, is the most reliable tool for identifying sources of biologically available heavy metal contamination (Goldberg *et al.*, 1978; Koide *et al.*, 1982; Hamed and Emara, 2006). Generally, mollusks accumulate metals in their tissues in proportion to the degree of environmental contamination which signifies their importance as bio-monitors of heavy metal pollution (Goldberg *et al.*, 1983; Elder and Mattraw, 1984; Bu-Olayan and Subrahmanyam, 1997).

Cowie (2006) observed that land snails are considered to be one of the worst pests found in the tropics. The source of the snails sold on the Madina market is the Akwapim hills. The *Achatina achatina* are handpicked directly from the wild of the Akwapim forest by farmers and brought on the market for sale in cane baskets. The geology of the Akwapim area is underlain by

Table 1: Nuclear data for the elements of interest quantified as short lived. (ti:td:tc = 2:1-10:10 min).

Element	Isotope (% Abund)	Nuclide	Cross-section (b)	Half-life	Gamma-ray energies (keV)
Al	²⁷ Al(100)	²⁸ Al	0.232	2.24 min	1778.9
V	⁵¹ V(99.75)	⁵² V	4.88±0.04	3.76 min	1434.1
Ca	⁴⁸ Ca(0.187)	⁴⁹ Ca	1.1±0.2	8.70 min	3084.4
Cl	³⁷ Cl(24.23)	³⁸ Cl	0.428±0.005	37.3 min	1642.4, 2167.5

Table 2: Nuclear data for the elements of interest quantified as medium lived. (ti: td: tc = 1 h: 24 h: 10 min).

Element	Isotope (% Abund.)	Nuclide	Cross-section (b)	Half-life	Gamma-ray energies (keV)
K	⁴¹ K(6.73)	⁴² K	1.46±0.03	12.36 h	1524.7
Na	²³ Na(100)	²⁴ Na	0.530±0.005	15.02 h	1368.6, 2754.1

thin-bedded shales, quartzite and feldsphalthic sandstone. The Akwapim forest is suitable for the cultivation of food and cash crops, notably; plantain, cassava, cocoa and vegetables. The farmers therefore use agrochemicals on their farms. There is therefore a possibility of contamination of the area with anthropogenic sources of heavy metals resulting from the use of agrochemicals and other farm practices. The habitat of the snail samples in this study, being the forest regions particularly the Akwapem forest gives concern for bio-monitoring. This study therefore, considers the assessment of trace elements in the *Achatina achatina* sold on the Madina market of Ghana, since the snails serve as a major source of protein.

METHODOLOGY

This research work was carried out in the laboratories of the Nuclear Chemistry and Environmental Research Center, National Nuclear Research Institute of the Ghana Atomic Energy Commission between September 2010 and February 2011.

Sampling area: Madina market is located in the Ga East municipal assembly of the Greater Accra region in Ghana. It is the largest market center in the municipality, hosting a market complex which provides services to traders in and around Madina. The market functions daily with Wednesdays and Saturdays as major market days. The strategic location of the market coupled with good accessibility has facilitated its growth leading to congestion and spill-off onto the nearby roads. Most dwellers in and around Accra get their supply of *Achatina achatina* from the Madina market.

Sample collection and preparation: The samples were captured in the forests of the Akwapim Mountains, Ghana and brought to the Madina market for retail. Fifteen composite samples of *Achatina achatina* were collected from fifteen sellers on the Madina market. The samples were packaged in polyethylene bags and transported on ice to the laboratory. The samples were rinsed with deionised water to remove dirt and debris of leaves and other foreign materials. Each composite sample was prepared by homogenizing five species of *Achatina*

achatina collected at each selling point. The samples were freeze dried and ground using a mortar and pestle to obtain powdered homogenous samples. Parts of the samples were prepared for Instrumental Neutron Activation Analysis (INAA) for the determination of Al, Ca, Cl, V, K and Na. The other part of the powdered samples were subjected to acid digestion and analyzed using atomic absorption spectrophotometer (VARIAN AA240 FS) for the determination of Cu, Zn, Fe, Mg, Mn, and Ni.

Instrumental neutron activation analysis: Two gram (2 g) of each powdered composite sample were weighed unto a pre-cleaned polyethylene sheet, wrapped and heat sealed. The sealed samples were then packed into 7 mL polyethylene vials and the vials were heat sealed for irradiation for determination of total Al, Ca, Cl, V, K and Na content by INAA. Three reference materials namely NIST-SRM 1566b (Oyster tissue), CRM-DORM-2 (Dogfish muscle) and NIST-SRM 1547 (Peach leaves) were prepared and packaged in a similar manner as the samples. Samples and standards were prepared and analyzed in triplicates. The samples were irradiated using the Ghana Research Reactor - 1 (GHARR-1) with a thermal flux of 5×10^{11} n/cm² when the reactor was operated at 15 KW. The elements of interest were assayed using different timing parameters to optimize detection and measurement. Al, Ca, V, and Cl were typically determined in the samples after 2 min irradiation, 1-10 min decay and 10 min counting period (ti: td : tc = 2: 1-10: 10 min). For Na and K, the samples were irradiated for 1 h and allowed to decay for 24 h and counted for 10 min. Nuclear data [IAEA-TECDOC-564, 1990] for these nuclides are provided in Table 1 and Table 2. The irradiated samples were counted by using a computer based gamma-ray spectroscopy system, consisting of an N-type high purity Germanium (HPGe) detector model GR2518 mounted on liquid nitrogen as a coolant, high voltage power supply model 3103, Spectroscopy amplifier model 2020, ACCUSPEC multi-channel analyzer emulation software card (all manufactured by Canberra industries inc.), and a micro computer for data acquisition, evaluation and analysis. The qualitative and quantitative analyses of the nuclides were achieved using the MAESTRO 32 software. The

Table 3: Mean concentration in mg/kg of trace elements in the *Achatina achatina* samples analyzed

Al	Ca	Cl	Fe	Cu	K	Mg	Mn	Na	Ni	Zn	V
13.32±1.04	586.78±2.16	2584.93±10.60	51.24±3.34	22.61±2.61	0.56±0.02	0.16±0.02	1.31±0.09	511.17±6.13	1.63±0.86	21.26±2.51	0.07±0.01
44.09±1.15	543.68±9.15	2382.84±8.12	61.08±2.09	8.61±1.81	0.19±0.01	0.13±0.01	2.55±0.14	533.35±2.09	0.94±0.05	14.53±4.14	0.14±0.06
29.50±1.01	360.93±1.19	2303.98±8.40	50.59±2.27	25.15±1.41	0.59±0.02	0.09±0.01	1.14±0.91	500.46±10.12	2.45±0.88	13.96±0.81	0.07±0.02
50.76±0.61	479.38±2.01	1855.75±10.18	55.41±1.19	19.97±4.21	0.53±0.01	0.12±0.03	1.29±0.55	321.02±6.10	2.33±0.18	12.59±1.18	0.11±0.01
34.51±0.44	353.37±4.12	1621.80±4.91	57.41±0.98	13.49±3.23	0.51±0.02	0.09±0.01	1.08±0.61	334.31±4.12	0.49±0.66	25.86±2.26	0.12±0.02
52.72±0.61	451.75±6.01	2127.02±5.12	49.73±4.12	22.46±0.91	0.62±0.01	0.10±0.01	0.66±0.08	443.29±5.44	1.92±0.09	13.78±1.08	0.11±0.01
49.27±3.15	566.96±2.09	1949.57±9.21	54.38±1.91	17.64±1.16	0.58±0.03	0.13±0.02	0.93±0.02	358.93±4.97	1.63±0.88	15.54±2.31	0.07±0.02
38.23±2.63	476.86±10.14	2432.06±11.40	45.35±2.33	25.64±3.26	0.60±0.02	0.13±0.01	1.18±0.09	551.11±6.52	2.04±1.02	13.99±1.19	0.05±0.01
38.37±1.60	384.96±2.71	2053.60±8.16	57.29±2.01	26.91±1.09	0.62±0.01	0.12±0.01	1.18±0.08	403.69±5.07	1.27±0.01	24.82±2.19	0.08±0.01
134.82±2.71	883.65±6.16	3657.06±10.60	84.05±1.09	17.88±0.16	0.63±0.01	0.23±0.02	1.06±0.04	460.56±8.23	3.43±1.01	16.79±1.34	0.55±0.02
126.21±4.12	498.43±3.41	2603.02±10.66	84.92±3.16	31.09±2.24	0.55±0.02	0.14±0.02	1.16±0.21	430.21±4.39	2.86±0.05	16.31±0.98	0.35±0.01
237.98±11.21	622.53±6.02	2650.20±9.62	232.86±6.03	28.12±4.21	0.59±0.03	0.17±0.01	1.99±0.07	529.34±8.01	3.88±0.05	14.06±2.10	0.84±0.02
307.05±5.10	457.45±4.97	2068.21±9.14	102.32±4.87	9.85±3.13	0.56±0.01	0.13±0.01	3.92±0.93	464.28±6.72	1.67±0.01	14.82±1.67	0.07±0.01
55.73±2.24	316.82±2.67	1756.41±10.40	105.19±2.67	20.76±4.31	0.53±0.04	0.09±0.01	0.49±0.82	320.25±2.94	0.08±0.02	10.75±0.70	0.02±0.01
63.00±4.23	599.86±5.01	2489.89±9.17	64.16±3.12	16.91±1.21	0.69±0.02	0.17±0.02	0.31±0.05	538.11±6.11	3.31±0.10	51.03±1.04	0.07±0.01
81.60±3.17	587.66±7.12	2348.87±12.10	51.08±1.09	26.39±1.56	0.63±0.01	0.16±0.02	0.89±0.03	456.09±5.14	0.04±0.01	14.86±3.10	0.14±0.01
24.70±1.96	489.45±6.12	1742.47±9.81	35.41±3.38	13.49±3.91	0.47±0.02	0.12±0.01	0.42±0.05	328.05±4.19	0.57±0.06	7.91±0.15	0.05±0.01

Table 4: Descriptive statistics of analytical results

Element	N	Range (mg/kg)	Mean (mg/kg)	SE
Al	17	13.32- 307.05	81.29	19.36
Ca	17	316.82- 883.65	509.44	32.38
Cl	17	1621.80- 3657.06	2240.5	1.16
Fe	17	35.41- 232.87	73.09	11.06
Cu	17	8.61- 31.09	20.41	1.59
K	17	0.19- 0.69	0.56	0.03
Mg	17	0.09- 0.23	0.13	0.01
Mn	17	0.31- 3.92	1.27	0.21
Na	17	320.25- 551.11	440.25	20
Ni	17	0.04- 3.88	1.79	0.28
Zn	17	7.91- 51.03	17.82	2.35
V	17	0.02- 0.84	0.17	0.05

quantitative analysis was done by converting the counts as area under the photo peak of the radionuclide by the comparator method.

Atomic absorption spectrometry: Hydrogen peroxide (MERCK, Germany) and Nitric acid (Sigma-Aldrich, Germany) were used for digestion. 0.5 g of powdered composite sample were weighed into Teflon beakers and 6 ml analytical grade HNO₃ and 1 mL H₂O₂ added. The digestion was achieved as described by Anim *et al.* (2011). The completely digested samples were allowed to cool to room temperature and the volume made up to 20 mL. Working standards of iron, magnesium, manganese, copper, zinc, and nickel (Spectrascan, Teknolab AB, Sweden) were prepared by diluting concentrated stock solutions of 1000 mg/L in de-ionised water. The digested samples were analyzed in triplicate, using a flame atomic absorption spectrophotometer (VARIAN AA240 FS). The blanks and calibration standard solutions were also analysed in a similar manner as the samples.

RESULTS AND DISCUSSION

Elemental burden: The analytical results of the snail samples are shown in Table 3. Table 4 shows a statistical summary of the results. The least concentration, 0.02 mg/kg was recorded for V while the highest concentration, 3657.06 mg/kg was recorded for Cl. The mean concentrations ranged between 0.13 mg/kg (Mg) to 2240.5 mg/kg (Cl).

The geology of the Akwapim area is characterized by thin-bedded shales, quartzite and feldspathic sandstone. Shales are rich in Mg, Al, K, Ca and Fe while feldspar is rich in K, Al and Na. Adriano (2001), noted that even though, levels of trace elements have been dropping since the mid 1970s in developed countries due to regulations, emissions and environmental accumulation will continue in developing countries that have no controls on trace metals. Nriagu (1984) also indicated that in many instances the inputs from anthropogenic sources exceed the contributions from natural sources several fold. It has therefore become evident that human activities have altered the global biogeochemical cycles of trace elements. Parent rock and metallic minerals dominate the natural sources while anthropogenic sources range from agriculture (fertilizers, animal manures, pesticides etc), metallurgy (mining, smelting, metal finishing etc), energy production (leaded gasoline, battery manufacture, power plants etc) and microelectronics to waste/scrap disposal (Adriano, 2001). Intensive land use stresses the land with continuous inputs and often heavy inputs of agrochemicals.

All the elements analyzed are of significance to human growth. Notably, high mean concentration, 2240.5 mg/kg was measured for Cl. This indicates its varying sources to the ecosystem. Apart from natural levels in plants and the soil, other inputs may be from agrochemicals such as the usage of chlorine containing pesticides. Chlorine in the form of chloride is essential for the proper distribution of CO₂ and the maintenance of

osmotic pressure in human tissues. It prevents the building of excessive fat and autointoxication (www.vitaminsdiary.com). Deficiency causes impaired digestion of foods and derangement of fluid levels in the body.

Fe forms part of haemoglobin, which allows oxygen to be carried from the lungs to the tissues. The mean concentration of Fe in the snail samples is 73.09 mg/kg. The content of Fe in the samples might have been contributed by the geology of the habitat of the snail samples. Severe Fe deficiency causes anaemia in humans. Mn which is an essential element for both animals and plants measured a mean concentration of 1.27 mg/kg in the samples. Deficiencies of Mn result in severe skeletal and reproductive abnormalities in mammals. Cu also forms an integral part of several enzymes and it is necessary for the synthesis of haemoglobin. It has a mean concentration of 20.41 mg/kg in the samples. The levels of copper and zinc in the samples, apart from natural sources might also have emanated from the input of fertilizers. Zn which is also an essential trace metal for both animals and humans measured a mean concentration of 17.82 mg/kg in the samples. A deficiency of zinc is marked by retarded growth, loss of taste and hypogonadism, leading to decreased fertility (Sivapermal *et al.*, 2007). The major source of Ni for humans is food and uptake from natural sources, as well as food processing (NAS-NRC, 1975). Its mean concentration in the samples measured 1.79 mg/kg. Ca is identified as an essential element in enzyme regulation, in the secretion of insulin in adults, and in regulation of muscle function. A higher mean concentration of 509.44 mg/kg was measured for Ca in the samples. The shales underlying the habitat of the snail samples might have influenced this trend. A decrease in Ca causes osteoporosis, a decrease in the density of the bone, evident in women after menopause.

Vanadium is a trace element that has only recently been discovered to be necessary for human life (Sullivan, 2002). The mean concentration was relatively low, measuring 0.17 mg/kg in the samples analyzed. It is found to help reduce blood sugar levels and may also slow down the formation of cholesterol in the blood. Currently, there are no known symptoms of vanadium deficiency in humans. Magnesium is an essential mineral that has a hand in many vital body functions including activating more than 300 enzymes and providing energy for almost all metabolic reactions and processes. The mean concentration of Mn in the samples was 1.27 mg/kg. It balances and controls K, Ca and Na. Lack of magnesium in humans causes irregular heartbeat, palpitations and reduced ability to detoxify (Holden *et al.*, 2003). It has been estimated that the average human body contains from 35 to 50 mg of Al. It has no known biological role. Al is one of the elements contained in the geology of the

Akwapim area and measured a mean concentration of 81.29 mg/kg. When levels of Al are high in the body, the bones act as a sink and subsequently releasing it slowly through the digestive system over a long period. Patients with kidney failure, however, face a multitude of problems, including the inability to excrete absorbed aluminium (European Aluminium Association, 2008). Sodium stimulates muscle contraction and helps maintain proper acid-base balance and in the transmission of nerve impulses together with Cl and K (www.healthvitaminsguide.com). Sodium measured a mean concentration of 440.25 mg/kg in the samples analyzed. The farmers and the market women handle the snails with their bare hands hence this practice might have influenced the levels of sodium. Potassium, even though is an element contained in the geology of the area, measured a very low mean concentration of 0.56 mg/kg. Potassium is critical to maintaining a normal heartbeat. It assists in muscle contractions and in maintaining appropriate levels of fluid and the electrolyte balance in the body cells. Deficiency results in muscular weakness, fatigue, nervous system and heart deterioration.

Multivariate analysis: The analytical results were subjected to Pearson correlation matrix, Principal component analysis and hierarchical cluster analysis using SPSS 16.0 package.

The Pearson's correlation matrix for the elements analyzed in the snail samples are shown in Fig. 1. The correlation coefficient matrix shows strong correlation between elements at 99 and 95% confidence levels. Strong correlations were recorded at 99% confidence level ($p<0.01$) and significant correlations were recorded at 95% confidence level ($p<0.05$). The correlation coefficient matrix measures how well the variance of each constituent can be explained by its relationship with others (Bhniyan *et al.*, 2010) The associations between elements of strong correlation were noted in Fig. 1 as follows: Al-Fe-Mn, Ca-Cl-Mg, Cl-Mg-Na, Fe-V, and Ni-V indicating similar sources within the groups while associations between elements of significant correlation were noted as follows: Al-V, Ca-Ni-V, Cl-Ni-V, Cu-K, Mg-Ni-V, and Na-Ni. The correlation coefficient matrix indicate that the elements have varying sources, however there is great level of interrelationships regarding their sources. The geology of the source of the snails sold on the Madina market coupled with the application of agrochemicals are the major sources for the above classifications.

The results of the Principal Component (PC) analysis generated by Varimax rotation method which reduced the original data set and explained about 81.7% of the total variance is shown in Table 5. The varimax rotated results explains the possible groups or sources that accounted for the elements present in the snail samples. Four

	Al	Ca	Cl	Fe	Cu	K	Mg	Mn	Na	Ni	Zn	V
Al	1											
Ca	.269	1										
Cl	.247	.843**	1									
Fe	.717**	.205	.242	1								
Cu	-.057	-.037	.135	.221	1							
K	.147	.152	.228	.081	.536*	1						
Mg	.357	.954**	.856**	.288	.076	.264	1					
Mn	.701**	.023	.082	.356	-.351	-.374	.059	1				
Na	.229	.386	.648**	.214	.170	.061	.446	.317	1			
Ni	.396	.519*	.596*	.458	.304	.384	.543*	.085	.491*	1		
Zn	-.108	.129	.145	-.092	-.079	.351	.249	-.217	.291	.282	1	
V	.560*	.584*	.571*	.802**	.315	.112	.603*	.170	.277	.639**	-.105	1

**. Correlation is significant at the 0.01 level

*. Correlation is significant at the 0.05 level

Fig. 1: Correlation matrix (significant figures in bold text)

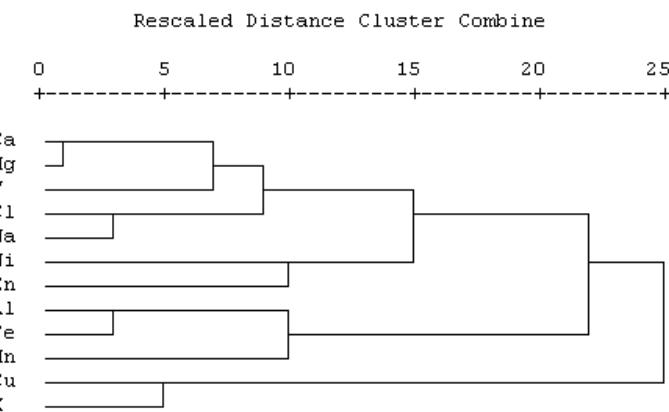


Fig. 2: A dendrogram of hierarchical cluster analysis using Ward method

Table 5: Rotated principal component analysis using Varimax with Kaiser Normalization method (significant figures are in bold text)

Element	PC1	PC2	PC3	PC4	Communalities
Al	0.159	0.901	-0.066	0.058	0.844
Ca	0.97	0.056	-0.02	0.031	0.946
Cl	0.913	0.135	0.074	0.181	0.89
Fe	0.177	0.85	0.243	-0.132	0.829
Cu	0.028	0.083	0.866	-0.093	0.767
K	0.093	0.001	0.77	0.37	0.738
Mg	0.928	0.144	0.074	0.153	0.912
Mn	-0.031	0.73	-0.586	0.082	0.883
Na	0.457	0.293	-0.051	0.544	0.593
Ni	0.521	0.429	0.385	0.338	0.717
Zn	0.094	-0.176	0.121	0.863	0.799
V	0.595	0.617	0.31	-0.233	0.885
Eigen value	4.783	2.261	1.645	1.114	
Variance (%)	29.556	23.294	16.851	11.994	
Cummulative (%)	29.556	52.85	69.701	81.695	

components were extracted for eigen values >1 with communalities ranging from 59.3% (Na) to 94.6% (Ca). Principal Component 1 (PC1) which accounted for 29.556% of the total variance is loaded on Ca, Cl, Mg, Na, Ni, and V. These elements may have been taking up by plants from the soil and consequently into the snails

through feeding. Mg, Ca and Na are notable constituents of the geology of the Akwapim area, the source of the snails sold on the Madina market. The second principal component (PC2) explains more than 23.294 % of the total variance and was loaded with Al, Fe, Mn, and V. The third principal component (PC3) with a total variance

of 16.851 % was loaded with Cu and K. Copper and potassium are principal constituents of fertilizers. Principal component four (PC4) which accounted for 11.994 % of the total variance was loaded with Na and Zn. The principal components show a favorable agreement with the Pearson's correlation coefficient matrix.

Cluster Analysis (CA) was utilized mainly to sort or monitor cases into groups or clusters so that the degree of association is strong between members of the same cluster and weak between members of different clusters. A dendrogram of the hierarchical cluster analysis using Ward method is shown in Fig. 2. Three main clusters were retained with the phenon line set at about 17 on the rescaled linkage distance. Cluster 1 (CA1) is loaded with Ca, Cl, Mg, Na, Ni, Zn, and V. This is very similar to the constituents of PC1. Cluster 2 (CA2) also loaded Al, Fe and Mn which also agrees well with PC2. The third cluster (CA3) consists of Cu and K. The third cluster however loads perfectly with PC3. The sources of the elements have been shown to originate from varying sources with groups within clusters and components having common sources.

CONCLUSION

It is interesting to note that the elements analyzed in the samples were all essential elements. However excessive levels may be harmful to human health. Results from the principal component analysis and hierarchical cluster analysis showed a very similar trend of relationships between the elements. There is also a favorable agreement between these results and the correlation coefficient results. Cu and K might be contributed largely by the application of agrochemicals. The geology, anthropogenic inputs from fertilizers, pesticides and herbicides are the likely sources of the other elements that were analyzed. Since the Akwapim area, the source of the snail samples sold on the Madina market is experiencing accelerated growth in commercial activities, the feeding demands of the populace and its environs thus will increase. This implies that more agrochemicals will be utilized to boost crop yield and as a result, the antecedent problem of anthropogenic inputs of metals will manifest. The assessment of trace metals in edible materials, particularly, should be done regularly to prevent the ever increasing population to being exposed to harmful levels of these elements.

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