Correlation Analysis of Elements in Tobacco Leaf, Cigarette and Cheroot Samples

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Abstract

Energy dispersive X-ray fluorescence spectroscopy was used for the multi-elemental analysis of four tobacco leaves, one brand of cigarette and cheroot. The dried samples of tobacco leaves, cigarette, cheroot and ashes of the samples have been analyzed for fourteen elements like potassium (K), calcium (Ca), arsenics (As), bromine (Br), rubidium (Rb), strontium (Sr), titanium (Ti), zirconium (Zr), iron (Fe), nickel (Ni), copper (Cu), zinc (Zn), selenium (Se) and lead (Pb). As, Ni, Cu, Zn, Sr, Se and Pb have the averages of 0.7, 1.28, 20.58, 57.38, 203.83, 0.5, and 3.73 ppm and 0.73, 1.75, 71.22, 184.3, 694.02, and 7.87 ppm in samples and ashed samples respectively. Statistical correlations are found to exist between K and Ca (-0.99), Sr and K (-0.8), Sr and Ca (+0.8), Sr and Br (+0.6), Pb and Br (-0.6), Zn and Sr (-0.8) and Cu and Ti (+0.9), Pb and Ti (+0.8) and Pb and Cu (+0.8).

Key words: EDXRF, tobacco leaf, cigarette, cheroot

Introduction

Tobacco, a plant of the genus *Nicotiana* is grown as an annual crop for utilization of its leaves, which are used in cigarettes for chewing and snuffing; and as a source of nicotine. As an annual crop, the tobacco plants are widely grown in Myingyan area, which is in the central part of Myanmar. They are grown in the farmland, and in the area near the bank of Ayeyarwaddy River. The tobacco leaves are mainly used in cigarettes, and the leaves, the stem and main root are used for the cheroots. The cheroots are the main products of Myingyan, and they are distributed around the country. Tobacco is an important industrial crop for all over the world. The leaves of this invaluable crop have usually been used for cigarette and related products and some of its trace elements are extremely hazardous for humans even at a very low level of intake.

The tobacco leaves and the cigarette smoke contain a complex mixture of several hundred chemical compounds, some of which are tars, nicotine, carbon monoxide, hydrogen cyanide and oxide of nitrogen. Many of these compounds are pharmacologically active, highly toxic, carcinogenic, mutagenic, and antigenic.

Cigarettes contain tobacco, paper and additives. Many additives are used in cigarette manufacture as well as paper. They contain heavy metals including lead and arsenic. The term cigarette refers to a tobacco cigarette are commonly used, but can apply to similar devices, such as cannabis. A cigarette is distinguished from a cigar by its smaller size, use of processed leaf, and paper wrapping, which is normally white, through other colors and flavors are also available. Cigars are typically composed entirely of whole-leaf tobacco. Cigarettes carry serious health risks, which are more prevalent than with other tobacco products. Nicotine, the primary psychoactive chemical in tobacco and therefore cigarettes is very addictive.

Cheroots are traditional product of Myanmar. Cheroots are mostly produced from Myingyan Township, which is in central part of Myanmar. There are about 50 production places of cheroot (Sae-Late-Khon) in Myingayan. Saelate (Sae- Paw- Late) is traditionally used in Myanmar, up to now.

Elemental compositions particularly trace elements in tobacco have been a subject of recent studies because of the probable contribution of the elements to the hazards associated with tobacco, cigarette and cheroot intake. An array of elements, ranging from the low atomic

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mass elements like Na, K and Ca to heavy transition and radioactive metals, have been reported and detected at various concentrations, in tobacco, cigarette and cheroot.

In order to investigate the elemental compositions of the tobacco leaves, cigarette and cheroot, EDXRF studies have been done. Ash samples also have been studied, because of the probable contribution of the residues of the cigarettes and cheroots. The present study determines the level of inorganic elements by Energy Dispersive X-ray Fluorescence (EDXRF) in tobacco leaves and cheroots produced in Myingyan, Myanmar. Attempt is also done to relate the concentration of these elements in the ash, produced by burning the cheroots compared with those detected in the cheroots.

Experimental Procedure

Four tobacco leaves samples that were collected from Na Bu Aing Village, Chaung Lal Village, Lal Thit Village and Lay Eain Tan Village in Myingyan Township, are labeled as T1, T2, T3, and T4 respectively. One cigarette sample labeled as C1 and one cheroot sample labeled as C2 which were analyzed in this study were collected from the local market and these are widely used in that region.

The collected samples were prepared by following steps before the Energy Dispersive X-ray Fluorescence (EDXRF) measurement.

1. The tobacco leaf samples were dried at room temperature until constant weight was obtained.
2. The dried tobacco leaf, cigarette, and cheroot samples were ground by using stainless steel motor with a steel pestle in order to obtain fine powder.
3. The fine powder samples were passed through the 325- mesh in order to obtain very fine powder sample, which are more suitable for X-ray measurement.
4. After getting very fine powder sample, each sample was weighted as 10g by using digital balance.
5. Each weighted sample was packaged by plastic bag in order to clean and not to mix other impurities and these are labeled.

In order to obtain the ash-sample of tobacco leaf, cigarette and cheroot, each dried sample are placed in the steel pot and then the pot was heated in which paper-wrap and filter of cigarette and cheroot samples were removed. Then, the ash-samples are prepared continue as the previous step 3, step 4 and step 5.

All prepared pellet samples were put into the sample changer, in order to measure the elemental concentration of the prepared samples. Sample identification and changer number were carefully recorded. All of the samples were analyzed 300 sec for each. The elemental concentration of samples and ash- samples were analyzed by using the SPECTRO XEPOS system. All measurements have been done in Experimental Nuclear Physics Laboratory, Department of Physics, Mandalay University.

Twelve samples of tobacco, cigarette, cheroot and their ashes were analyzed by EDXRF method. Elemental concentration of each sample can be measured by EDXRF analysis method. The percentage ratio of elements for each sample has been calculated by using EDXRF results. Then, all statistical and correlation calculations have been done by using Microsoft Excel (version 2007).

Results and Discussions

The percentage ash content ranges from 10.37 % to 19.88% for the Tobacco leaves samples. The percentage ash content in cigarette sample is 23.02 % and that in cheroot sample is 29.03%. Statistical parameters for fourteen elements such as K, Ca, As, Br, Rb, Sr, Ti, Zr, Fe, Ni, Cu, Zn, Se and Pb, that are analyzed in all samples are shown in Table (1). The percentage ratio of the mean concentrations for the elements determined in all samples, are shown in Table (2). Table (3) shows the correlation analysis between the elements determined for all samples.

The percentage coefficient of variation for elements like Br, K, Rb and Zr are high for the tobacco leaf, cigarette, cheroot and their ash-samples. The percentage coefficient of variation for the elements like As, Ca, Fe, Cu and Zn are high for only ash-samples. This indicates that their levels in samples and ash-samples vary over a wide range from their mean concentrations.

The essential elements of plants, Ca and K, constitute about 98 % percent-ratio of the elements determined in the samples with Ca levels generally higher than K levels, in Table (2). The percentage concentration for the elements like Br, Ti, Fe and Ni decreases from the sample to their ash-samples. It occurs that the mean concentrations of the potentially toxic elements like As, Se and Pb, decrease in the percentage ratio from the samples to their ash-samples. The mean concentrations of the elements Rb, Sr, and Cu are the same for the samples and ash-samples.

Table (1) Statistical data on the elemental composition of the tobacco leaves, cigarette and cheroot samples and their ash-samples

Elements	Sample size	Concentration Range (ppm)		Mean (ppm)		Standard deviation (ppm)		Coefficient of Variation (%)	
		Sample	Ash	Sample	Ash	Sample	Ash	Sample	Ash
As	6	0.5-0.9	0.4-1.4	0.7	0.73	0.15	0.36	22	48.43
Br	6	11.6-93.4	43.7-313.9	64.67	199.63	30.09	97.62	46.54	48.90
K	6	6341-26520	18300-120200	14634.7	67053	7279.6	41063	49.74	61.24
Rb	6	13-49.4	29-199	25.28	99	13.17	67.51	52.10	68.19
Ca	6	13.9-28.6	41.1-126.7	20.58	71.22	5.46	31.19	26.54	43.80
Sr	6	77.9-284.8	308.4-920.9	203.83	694.02	76.44	240.18	37.50	34.61
Ti	6	104.3-246.3	178-510	182.08	296.98	52.19	119.15	28.66	40.12
Zr	6	1-10.8	1-20.4	3.85	4.23	4.49	7.92	116.49	187.10
Fe	6	1060-2881	568.9-4511	2086.83	2660.7	742.14	1504.3	35.56	56.54
Ni	6	0.7-1.5	0.8-2.2	1.28	1.75	0.31	0.51	23.85	29.03
Cu	6	13.9-28.6	41.1-126.7	20.58	71.22	5.46	31.19	26.54	43.80
Zn	6	36.5-98	86.6-423.1	57.38	184.3	22.91	126	39.93	68.37
Se	6	0.4-0.7	0.8-1.2	0.5	1	0.13	0.14	25.2	14.1
Pb	6	2.6-6	4.1-13	3.73	7.87	1.28	2.89	34.18	36.80

Table (2) The percentage ratio of the elements determined in tobacco, cigarette, cheroot and their ash-samples

	T1	TA1	T2	TA2	T3	TA3	T4	TA4	C1	CA1	C2	CA2
K	22.70	24.18	18.90	23.06	32.97	36.04	13.70	13.83	47.11	56.52	31.35	43.06
Ca	71.40	72.67	74.02	73.09	60.20	62.97	81.08	83.64	50.26	42.01	65.16	55.19
As	0.001	0.0002	0.002	0.0003	0.001	0.006	0.001	0.0003	0.0009	0.0002	0.0007	0.0003
Br	0.1	0.073	0.143	0.109	0.093	0.013	0.189	0.155	0.158	0.135	0.108	0.106
Rb	0.034	0.029	0.018	0.016	0.013	0.089	0.015	0.013	0.032	0.029	0.046	0.061
Sr	0.438	0.425	0.553	0.529	0.147	0.139	0.61	0.608	0.268	0.225	0.355	0.364
Ti	0.37	0.161	0.464	0.203	0.494	0.24	0.392	0.129	0.173	0.089	0.232	0.091
Zr	0.015	0.0004	0.002	0.0006	0.001	0.009	0.001	0.0006	0.002	0.004	0.002	0.0003
Fe	4.934	2.329	4.17	2.914	5.833	0.266	3.894	1.538	1.875	0.915	2.594	1.031
Ni	0.001	0.0008	0.002	0.001	0.003	0.009	0.003	0.001	0.001	0.0003	0.002	0.001
Cu	0.034	0.029	0.036	0.031	0.053	0.051	0.029	0.026	0.016	0.015	0.031	0.015
Zn	0.084	0.088	0.071	0.047	0.187	0.189	0.073	0.065	0.095	0.306	0.108	0.076
Se	0.001	0.006	0.0007	0.0006	0.0008	0.0003	0.0007	0.0006	0.0009	0.0003	0.001	0.0005
Pb	0.007	0.003	0.009	0.005	0.012	0.005	0.004	0.003	0.005	0.003	0.005	0.003

The percentage ratios of the potentially toxic elements like As, Se and Pb decrease from the sample to their ash- sample. Those indicating these elements are constituents of the smoke released during tobacco burning, a large portion of which are ingested during smoking of tobacco, cigarette and cheroot.

According to the Pearson's correlation matrix, significantly high negative correlation is found to exist between the elements K and Ca (-0.99) in the samples. Moreover, significantly high positive correlation is found to exist between the elements Ti and Fe (0.91) in samples. Some level of correlations are also observed between K and Sr (-0.82), Ca and Sr (0.86), Rb and Se (0.89), Sr and Zn (-0.9), Ti and Cu (0.83), Ti and Pb (0.73), Fe and Cu (0.89), Fe and Pb (0.76), and Cu and Pb (0.86) in the samples.

The negative correlation between the elements K and Ca (-1) is significantly high for ash-samples, and the positive correlation between the elements As and Ni (+1) is also significantly high for ash- samples. Some level of negative correlations in ash-samples are K and Sr (-0.78), Ca and Zn (-0.8), As and Br (-0.8), Br and Rb (-0.8), Br and Ni (-0.84), Br and Cu (-0.79), Rb and Sr (-0.78), Rb and Fe (-0.75), Sr and Zr (-0.83), and Sr and Zn (-0.8).

Some level of positive correlations are K and Zn (0.8), Ca and Sr (0.76), As and Rb (0.82), As and Zr (0.91), As and Cu (0.86), Rb and Ni (0.82), Sr and Fe (0.75), Ti and Cu (0.95), Ti and Pb (0.88), Zr and Ni (0.88), Ni and Cu (0.87) and Cu and Pb (0.77) in the ash-samples.

The presence of potentially toxic elements like, As, Se and Pb in tobacco, cigarette and cheroot sample and their ash- samples could be one of the factors for the health hazards of tobacco, cigarette and cheroot ingestion, which is normally exclusively attributed to nicotine and the volatile gases like CO, HCN, NO, that are emitted from tobacco smoke.

For the samples, the high negative correlation between K and Ca is (-0.99), and between K and Sr is (-0.82), and the correlation between Ca and Sr is positive good correlation of 0.86. This means that Ca and Sr have similar chemical property to react with K. The negative good correlation between Rb and Ti is (-0.78), and between Rb and Ni is (-0.65), and the correlation between Ti and Ni is positive good correlation of 0.6. This means that Ti and Ni have similar chemical property to react with Rb. Similar result occurs between the pairs of elements (Br and Cu) and (Br and Zn). The high positive correlation between Cu and Fe is (0.89) and between Pb and Fe is (0.76), and the correlation between Cu and Pb is positive high correlation of 0.86.This means that elements Fe, Cu and Pb have all together correlation. The similar properties between the elements Ti, Fe and Cu have been observed in samples.

For ash- samples, the high negative correlation between K and Ca is (-1), and between K and Sr is (-0.78), the correlation between Ca and Sr is positive high correlation of 0.76. This means that Ca and Sr have similar chemical property to react with K. The similar properties have been observed between the pairs of elements (Ni and Br) and (Cu and Br), and the pairs of elements (Rb and Sr) and (Rb and Fe). The negative high correlation between the elements Sr and Zr is (-0.8), and between the elements Sr and Zn is (-0.8), the correlation between Zr and Zn is positive good correlation of 0.65. This means that the elements Zr and Zn have similar chemical property to react with the element Sr. Similarly, it was also observed that the element Br and Sr also have the similar chemical property to react with the element As. The high positive correlation between As and Ni is (+1), and As and Zr is (0.91), the correlation between Ni and Zr is positive correlation of 0.88. Therefore, elements As, Ni and Zr have all together correlation, and the elements Ti, Cu and Pb are all together correlated.

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Table (3) Pearson's correlation matrix of the elements in tobacco leaf, cigarette, and cheroot samples

Bold and italic numbers represent the ash-samples.

	K	Ca	As	Br	Rb	Sr	Ti	Zr	Fe	Ni	Cu	Zn	Se	Pb
	1.00													
K	***1.00***													
	-0.99													
Ca	***-1.00***	***1.00***												
	-0.44	0.37												
As	***0.09***	***-0.06***	***1.00***								a			
	-0.23	0.30	0.18											
Br	***-0.07***	***0.05***	***-0.83***	***1.00***										
	0.39	-0.31	-0.50	-0.32										
Rb	***0.41***	***-0.38***	***0.82***	***-0.80***	***1.00***									
	-0.82	0.86	0.46	0.60	-0.14									
Sr	***-0.78***	***0.76***	***-0.66***	***0.63***	***-0.78***	***1.00***								
	-0.63	0.53	0.57	-0.18	-0.78	0.17								
Ti	***-0.42***	***0.42***	***0.71***	***-0.73***	***0.33***	***-0.14***	***1.00***							
	-0.17	0.17	-0.09	-0.42	0.35	0.12	0.01							
Zr	***0.39***	***-0.36***	***0.91***	***-0.67***	***0.73***	***-0.83***	***0.51***	***1.00***						
	-0.47	0.37	0.26	-0.46	-0.60	-0.07	0.91	0.29						
Fe	***-0.58***	***0.54***	***-0.62***	***0.31***	***-0.75***	***0.75***	***0.12***	***-0.72***	***1.00***					
	-0.43	0.40	0.05	0.14	-0.65	0.07	0.60	-0.61	0.45					
Ni	***0.04***	***0.00***	***1.00***	***-0.84***	***0.82***	***-0.62***	***0.73***	***0.88***	***-0.59***	***1.00***				
	-0.29	0.19	0.19	-0.62	-0.48	-0.29	0.83	-0.01	0.89	0.60				
Cu	***-0.36***	***0.38***	***0.86***	***-0.79***	***0.49***	***-0.28***	***0.95***	***0.67***	***-0.15***	***0.87***	***1.00***			
	0.42	-0.50	-0.33	-0.62	-0.21	-0.85	0.28	-0.25	0.45	0.42	0.70			
Zn	***0.80***	***-0.79***	***0.28***	***-0.10***	***0.27***	***-0.78***	***-0.19***	***0.65***	***-0.62***	***0.22***	***-0.06***	***1.00***		
	0.48	-0.44	-0.64	-0.59	0.89	-0.41	-0.62	0.57	-0.28	-0.65	-0.22	0.09		
Se	***-0.32***	***0.30***	***-0.25***	***-0.22***	***-0.21***	***0.18***	***0.07***	***-0.34***	***0.46***	***-0.23***	***0.03***	***-0.25***	***1.00***	
	0.03	-0.15	0.40	-0.61	-0.50	-0.47	0.73	-0.02	0.76	0.29	0.86	0.69	-0.24	1.00
Pb	***-0.16***	***0.16***	***0.64***	***-0.58***	***0.34***	***-0.21***	***0.88***	***0.51***	***0.07***	***0.65***	***0.77***	***-0.08***	***-0.32***	***1.00***