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Metal Distribution in Pakistani and Foreign Brands of Cigarette Tobacco

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The most common form of tobacco use is the manufactured cigarette (Stanley 1993) and tobacco consumption through cigarette smoking is a problem assuming an alarming proportion in the world. The general conformations on to the associated impacts of tobacco abuse make chemical analysis of different brands of cigarettes (both local and imported), with respect to variation in formulation of cigarettes according to manufacturers, a worthwhile exercise. Information from such an exercise could assist in proper air quality management for human protection. Based on current smoking trends, tobacco will soon become the leading cause of death worldwide, causing more deaths than HIV, tuberculosis, maternal mortality, automobile accidents, homicide and suicide combined (Barnum 1994). Environmental pollution due to heavy toxic trace metals emanating from cigarette tobacco has become a serious problem causing much concern for many years. Smoking contributes towards the toxic effects impairing human health conditions. Tobacco smoking over several decades is one causes of cancer in the lungs, oral cavity, pharynx and esophagus, pancreas, bladder and possibly in kidney and liver.

Comparative evaluations have also appeared in literature regarding the distribution of metals in cigarette tobacco. A recent study reported high levels of Pb, Zn, Cd, Cu and Ni in the saliva of smokers in Nigeria (Ebisike et al. 2004). These metals are part of over 4000 chemical compounds identified in tobacco (including 433 known carcinogens) and 500 in smoke (Siem 2000). Bates et al. (1999) reported that there are 600 tobacco additives allowed in the cigarettes in UK. At least twenty metals have been detected in tobacco smoke and these include: Cr, Hg, Cd, Pb etc. most of them are toxic and affect the environment. Zn is primarily an outdoor metal whose only known indoor source is cigarette smoking (Wallace et al. 1997 and Jones et al. 2000). It is known to exist in very small particles thus constituting great health impact. Both epidemiological and mechanistic data are consistent with a facilitative role for Pb in carcinogenesis (Silbergeld 2003). Chao and Wong (2002) and Afroz et al. (2003) stressed the health impact of Pb. Established health related problems of Cd and Ni motivated Thomaidis et al. (2003) to characterize them along with other metals in Athens atmosphere.

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The present study pertains to the comparison and estimation of Ni, Cd, Cr, Zn, Pb and Cu in cigarette tobacco in as many as thirty individual cigarette samples of Pakistani and foreign origin. The broader objective of this study stems from an environmental angle aimed at an assessment of the levels of heavy toxic trace metals emanating from the cigarette tobacco which causes a serious health impact on population and to devise abatement strategies towards metal pollution of atmosphere based on the data. This work also helps to find correlation for pairs of metals in terms of their origin and distribution in the atmosphere. In the view of the above objectives, it is anticipated that our attempt will have an effective role to play in the scenario of present state of affairs related to the environmental pollution. This article is a step to produce baseline data and information to this effect.

MATERIALS AND METHODS

Selected heavy metals (Ni, Cr, Zn, Cd, Pb and Cu) were estimated in tobacco of various brands of cigarettes. In total thirty cigarette samples were obtained randomly from local market for analysis: 15 each of Pakistani and foreign origin. The information on sample codes and description of make for the local and foreign versions of samples is given in the Table 1 and 2. Full cigarettes duly packed in their original cases were procured and stored in a cool and dry place in the laboratory prior to analysis. For analysis, the filter portion if any, of a cigarette was cut away, the wrapper pealed off and the tobacco so obtained was weighed to get the total mass of tobacco in a single cigarette unit. Using wet digestion method, a known mass of tobacco sample was digested in 4:1 (v/v) $HNO_3/HClO_4$ mixture (NIOSH Method-7300, 1984).

Table 1. Information on samples codes and make of Pakistani cigarettes.

S. No.	Sample Code	Description
1.	PT-1	Capstan, King size
2.	PT-2	Cash, King size filter
3.	PT-3	Diplomat, King size filter
4.	PT-4	Embassy Kings
5.	PT-5	John Player Gold Leaf
6.	PT-6	Gold Street International, micron filter
7.	PT-7	Gold Flake, Wills, King size filter
8.	PT-8	K-2, King size filter
9.	PT-9	Morven Gold, King size Virginia
10.	PT-10	Princeton, luxury length
11.	PT-11	Press, filter cigarettes
12.	PT-12	Red and White, King size filter
13.	PT-13	Royals, filter cigarettes
14.	PT-14	Tanders, Virginia
15.	PT-15	Wills Kings

Table 2. Information on samples codes and make of foreign cigarettes.

S. No.	Sample Code	Description
1.	FT-1	Benson and Hedges, special filter (UK)
2.	FT-2	Business Club, Virginia blend, King size filter (UK)
3.	FT-3	Captain Black, filters, little cigars (USA)
4.	FT-4	Cartier, Vendome, lights, pearl tipped (UK)
5.	FT-5	Camel (USA)
6.	FT-6	Dunhill, International, filter deluxe (UK)
7.	FT-7	Davidoff (Germany)
8.	FT-8	Knights Bridge (Germany)
9.	FT-9	London, King size filter (UK)
10.	FT-10	Marlboro, filter class A cigarettes (USA)
11.	FT-11	Mild 88 (Korea)
12.	FT-12	More, menthol filter class A cigarettes (USA)
13.	FT-13	Rothman's Lights (UK)
14.	FT-14	Seven Stars, charcoal filter cigarettes (Japan)
15.	FT-15	555, filter kings (UK)

The selected metal levels were estimated by the Atomic Absorption Spectrophotometric method using optimum analytical conditions maintained on Shimadzu AAS System, AA-670 Japan. Blanks were simultaneously prepared for each metal in the acids and blank filters. The blank levels were approximately <10% of the estimated metal concentrations. All reagents used were of AAS grade (certified purity > 99.99%) purchased from E-Merck. The metal stock solutions (1000 ppm) were used to prepare working standards. The accuracy of the method was evaluated using a standard reference material obtained from the National Institute of Health, Islamabad, Pakistan; where inter laboratory comparison of the data was also conducted. Normally, the two results agreed within ±2.0% for triplicate runs of the tobacco samples. Statistical analysis of the data was performed with STATISTICA software (StatSoft Inc. 1999).

RESULTS AND DISCUSSION

For the determination of heavy metal distribution in cigarette, only popular local and foreign brands have been selected ranging from simple to king size and filter versions. The standard analytical conditions employed during the measurements are given in Table 3. Concentration level of six metals (Ni, Cr, Zn, Cd, Pb and Cu) in various brands of cigarette is expressed in Table 4 and 5 as $\bar{X} \pm SD$ with an overall precision between ±1.0 to ±1.5%. Large spread around mean concentration levels is associated with these metals, as shown by the respective SD values. Figure 1 and 2 indicate the extreme ranges of metal concentration levels of various versions of cigarette. The analytical results showed highest concentration for Zn in PT-4 (429 μg/cig.) and FT-9 (88 μg/cig.). On the whole, foreign brands are only slightly cleaner with respect to the Zn contents in relation to the counterparts from the Pakistani brands. Distribution of Cd gives a six-fold

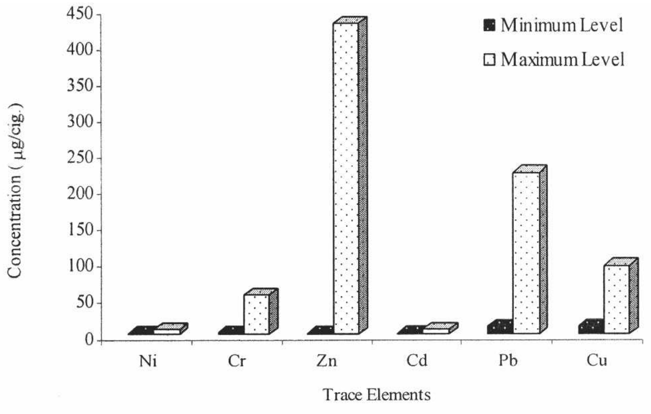

Figure 1. Extreme ranges of metal concentrations levels in tobacco of Pakistani brands of cigarettes.

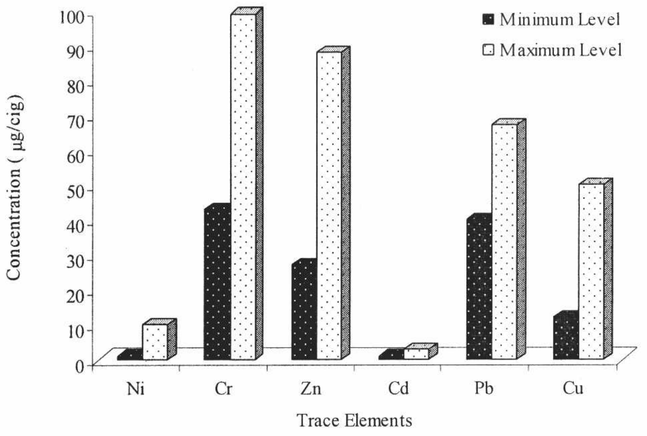

Figure 2. Extreme ranges of metal concentrations levels in tobacco of foreign brands of cigarettes.

dispersion between the extreme concentrations. In this respect the distribution of Cd in Pakistani brands of cigarette is much more restricted than that of Ni, a case which finds a parallel for the foreign brands of cigarette as well.

Table 3. Analytical conditions for atomic absorption analyses.

Element	λ (nm)	Flame	Detection Limit (ppm)
Cd	228.8	Air-C_2H_2	0.02
Cr	357.9	Air-C_2H_2	0.09
Cu	324.8	Air-C_2H_2	0.09
Ni	232.0	Air-C_2H_2	0.10
Pb	217.0	Air-C_2H_2	0.20
Zn	213.9	Air-C_2H_2	0.02

Certain elevated levels were observed for Cr metal giving a 27 fold enhancement ratio between the extreme values in local brands. Cr levels in case of foreign brands of cigarettes are very divergent, spanning between 43 μg/cig (FT-15) to 99 μg/cig. (FT-3). Thus, Cr concentration is marginal in local cigarette tobacco as compared to the foreign cigarettes. The case of Pb is unique in the sense that its level in both the brands is not very much divergent, they are rather consistent with only one or two exceptions of high concentrations (PT-6) 222 μg/cig. However, in all other cases the average ratio value is 4 to 5. Cu concentration varied between 94 μg/cig (PT-6) to 50 μg/cig. (FT-13) for local and imported brands, respectively. The comparative evaluation puts concentration of Zn metal at rank No.1 in the tobacco of Pakistani brands of cigarettes while in the tobacco of foreign brands, Cr and Zn are the most dominating metals. This numerical assessment was important to evolve a clear cut picture as to the quality of available cigarettes in terms of value index based on maximum and minimum metal concentrations.

The correlation coefficient values pertaining to both brands of cigarettes appear in the Table 6 and 7. The linear coefficient study was embarked with the objective to explore the possible correlation between pairs of metals in the tobacco of local and foreign cigarettes. The correlation statistics reveal strong positive correlation for Cu–Pb (0.837) and Zn–Cr (0.619). In the counter case for the foreign cigarettes, only Ni is strongly and positively correlated with Zn (0.580). There is a marginal positive correlation between Zn–Cr and Pb–Cd, but these are too naive to warrant any mutual dependence of significance. This correlation study indicates a clear difference between tobacco quality of cigarettes of both brands.

A comparative t-value assessment was incorporated on the basis of a hypothesis acclaiming either a common or different origin of the tobacco used in the manufacture of local and imported brands of cigarettes, the results of which appear in Table 8. Based on this information Cr, Zn, Pb, Ni and Cu fit within the framework of the hypothesis proclaiming that tobacco from both of sources has some common origin. However, in the case of Cd the hypothesis is rejected, thus, the contribution of Cd in the local tobacco is perhaps interplay of local conditions of manufacture, role of blending materials, addition of additives and stabilizers and incorporation of perfumes or other chemicals so as to enhance the aesthetic acceptance of the product.

Table 4. Trace elements concentration level in tobacco of different Pakistani brands of cigarettes.

Trace Elements	Concentration $\overline{X} \pm$ S.D (μg / cig.)														
	PT-1	PT-2	PT-3	PT-4	PT-5	PT-6	PT-7	PT-8	PT-9	PT-10	PT-11	PT-12	PT-13	PT-14	PT-15
Ni	3±0.2	6±0.3	6±0.3	4±0.2	BDL*	1±0.1	1±0.1	2±0.1	2±0.1	BDL*	2±0.1	1±0.1	4±0.2	2±0.1	1±0.1
Cr	6±0.3	42±0.5	47±0.5	53±0.3	54±0.2	44±0.5	2±0.1	7±0.3	9±0.3	5±0.3	19±0.4	6±0.3	8±0.2	2±0.1	23±0.3
Zn	5±0.3	10±0.3	6±0.4	429±5.0	213±2.0	82±0.5	41±0.3	23±0.3	16±0.4	52±0.4	7±0.2	BDL*	1±0.1	BDL*	48±0.4
Cd	2±0.2	3±0.2	5±0.3	6±0.3	3±0.1	1±0.1	3±0.2	4±0.2	3±0.2	3±0.1	4±0.2	3±0.2	5±0.2	4±0.2	3±0.2
Pb	11±0.2	36±0.3	49±0.5	39±0.4	25±0.3	222±2.0	35±0.4	25±0.2	30±0.3	50±0.3	44±0.4	37±0.3	46±0.4	50±0.4	47±0.3
Cu	24±0.2	22±0.3	21±0.2	20±0.2	52±0.4	94±1.0	11±0.1	15±0.2	18±0.2	22±0.3	14±0.2	13±0.2	15±0.2	16±0.3	26±0.4

* BDL = Below Detection Limit

Table 5. Trace elements concentration level in tobacco of different foreign brands of cigarettes.

Trace Elements	Concentration $\overline{X} \pm$ S.D (μg / cig.)														
	FT-1	FT-2	FT-3	FT-4	FT-5	FT-6	FT-7	FT-8	FT-9	FT-10	FT-11	FT-12	FT-13	FT-14	FT-15
Ni	1±0.1	10±0.3	5±0.2	4±0.2	5±0.3	2±0.2	5±0.3	3±0.2	6±0.3	7±0.3	5±0.2	4±0.2	2±0.2	6±0.2	2±0.1
Cr	73±0.5	85±0.6	99±0.7	64±0.5	52±0.5	80±0.6	66±0.5	79±0.6	87±0.6	57±0.5	55±0.4	60±0.5	60±0.6	70±0.5	43±0.5
Zn	43±0.4	79±0.5	47 0.4	62±0.5	30±0.4	50±0.5	87±0.5	48±0.5	88±0.6	73±0.5	56±0.3	50±0.3	45±0.3	39±0.4	27±0.4
Cd	3±0.2	3±0.2	3±0.1	2±0.1	2±0.2	1±0.1	1±0.2	2±0.2	3±0.2	2±0.1	2±0.1	2±0.1	3±0.2	2±0.1	2±0.1
Pb	55±0.5	46±0.4	48±0.3	40±0.3	52±0.5	40±0.4	46±0.3	67±0.4	63±0.5	50±0.4	56±0.5	55±0.5	59±0.5	52±0.4	47±0.4
Cu	15±0.2	18±0.2	30±0.3	13±0.2	12±0.2	21±0.2	41±0.3	19±0.2	13±0.2	20±0.2	13±0.1	14±0.2	50±0.3	12±0.2	23±0.2

Table 6. Correlation coefficient values for pairs of metals in tobacco of cigarettes of Pakistani origin.

	Ni	Cd	Cr	Zn	Pb	Cu
Ni	–	0.499	0.337	– 0.027	– 0.167	– 0.269
Cd		–	0.143	0.362	– 0.442	– 0.576*
Cr			–	0.619*	0.302	0.533*
Zn				–	0.029	0.221
Pb					–	0.837**
Cu						–

* = Correlation is significant at 0.05 level
** = Correlation is significant at 0.01 level

Table 7. Correlation coefficient values for pairs of metals in tobacco of cigarettes of foreign origin.

	Ni	Cd	Cr	Zn	Pb	Cu
Ni	–	0.164	0.248	0.580*	– 0.112	– 0.230
Cd		–	0.362	0.001	0.408	0.011
Cr			–	0.363	0.059	0.013
Zn				–	– 0.040	0.097
Pb					–	– 0.030
Cu						–

* = Correlation is significant at 0.05 level

Table 8. Comparative t-values for various metal pairs for tobacco of cigarettes.

S. No.	Metal	t-value	Critical t-value Confidence Level 95 %*	99 %**	Remarks
1.	Ni	1.29	1.701	2.467	Hypothesis is accepted.
2.	Cd	3.45	1.701	2.467	Hypothesis is rejected.
3.	Cr	0.40	1.701	2.467	Hypothesis is accepted.
4.	Zn	0.003	1.701	2.467	Hypothesis is accepted.
5.	Pb	0.0045	1.701	2.467	Hypothesis is accepted.
6.	Cu	0.043	1.701	2.467	Hypothesis is accepted.

* = At 95 % confidence level, $\alpha = 5$ %
** = At 99 % confidence level, $\alpha = 1$ %

The study quantitatively demonstrated that levels of metals were mostly well above the stipulated safe limit of ingestion laid down by WHO. For future strategies, the cigarettes may be blended to mask heavy toxic trace metals either through filtration of smoke or through chemical complexation. The work makes it imperative to have a strict check on the quality of both Pakistani and foreign cigarettes, especially in terms of toxic metals, thus warding off possible health and environmental impacts.

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