Chapter 6

Determination of Trace Elements Using ICP-AES Technique

Introduction

Inductively Coupled Plasma (ICP) technique has been applied in this experiment because it is an excellent analytical tool for the spectrochemical analysis of solvents to determine the concentration of elements such as Pb, Zn, Cd, Cu, Ca and Mg. Its lower limit of detection can reach below 1 ppm. Thus, the precision and accuracy of performance of the ICP is the reason why it is applied in this study.

Since we are living in an environment surrounded by toxic elements, our body is exposed to these chemicals at the level that could affect our human biochemistry. Some chemicals are capable of inducing subtle yet insidious health effects, especially for children. The metals such as lead, mercury, arsenic, aluminium, cadmium, zinc and manganese, are often accumulated in certain organs and can cause adverse effects on the physiology of those organs.

The components of our teeth would appear to be a suitable indicator of these heavy metals in long-term exposure (K.Griinke et.al., 1996). Thus, in this study, 199 human teeth have been collected from two areas, namely the Klang Valley (113 samples) and Malacca (86 samples) for the study of the concentration level of Pb, Cd, Zn, Cu, Mg and Ca. The living and working environment surrounding the donors are vital for this study, thus, Klang Valley and Malacca have been chosen; the former to the industrial area and the latter agricultural. Donors' background were collected in order to make a study to see if there is any correlation between the living environment and the elements' concentrations.

In this chapter the elements' concentrations level against the donors' age and residential area, types of tooth, and the donors' working environment would be presented and discussed.

6.1 The Calibration of ICP-AES

The system program employs the 2-point straight-line method to tabulate the calibrations. Each background correction is made for the system calibration from the 6 blank samples. These blank samples are prepared according to the preparation for each known concentration of elements from the standard solutions (Anal R Grade). The blank samples for calibration are found to be free from these elements (Pb, Cd, Zn, Cu, Mg and Ca).

Table 6.1 shows the concentration of the elements found in 3 blank samples. These samples went through the same procedures as the preparation of the tooth sample. The results show very low concentration for the elements with the exception

of Ca, which the contamination is suspected to come from the filter paper. Therefore, the measured concentrations of each element are adjusted from these background values.

Table 6.1: The Average Concentration of Blank Samples for Each Element

	1 (ppm)	2 (ppm)	3 (ppm)	Mean (ppm)	Standard Deviation (ppm)	% of S.D
Pb	0.0021	0.0046	0.0017	0.0028	0.0016	56.1
Cd	0.0019	0.0025	0.0009	0.0018	0.0008	45.8
Zn	0.0055	0.0056	0.0055	0.0056	0.0001	1.8
Cu	0.0291	0.0349	0.0355	0.0332	0.0035	10.7
Mg	0.2023	0.202	0.2012	0.2019	0.0006	0.3
Ca	0	0	0	0	0	0

Systematic errors are inherent in the method, and may be derived from each step in the analytical process. Hence, there are some approaches to obviating systematic errors. One of them is the empirical calibration method. Since this analysis system is calibrated with synthetic standards of known composition, reasonably good empirical corrections for determinant errors can be obtained. This approach assumes that the concentrations of standards are known with a high degree of confidence, and the contamination of the standards from the surroundings must be scrupulously avoided.

The ICP-AES system makes 3 measurements for each element in a given sample, and the standard deviation for each respective element is then calculated.

Figure 6.1 shows the average standard deviation for each element. The standard deviation for Cu, Zn, Mg and Ca are less than 5%, while Pb and Cd has a high value of about 25% and 15% respectively. Lower percentage of standard deviation means more precise measurements and imply accuracy as well as a good

evaluation of the reproducibility. But the high standard deviation yielded for Pb and Cd implies that the low concentration of the elements approach the system detection limit. The range of Pb concentrations is in between 0.713 ± 0.039 μg (g tooth mass)$^{-1}$ to 55.512 ± 8.945 μg (g tooth mass)$^{-1}$, while the concentrations of Cd is in between 0.0181 ± 0.002 μg (g tooth mass)$^{-1}$ to 3.910 ± 0.072 μg (g tooth mass)$^{-1}$.

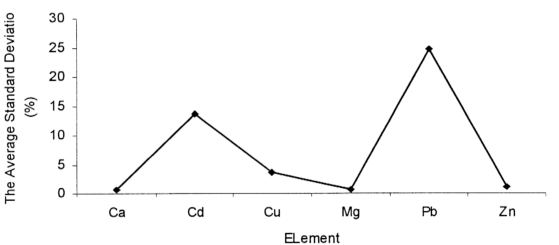

Figure 6.1: The Average Standard Deviation for Each Element

6.1.1 Distribution of the Concentrations of Each Element in Klang Valley and Malacca Samples

Figures 6.2 to 6.12 shows the distribution of the concentration of each element, which are divided accordingly to the area of Klang Valley and Malacca for various types of teeth (Incisor, Canine, Premolar and Molar). The total sample of 199 teeth from the donors of the Klang Valley area (113 samples: 58 female samples and 55 male samples) and Malacca (86 samples: 53 female samples and 33 male samples) are analyzed. The tooth mass varies from 0.1580 ± 0.0001 g to 2.5763 ± 0.0001 g, with the average and median of 1.0814 g and 0.9726g respectively. The

number of teeth for Incisor, Canine, Premolar and Molar are 33, 19, 66 and 81 respectively.

6.2 Concentration of Pb

Figures 6.2 and 6.3 show the distribution of concentration of Pb versus the age of donors from Klang Valley and Malacca. The Pb concentration for these groups from Klang Valley varies from 1.412 ± 0.835 μg (g of tooth mass)$^{-1}$ to 53.802 ± 6.483 μg (g of tooth mass)$^{-1}$, with an average and median of 11.755 ± 2.821 μg (g of tooth mass)$^{-1}$ and 7.801 ± 1.973 μg (g of tooth mass)$^{-1}$ respectively. The Malacca samples range from 0.713 ± 0.039 μg (g of tooth mass)$^{-1}$ to 55.512 ± 8.945 μg (g of tooth mass)$^{-1}$, with an average and median of 18.982 ± 4.805 μg (g of tooth mass)$^{-1}$ and 18.863 ± 4.149 μg (g of tooth mass)$^{-1}$ respectively. Most of the donors in the Klang Valley are from Kinrara, Kuchai, Old Klang road, OUG, Sri Sentosa and Puchong, while the donors from Malacca are scattered all over the residential areas such as Bukit Beruang, Maling Jaya, Bukit Baru, Tanjung Keling, Alor Gajah, Merlimau, Semabok and Bukit Berendam.

The samples from Malacca tend to contain slightly higher concentration (on average) of lead compared with samples from Klang Valley. However, the significance of these differences could not be assessed, as no information on geographical stability or local conditions, that can affect the results from Malacca donors was available.

Both areas where the samples were collected have obviously shown the concentration of Pb to exceed the median level. Figure 6.3 (a) shows the samples from Klang Valley which reflects a significant enhancement are from donors who

are working in the factory environments (welding metal, wire, automobile, refrigerator, aluminium) and as a taxi driver, which their concentration of Pb is higher than the median level of 7.801 ± 1.973 μg (g tooth mass)$^{-1}$ for Klang Valley. The average lead concentration of this group was measured at 18.617 ± 3.980 μg (g tooth mass)$^{-1}$ compared with the samples from non-industry working environment at 6.671 ± 2.581 μg (g tooth mass)$^{-1}$.

Also, 21 samples of the teeth whose ages are over 40 year-old are found to have the average tooth-Pb level of 18.238 ± 4.203 μg (g tooth mass)$^{-1}$. Twenty-seven (27) samples from Malacca were found to exceed the median Pb level, with the average tooth-Pb level of 28.705 ± 6.540 μg (g tooth mass)$^{-1}$. Eighteen of the 40 year-old samples had an average tooth-Pb level of 27.215 ± 6.747 μg (g tooth mass)$^{-1}$.

These observations of raised Pb concentrations in the teeth of persons of more mature years are supported by the results done by Steenhout and Pourtois (1981) and (L.T.Chew *et.al.*, 2000). The findings give a direct evidence for the accumulation of Pb in human teeth.

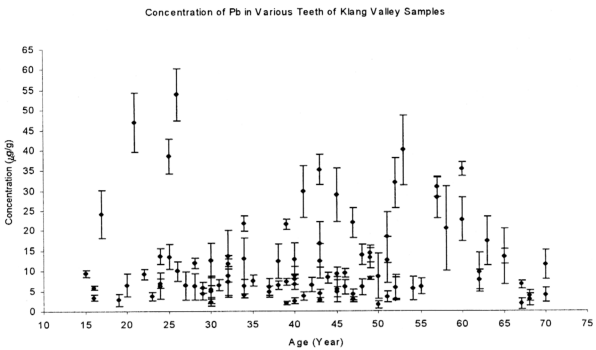

Figure 6.2: Distribution of Pb with different concentration in various teeth of Klang Valley samples

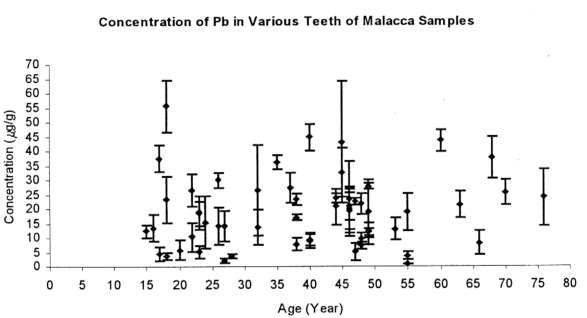

Figure 6.3: The concentration of Pb as a function of Age in various teeth originated from Malacca samples

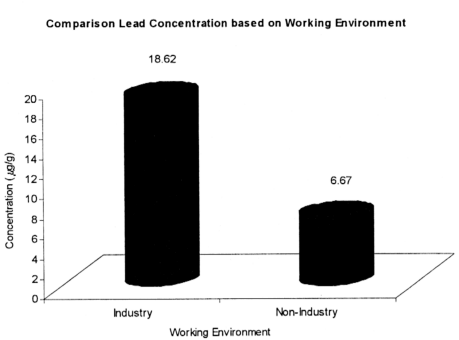

Figure 6.3 (a): Comparison the Lead Concentration based on Working Environment

6.3 Concentration of Zn

Figures 6.4 and 6.5 show the distribution of Zn concentration in various types of teeth versus the age of the donors from Klang Valley and Malacca. The mean tooth-Zn level for Klang Valley and Malacca are 103.645 ± 0.929 µg (g of tooth mass)$^{-1}$ and 120.667 ± 1.252 µg (g of tooth mass)$^{-1}$ respectively. The samples of Klang Valley show the concentration of Zn from 26.470 ± 0.153 µg (g of tooth mass)$^{-1}$ to 296.630 ± 2.762 µg (g of tooth mass)$^{-1}$, with the median of 80.510 ± 0.647 µg (g of tooth mass)$^{-1}$; while the samples of Malacca show the range of Zn concentrations from 39.030 ± 0.458 µg (g of tooth mass)$^{-1}$ to 382.095 ± 1.248 µg (g of tooth mass)$^{-1}$, with the median of 103.516 ± 0.914 µg (g of tooth mass)$^{-1}$. It is

interesting to note that the difference in the concentration of Zn for these two places is probably due to the presence of a large Pb/Zn smelter in Malacca. The Zn results tend to support the Pb data (P. D. Kluckner and D. F. Brown, 1980)

A total of 49 samples from Klang Valley show Zn concentration to have exceeded the median level of 80.150 ± 0.647 μg (g of tooth mass)$^{-1}$, with the mean tooth-Zn level of 151.759 ± 1.395 μg (g of tooth mass)$^{-1}$ and average age at 45.28 years.

34 samples from Malacca contribute the mean tooth-Zn level of 153.199 ± 1.658 μg (g of tooth mass)$^{-1}$ with the average age of 43.09 years, which is higher than the median level of 103.516 ± 0.914 μg (g of tooth mass)$^{-1}$.

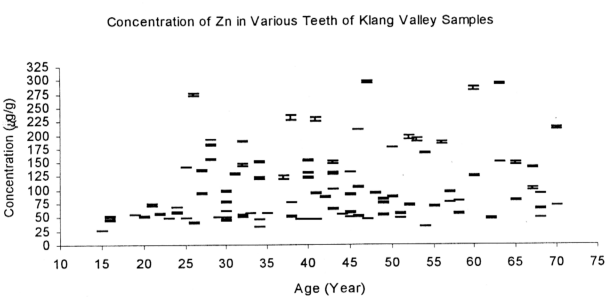

Figure 6.4: Distribution of Zn with different concentration in various teeth of Klang Valley samples

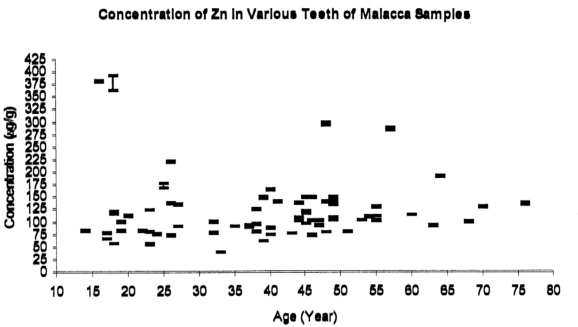

Figure 6.5: Distribution of Zn with different concentration in various teeth of Malacca samples

6.4 Concentration of Cu

Figures 6.6 and 6.7 show the distribution of Cu in various types of teeth versus the age for Klang Valley and Malacca. The Cu concentration ranges from 0.346 ± 0.121 µg (g of tooth mass)$^{-1}$ to 37.945 ± 1.207 µg (g of tooth mass)$^{-1}$ and 0.613 ± 0.391µg (g of tooth mass)$^{-1}$ to 54.754 ± 1.537 µg (g of tooth mass)$^{-1}$ for the samples of Klang Valley and Malacca respectively. Klang Valley shows the mean tooth-Cu level to be 9.202 ± 0.419 µg (g of tooth mass)$^{-1}$, with the median of 6.455 ± 0.302 µg (g of tooth mass)$^{-1}$, while the Malacca samples show the mean tooth-Cu level to be at 15.347 ± 0.428 µg (g of tooth mass)$^{-1}$ with the median of 12.286 ±

0.319 μg (g of tooth mass)$^{-1}$. These concentrations of Cu results are supported by the work done by P. D.Kluckner and D. F. Brown (1980). These Cu data reflect the samples of Malacca have about 60% more concentration than the samples of Klang Valley.

The donors' average age of 44.49 possess the mean tooth-Cu of 14.582 ± 0.573 μg (g of tooth mass)$^{-1}$, which was higher than the median of 6.455 ± 0.302 μg (g of tooth mass)$^{-1}$ for Klang Valley samples. As compared with the samples from Malacca area, the average age stand at 41.15, with the mean tooth-Cu of 23.314 ± 0.530 μg (g of tooth mass)$^{-1}$.

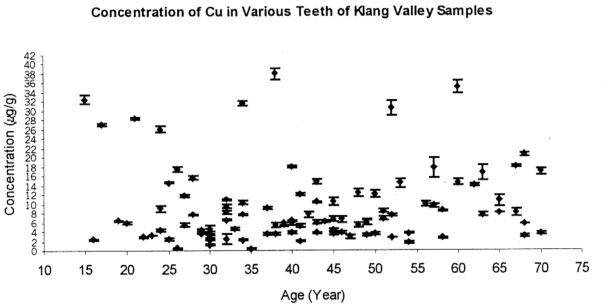

Figure 6.6: Distribution of Cu with different concentration in various teeth of Klang Valley samples

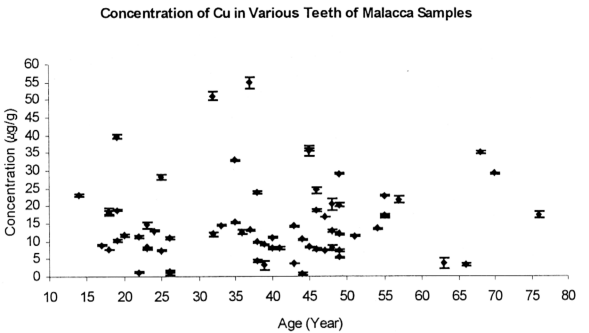

Figure 6.7: Distribution of Cu with different concentration in various teeth of Malacca samples

6.5 Concentration of Cd

Figures 6.8 and 6.9 show the distribution of Cd concentration versus the age of samples from Klang Valley and Malacca respectively. The samples of Klang Valley show the concentration range from 0.0181 ± 0.002 µg (g of tooth mass)$^{-1}$ to 3.910 ± 0.072 µg (g of tooth mass)$^{-1}$, while the samples from Malacca show the concentration to be in between of 0.039 ± 0.019 µg (g of tooth mass)$^{-1}$ and 3.511 ± 0.039 µg (g of tooth mass)$^{-1}$. The mean tooth-Cd for Klang Valley and Malacca reflects the results at 0.324 ± 0.050 µg (g of tooth mass)$^{-1}$ and 0.285 ± 0.032 µg (g of

tooth mass)$^{-1}$ respectively. While the median level for both areas shows at 0.181 ± 0.038 μg (g of tooth mass)$^{-1}$ and 0.142 ± 0.024 μg (g of tooth mass)$^{-1}$ respectively. The Cd concentration stated above shows no significant difference between the samples from Klang Valley and Malacca. Ellis et al (1979) reported that the most important contribution of Cd is from the intake of food and by cigarette smoke inhalation. Therefore, from the analysis of Cd data, these two factors may be the culprit to contribute Cd in donors' teeth. Table 6.2 showed the findings of Cd in certain parts of body by Lars Ahlgren and Soren Mattson (1981).

The results also show that 40 samples from Klang Valley with the average age of 43.55 possesses the mean tooth-Cd of 0.545 ± 0.073 μg (g of tooth mass)$^{-1}$, which is higher than the median level of 0.181 ± 0.038 μg (g of tooth mass)$^{-1}$, while the Malacca samples show the average age at 38.5 years with the mean tooth-Cd of 0.486 ± 0.039 μg (g of tooth mass)$^{-1}$, higher than the median level of 0.142 ± 0.024 μg (g of tooth mass)$^{-1}$.

Table 6.2: Measured cadmium concentration in persons (Lars Ahlgren and Soren Mattson, 1981)

Age	Cd Concentration			
	Kidney cortex (μg g^{-1})	Blood (μg l^{-1})	Urine (μg l^{-1})	Teeth* μg (g of tooth mass)$^{-1}$
35	143 ± 45	3.3	4.4	0.181 ± 0.043
64	36 ± 13	7.0	13.8	0.098 ± 0.010
54	137 ± 42	29.0	28.5	0.106 ± 0.019
35	47 ± 17	5.1	9.9	0.221 ± 0.105
33	30 ± 22	4.7	6.4	0.112 ± 0.032

The concentration of Cd from teeth samples is lower than the concentration of cadmium in kidney cortex, blood and urine as reported by Friberg et al (1974) and Kjellstrom and Nordberg (1978).

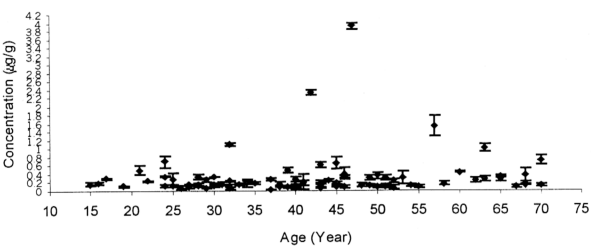

Figure 6.8: Distribution of Cd with different concentration in various teeth of Klang Valley samples

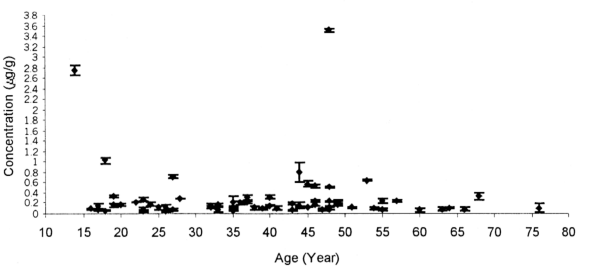

Figure 6.9: Distribution of Cd with different concentration in various teeth of Malacca samples

6.6 Concentration of Ca

Figures 6.10 and 6.11 show the distribution of Ca concentration versus the age of the samples from the Klang Valley and Malacca respectively. The mean tooth-Ca level stands at 23257 ± 130 µg (g tooth mass)$^{-1}$ and 18215 ± 92 µg (g tooth mass)$^{-1}$ for the samples of Klang Valley and Malacca respectively. The median level for the both areas are at 23482 ± 126 µg (g tooth mass)$^{-1}$ and 18389 ± 81 µg (g tooth mass)$^{-1}$ respectively. The concentrations of Ca range from 11099 ± 44 µg (g tooth mass)$^{-1}$ to 37238 ± 132 µg (g tooth mass)$^{-1}$ and 8829 ± 41 µg (g tooth mass)$^{-1}$ to 26542 ± 52 µg (g tooth mass)$^{-1}$ respectively. The Ca concentration of Klang Valley is found slightly higher than the samples from Malacca. On the whole, the

concentration of Ca in the samples show that no significant changes with the increase in age of the donors'.

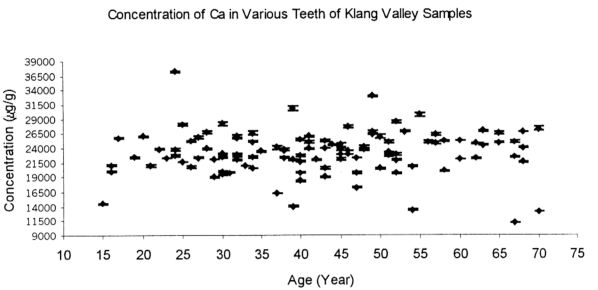

Figure 6.10: Distribution of Ca with different concentration in various teeth of Klang Valley samples

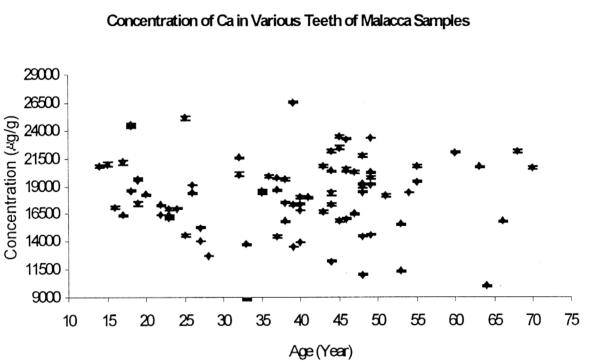

Figure 6.11: Distribution of Ca with different concentration in various teeth of Malacca samples

6.7 Concentration of Mg

Figure 6.12 reflects the distribution of Mg in the samples of Klang Valley. The concentration of Mg scatters from 1656 ± 4 µg (g tooth mass)$^{-1}$ to 5890 ± 19 µg (g tooth mass)$^{-1}$, with the mean tooth-Mg and median level at 3510 ± 21 µg (g tooth mass)$^{-1}$ and 3408 ± 17 µg (g tooth mass)$^{-1}$ respectively. The concentration of Mg is noted to be constant throughout the age of the samples.

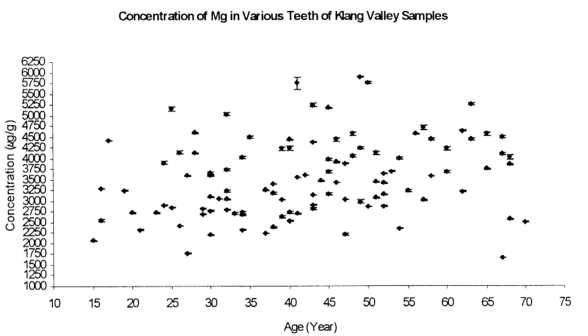

Figure 6.12: Distribution of Mg with different concentration in various teeth of Klang Valley samples

6.8 Results of Comparison of Average Concentration for each Element between Male and Female from the samples of Klang Valley and Malacca

Figures 6.13 to 6.17 show the results of comparing the average concentration for each element between male and female from the samples of Klang Valley and Malacca.

Figure 6.13 shows the average concentration for Pb, which the female samples from Malacca has the highest concentration of 21.2 μg (g of tooth mass)$^{-1}$ compared with other groups. The average concentration of Pb for Malacca male samples also show to be the second highest at 15.0 μg (g of tooth mass)$^{-1}$, compared

with the female and male samples from Klang Valley at 12.3 μg (g of tooth mass)$^{-1}$ and 11.1 μg (g of tooth mass)$^{-1}$ respectively.

However, the average concentration of Zn shows no significant difference between female samples from Klang Valley and Malacca as shown in figure 6.14. Both register a concentration of Zn at 110.8 μg (g of tooth mass)$^{-1}$ and 105.9 μg (g of tooth mass)$^{-1}$ respectively. But the male sample from Malacca shows a higher average concentration of Zn at 148.4 μg (g of tooth mass)$^{-1}$ as compared with 95.2 μg (g of tooth mass)$^{-1}$ of Klang Valley samples.

Figure 6.15 shows the average concentration of Cd to be slightly higher for female samples coming from Klang Valley than from Malacca, which are registered at 0.35 μg (g of tooth mass)$^{-1}$ and 0.26 μg (g of tooth mass)$^{-1}$ respectively. This can be imply that females in industrialized city have more intense smoking habit than the females in Malacca as suggested by Ellis *et.al.* (1979). But the average concentration of Cd does not show significant difference between male samples from Klang Valley and Malacca, which both registered at 0.30 μg (g of tooth mass)$^{-1}$ and 0.32 μg (g of tooth mass)$^{-1}$ respectively.

The average concentration of Cu is higher from the samples of Malacca compared with the samples of Klang Valley as shown in figure 6.16. Both male and female from Malacca have the average concentration of Cu at 16.25 μg (g of tooth mass)$^{-1}$ and 13.98 μg (g of tooth mass)$^{-1}$ respectively. The average concentration of Cu for female and male samples from Klang Valley are 9.76 μg (g of tooth mass)$^{-1}$ and 8.64 μg (g of tooth mass)$^{-1}$ respectively.

The average concentration of Ca is found to be higher for the both female and male samples from Klang Valley as compared with the Malacca counterparts. This trend has been noted in figure 6.17, where the Ca average concentration of female and male samples from Klang Valley are registered at the level of 23591 μg (g of tooth mass)$^{-1}$ and 22916 μg (g of tooth mass)$^{-1}$ respectively whereas Malacca samples only show the Ca concentration of 18311 μg (g of tooth mass)$^{-1}$ and 18048 μg (g of tooth mass)$^{-1}$ respectively.

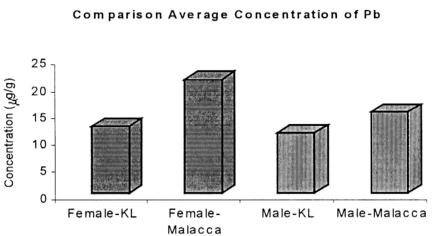

Figure 6.13: The Average Concentration of Pb between Male and Female from Klang Valley and Malacca

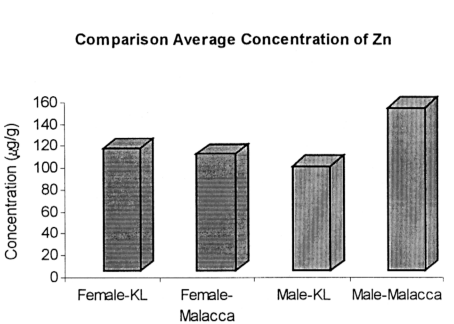

Figure 6.14: The Average Concentration of Zn between Male and Female from Klang Valley and Malacca

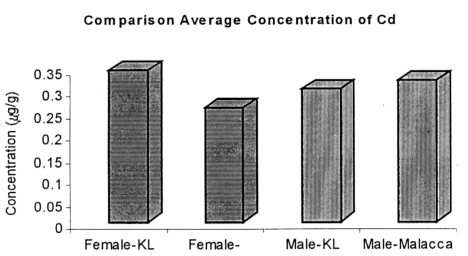

Figure 6.15: The Average Concentration of Cd between Male and Female from Klang Valley and Malacca

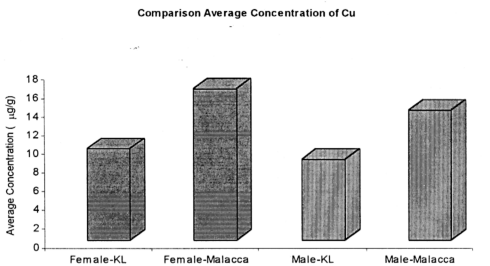

Figure 6.16: The Average Concentration of Cu between Male and Female from Klang Valley and Malacca

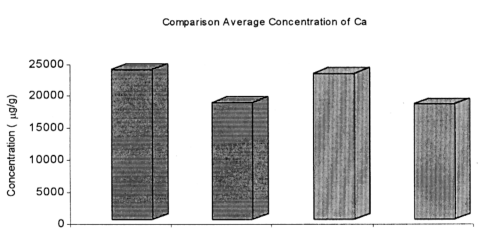

Figure 617: The Average Concentration of Ca between Male and Female from Klang Valley and Malacca

6.9 The Distribution of Concentrations for Each Element in Different Types of Tooth

It is found that incisor tooth contains higher concentration of Pb, Zn, Cu, Cd and Mg as compared with Canine, Premolar and Molar as shown in figures 6.18, 6.19, 6.21, 6.22 and 6.23. However, the average concentration of Ca is constant over these 4 types of tooth as shown in figure 6.20, which records at 21388 ± 114 μg (g of tooth mass)$^{-1}$. Canine is the tooth that contains low concentration of Pb and Cd compared with the other types.

Figure 6.18 shows the Incisor tooth has the higher average concentration of Pb, which records at 22.881 ± 5.370 μg (g of tooth mass)$^{-1}$ compared with Canine, Premolar and Molar. The average concentration of Pb in these three types of tooth is quite constant at the level of ~13 μg (g of tooth mass)$^{-1}$.

The Incisor tooth is found to contain higher average concentration of Zn compared with the other types of tooth as shown in figure 6.19. The average concentration of Zn in Incisor tooth is 154 ± 2 μg (g of tooth mass)$^{-1}$ compared to the lower average concentration of Zn, which was recorded at the level of ~104 μg (g of tooth mass)$^{-1}$ for Canine, Premolar and Molar.

The average concentration of Cd is recorded to be highest at 0.394 ± 0.071 μg (g of tooth mass)$^{-1}$ from the Incisor tooth as shown in figure 6.21, while Canine tooth shows to contain lower Cd at 0.159 ± 0.034 μg (g of tooth mass)$^{-1}$ compared with the average concentration of Cd for Premolar and Molar at the constant level of ~ 0.3 μg (g of tooth mass)$^{-1}$.

Figure 6.22 also shows the average concentration of Cu in Incisor and is found to be the highest among the 4 types of tooth at 16.631 ± 0.724 μg (g of tooth mass)$^{-1}$. Premolar has second highest concentration of Cu at 13.598 ± 0.395 μg (g of tooth mass)$^{-1}$ compared with Canine and Molar.

In view of human tooth development occurs in stages, that the permanent incisors, canines and first molars erupt in prior compared to others; which started from age six to nine. The molars erupt from age 10 to 12, and the second molars come in by age 13. The third molars, or wisdom teeth, usually erupt by the age of 21 (http://encarta.msn.com). Since human tooth compartments would appear to be suitable indicators for these heavy metals for long-term exposure and accumulated (K.Griinke, et.al, 1996), therefore, it was clearly noted that Incisor tooth shows the highest concentrations for Pb, Zn, Cu and Cd. The findings are also directly evidence for the accumulation of these elements in human teeth.

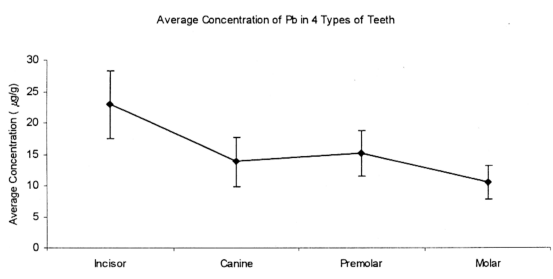

Figure 6.18: Comparison of Average Concentration of Pb in Various Types of Teeth

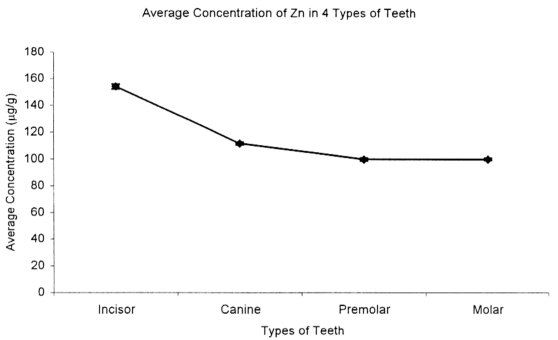

Figure 6.19: Comparison of Average Concentration of Zn in Various Types of Teeth

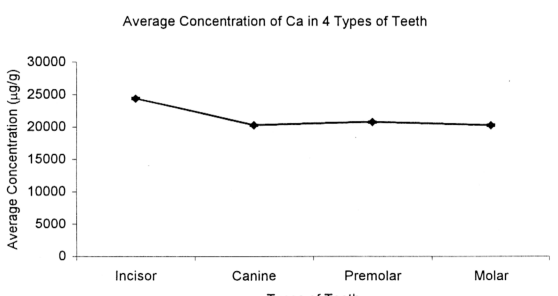

Figure 6.20: Comparison of Average Concentration of Ca in Various Types of Teeth

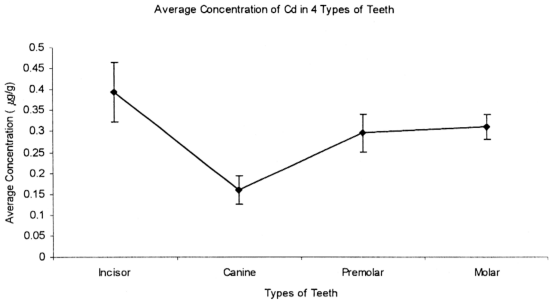

Figure 6.21: Comparison of Average Concentration of Cd in Various Types of Teeth

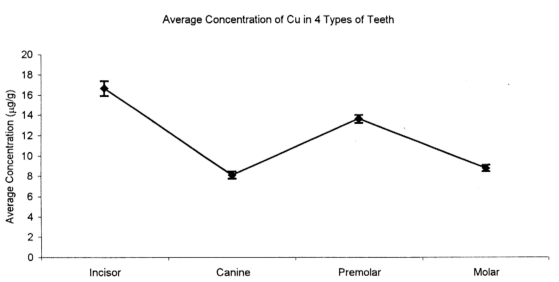

Figure 6.22: Comparison of Average Concentration of Cu in Various Types of Teeth

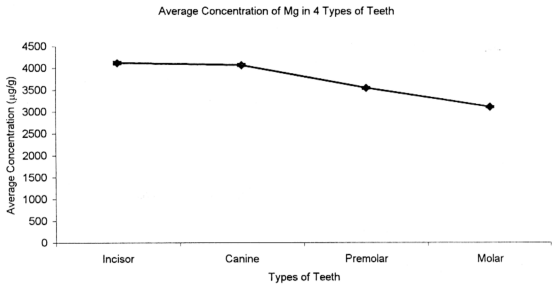

Figure 6.23: Comparison of Average Concentration of Mg in Various Types of Teeth

6.10 Comparison of the Average Concentration of Each Element for the Different Age Groups and Ethnicity

A comparison of the average concentration of each element via the age group of the samples has been plotted out in figures 6.24 to 6.29. No significant trend in terms of age and ethnic could be traced from these figures.

However, the Chinese ethnic seems to have higher concentration of Pb, Cu, Zn and Cd throughout the whole range of age group as compared with the other ethnics. The age group of 56-65 years for Chinese ethnic shows the highest average concentration of Pb at 23.319 ± 4.506 µg (g of tooth mass)$^{-1}$ as compared with the Malay ethnic at 15.429 ± 4.786 µg (g of tooth mass)$^{-1}$ (no Indian samples were available for this age range). Another high average concentration of Pb has been noted for the Chinese at the age group between 15-25 to be at the level of 21.013 ± 4.434 µg (g of tooth mass)$^{-1}$ compared with the Malays and Indians which is at

16.422 ± 4.009 μg (g of tooth mass)$^{-1}$ and 9.327 ± 3.782 μg (g of tooth mass)$^{-1}$ respectively. Chinese ethnic show higher average concentration of Pb for the age group between 36-45, with the Pb concentration recording at 21.840 ± 6.424 μg (g of tooth mass)$^{-1}$ compared with Malay and Indian ethnic at 15.067 ± 2.685 μg (g of tooth mass)$^{-1}$ and 5.348 ± 1.996 μg (g of tooth mass)$^{-1}$ respectively. However, the average concentration of Pb is not clearly distinguishable between the three ethnic for the age groups between 26-35 and 46-55.

Chinese ethnic tends to have a higher average concentration of Cd for the two age groups between 15-25 and 56-65 with the Cd concentration at 0.685 ± 0.042 μg (g of tooth mass)$^{-1}$ and 0.425 ± 0.062 μg (g of tooth mass)$^{-1}$ respectively compared with Malay and Indian ethnic. While Indian ethnic has a higher average concentration of Cd for the age group between 36-45 at 0.644 ± 0.065 μg (g of tooth mass)$^{-1}$ compared with Malay and Chinese ethnic at 0.200± 0.045 μg (g of tooth mass)$^{-1}$ and 0.204 ± 0.030 μg (g of tooth mass)$^{-1}$ respectively. For the age groups between 26-35 and 66-75, show no significant difference is focused for these three ethnic. However the Indians show to have a lower average concentration of Cd at 0.085 ± 0.022 μg (g of tooth mass)$^{-1}$ compared with Malay and Chinese for age group between 46-55 years.

Chinese ethnic show a slightly higher average concentration of Zn compared with other ethnic for the age groups of 15-25, 26-35, 36-45 and 46-55 years. However, for the age group of 56-65, a significant difference of average concentration of Zn has been noted, whereby the Zn concentration of Chinese ethnic

is recorded at 160 ± 1 μg (g of tooth mass)$^{-1}$ compared with 73 ± 1 μg (g of tooth mass)$^{-1}$ for Malay ethnic (no Indian sample collected for this age group).

Chinese ethnic again shows a slightly higher concentration of Cu for age groups of 15-25, 36-45, 46-55 and 56-65 years compared with Malay and Indian ethnic. The Cu average concentration for Chinese ethnic ranges from 7.706 ± 0.388 μg (g of tooth mass)$^{-1}$ to 19.361 ± 0.561 μg (g of tooth mass)$^{-1}$ compared with Malay and Indian ethnic of 6.740 ± 0.669 μg (g of tooth mass)$^{-1}$ to 15.075 ± 0.343 μg (g of tooth mass)$^{-1}$ and 6.456 ± 0.330 μg (g of tooth mass)$^{-1}$ to 20.485 ± 0.332 μg (g of tooth mass)$^{-1}$ respectively.

No significant differences has been noted for the average concentration of Mg and Ca, with their average concentration stands at the level of 3000 μg (g of tooth mass)$^{-1}$ and 20000 μg (g of tooth mass)$^{-1}$ respectively via the age groups of each ethnic origin represents. No further information on the environment for each donor is available, thus the likely reason for further explain could not be ascertain.

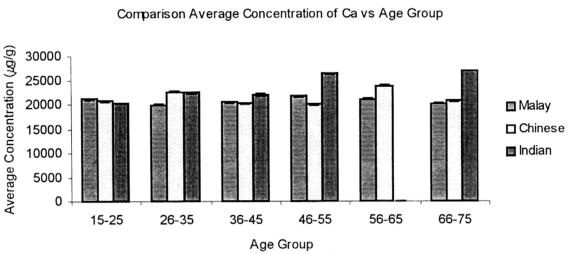

Figure 6.24: Comparison the Average Concentration of Ca via the Age Group for Each Ethnic

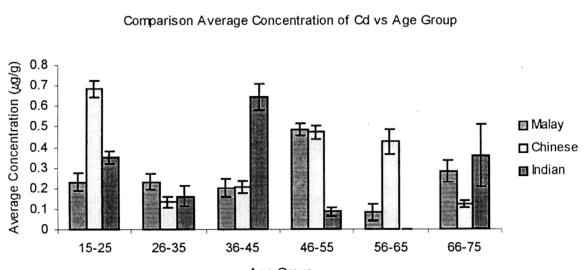

Figure 6.25: Comparison the Average Concentration of Cd via the Age Group for Each Ethnic

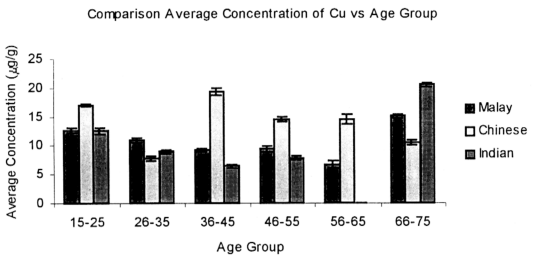

Figure 6.26: Comparison the Average Concentration of Cu via the Age Group for Each Ethnic

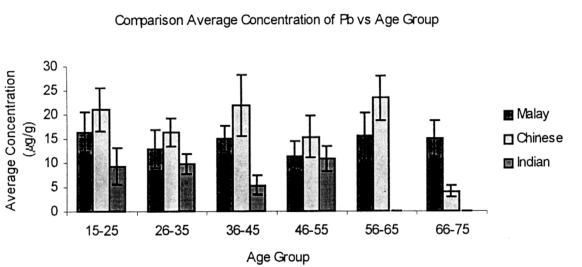

Figure 6.27: Comparison the Average Concentration of Pb via the Age Group for Each Ethnic

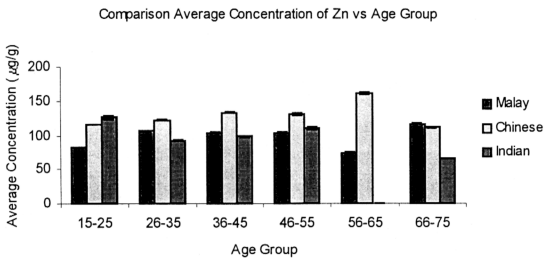

Figure 6.28: Comparison the Average Concentration of Zn via the Age Group for Each Ethnic

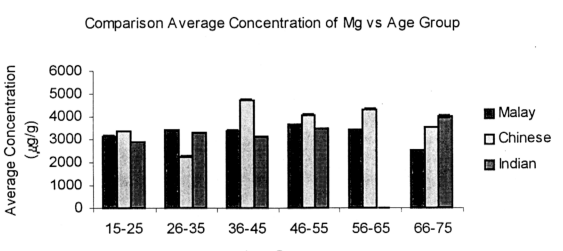

Figure 6.29: Comparison the Average Concentration of Mg via the Age Group for Each Ethnic

6.11 Conclusion

The ICP-AES technique shows to be an excellent measurement for low concentration elements such as Cu, Zn, Mg and Ca, which the average standard deviation for each of them to be less than 5%. However, for Pb and Cd, a high value of standard deviation being 25% and 15% respectively was found. These results imply that the low concentration of the Pb and Cd approaches the system detection limit.

Malacca samples tend to show slightly higher concentration of elements compared to the Klang Valley samples. The comparison has been made through the average concentration of elements relative to their median level of concentration. This trend could be noticed for the elements of Pb, Zn, Cu and Cd.

The working environment for those donors involving in factory activities shows to have concentration of Pb higher than the median level. This scenario has been noted especially from the Klang Valley samples. The level of Pb concentration is higher due to input from the welding metal factory, wire production, automobile factory, aluminium production and etc.

Basically, the results of comparison of average concentration for each element between the male and female from the samples of Klang Valley and Malacca did not show any significant trends. However, the average concentration of Cd was found to be slightly higher for female samples from Klang Valley compared with the samples from Malacca, while the male samples from these areas did not give any significant difference. This could be explained probably by the smoking

habit, which is expected to be more intense for females living in Klang Valley area compared with Malacca.

Incisor tooth shows significant differences from Canine, Premolar and Molar, whereby the average concentration of Pb, Zn, Cu, Cd and Mg is higher. The only exception is the distribution of Ca in the Incisor, which is in constant match with the other types of tooth.

The average concentration for each element was also being studied as a factor of ethnic group compared between various age; Malay, Chinese and Indian. But on the whole there are significant trends in term of age and ethnic and could be traced from these results. However, the Chinese ethnic shows to have a higher concentration of Pb, Cu, Zn, and Cd throughout the whole range of age group compared with the other ethnic.

References:

Ellis, K.J., Varstsky, D., Zanzi, I., Cohn, S.H. and Yasumura, S., 1979, *Cadmium: invivo measurement in smokers and non smokers, Science,* N.Y. 205 323.

Friberg, L., Piscator, M., Nordberg, G. and Kjellstrom, .T., **1974**, *Cadmium in the Environment 2nd edn (*Cleveland, Ohio: CRC)

K. Griinke, H.J.Stark, R. Wennrich, U. Franck, 1996. *Determination of traces of heavy metals (Mn, Cu, Zn, Cd and Pb) in microsamples of teeth material by ETV-ICP-MS*, Fresenius J Anal Chem, 354: 633-635

Kjellstrom, T. And Nordberg, G.F., **1978**, *Environ. Health,* 31, 292

L.T.Chew, D.A.Bradley, Y.A.Amin and M.J.Maah, 2000, *Zinc, Lead and Copper in Human Teeth measured by Induced Coupled Argon Plasma Atomic Emission Spectroscopy (ICP-AES)*, Applied Radiation and Isotopes 53, 633-638.

Lars Ahlgren and Soren Mattsson, 1981, *Cadmium in man measured in vivo by x-ray fluorescence analysis,* Phys.Med.Biol. Vol.26, No. 1, 19-26

Paul D. Kluckner and David F.Brown, 1980, *Analysis of Teeth By Plasma Emission Spectrometry,* Developments in Atomic Plasma Spectrochemical Analysis, Proceedings of International Winter Conference San Juan, Puerto Rico, 7-11 January 1980, pg.713-717.

Steenhout, A., Pourtois, M., 1981. *Lead accumulation in teeth as a function of age with difference exposure*, Br. J. Ind. Med., 38, 297.