# DETERMINATION OF TRACES OF HEAVY ELEMENTS (Pb, Zn, Cu, Cd, Ca and Mg) IN HUMAN TEETH FROM KLANG VALLEY AND MALACCA USING ICP-AES AND XRF TECHNIQUES

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*To my beloved parents*

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# *Abstract*

X-ray Fluorescence (XRF) and Inductively Coupled Plasma—Atomic Emission Spectrometry (ICP-AES) have been used to study the concentration of heavy metals in human teeth.

XRF technique has been used to determine Pb concentration in human teeth with the excitation source of Tc-99m combined with an XR-100T-CZT detector. The sensitivity of this system to determine the concentration of Pb lower than 800 ppm was constrained by Tc-99m's γ-ray energy of 140.5 keV. High percentage errors in the calculation of average mean of differences for each concentration (from 100 ppm to 800 ppm) were found if compared with the respective background measurements which caused the failure of setting up a standard calibration for this system.

To further determine the expected experimental counts measured by this XRF technique, a simple theoretical model has been developed to calculate the total count for the peak of Pb $K_{\alpha 1}$.

ICP-AES was used to determine Pb, Zn, Cd, Cu, Ca and Mg levels in 199 exfoliated human teeth (all of which required extraction for orthodontic reasons) from Klang Valley and Malacca areas. Lead concentrations for these groups were found to rang from $0.713 \pm 0.039$ μg (g of tooth mass)$^{-1}$ to $55.512 \pm 8.945$ μg (g of tooth mass)$^{-1}$, while for other toxic elements, Cd ranged in between of $0.0181 \pm$

0.002 μg (g of tooth mass)$^{-1}$to 3.9110 ± 0.072 μg (g of tooth mass)$^{-1}$. Zn and Cu showed the concentration levels from 26.470 ± 1.252 μg (g of tooth mass)$^{-1}$ to 296.630 ± 2.762 μg (g of tooth mass)$^{-1}$ and 0.346 ± 0.121 μg (g of tooth mass)$^{-1}$ to 54.754 ± 1.537 μg (g of tooth mass)$^{-1}$ respectively. The concentration levels for Ca and Mg were found higher if compared with others, which in between 8828 ± 40.551 μg (g of tooth mass)$^{-1}$ to 37238.024 ± 131.961 μg (g of tooth mass)$^{-1}$ and 1655.792 ± 4.108 μg (g of tooth mass)$^{-1}$ to 5889.979 ± 18.851 μg (g of tooth mass)$^{-1}$ respectively.

This study also showed the working environment especially for those donors involved in factory activities (welding metal, wire, automobile, refrigerator, alumininium) seemed to provide lead concentrations higher than the median level. This trend was noted especially from the Klang Valley samples.

Besides, the correlation coefficients had been calculated to investigate the two relationships, namely (1) the relationship between the element concentration and the age of donor, (2) the relationship between each element.

The correlation coefficients for Mg and Ca, and Zn and Cd, were calculated at 0.251 and 0.416 respectively. These coefficients were further determined by using a tow-tailed T-test to determine the significant of them at the 1% level. This statistical test showed there is some correlation between Zn and Cd, and Ca and Mg.

The findings also showed that the female samples indicated the concentration of Pb increased as the age of female donors increased.

# ***Abstrak***

Kaedah 'X-ray fluorescent' (XRF) dan 'Inductively Coupled Plasma—Atomic Emission Spectrometer' (ICP-AES) telah digunakan untuk mengkaji kepekatan logam berat di dalam gigi manusia.

Teknik XRF telah digunakan untuk menentukur kepekatan plumbum di dalam gigi manusia dengan sumber radioaktif Tc-99m sebagai penguja, dan alat pengesan XR-100T-CZT. Kepekaan sistem ini untuk menentukan kepekatan Pb yang lebih rendah daripada 800 ppm telah dihadkan oleh tenaga sinaran gamma bagi Tc-99m, iaitu 140.5 keV. Peratusan ralat yang tinggi dalam pengiraan bagi "Average Mean of Differences" untuk setiap kepekatan dari 100 ppm ke 800 ppm akan didapati jika dibandingkan dengan pengukuran nilai latar belakang yang terlibat. Oleh kerana itu, eksperimen XRF ini tidak sesuai untuk mendapatkan satu piawai penentukuran bagi sistem ini.

Untuk penentuan kejituan eksperimen ini, satu model kiraan teori telah digunakan. Model kiraan ini telah digunakan untuk menentu jumlah bilangan bagi puncak $K_{\alpha 1}$, bagi Pb.

ICP-AES digunakan untuk menentukan kepekatan bagi Pb, Zn, Cd, Cu, Ca dan Mg di dalam gigi manusia, di mana sejumlah 199 sampel telah dikumpul dari kawasan Lembah Klang dan Melaka. Kepekatan Pb bagi dua kawasan ini berada di antara $0.713 \pm 0.039$ μg (seunit jisim dalam gram)$^{-1}$ dan $55.512 \pm 8.945$ μg (seunit

jisim dalam gram)$^{-1}$, di mana bagi unsur-unsur yang lain, seperti Cd, kepekatannya berada di antara 0.0181 ± 0.002 μg (seunit jisim dalam gram)$^{-1}$ dan 3.9110 ± 0.072 μg (seunit jisim dalam gram)$^{-1}$. Manakala Zn dan Cu menunjukkan kepekatan masing-masing berada di takat dari 26.470 ± 1.252 μg (seunit jisim dalam gram)$^{-1}$ kepada 296.630 ± 2.762 μg (seunit jisim dalam gram)$^{-1}$ dan dari 0.346 ± 0.121 μg (seunit jisim dalam gram)$^{-1}$ kepada 54.754 ± 1.537 μg (seunit jisim dalam gram)$^{-1}$. Kepekatan bagi Ca dan Mg telah didapati tinggi jika dibandingkan dengan yang lain, di mana kepekatan berada di takat antara 8828 ± 40.551 μg (seunit jisim dalam gram)$^{-1}$ kepada 37238.024 ± 131.961 μg (seunit jisim dalam gram)$^{-1}$ dan 1655.792 ± 4.108 μg (seunit jisim dalam gram)$^{-1}$ kepada 5889.979 ± 18.851 μg (seunit jisim dalam gram)$^{-1}$ masing-masing.

Kajian ini juga memaparkan pengaruh kesan negatif alam sekitar terhadap penderma-penderma gigi sampel ini, terutamanya bagi mereka yang terlibat dalam aktiviti-aktiviti kilang (seperti di kilang besi, kilang wayar, kilang kereta, kilang peti sejuk, kilang aluminium). Kepekatan Pb bagi kumpulan sampel tersebut adalah lebih tinggi daripada paras median dan paling ketara bagi sampel dari Lembah Klang.

Di samping itu, 'correlation coefficient' telah dikira untuk mengkaji 2 jenis perhubungan, iaitu (1) kepekatan unsur-unsur dengan umur penderma-penderma sampel, dan (2) perhubungan di antara setiap unsur.

Didapati bahawa 'correlation coefficient' bagi Mg-Ca, dan Zn-Cd, adalah berada di 0.251 dan 0.416 masing-masing. 'Correlation coefficient' ini telah ditentusahkan selanjutnya dengan menggunakan kaedah statistik, iaitu "t-test" pada paras 1%. Ini telah menyesahkan perhubungan di antara Mg-Ca dan Zn-Cd.

Kajian ini juga menunjukkan bahawa kepekatan Pb untuk sampel bagi kumpulan wanita meningkat secara langsung dengan umur mereka.

# *Contents*