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Heavy Metals in Human Hair Related to Age Groups and Automotive Pollution Levels of Bandarlampung City, Indonesia

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Metallic elements are found in all living organisms, where they play a variety of roles. Some metals are essential elements and their deficiency results in impairment of biological function, but when present in excess, essential metals may also become toxic. Metals as elements or metallic compounds constitute a certain part of the earth's crust. In the air metals may occur as aerosols, and in some instances as vapor. A number of metals is thus found in the fly ash from coal-fired power plants. Depending on the source of the coal, the fly ash may contain different concentration of Pb, Cd, Zn, As etc. (Friberg et. al. 1986). According to Tugaswati et.al. (1988), the increase automobile use is followed by an increase in fuel consumption. Leaded gasoline which is used as fuel in motor vehicles gives rise to air pollution in the form of lead-containing aerosols, particularly in cities a long highways.

Hair is a metabolic end product that incorporates metals into its structure during the growth process. Therefore the determination of heavy metals content in hair is understood to play an important role in exposure assessment and has been explored as a tool for monitoring the impact of environmental pollution on the inhabitants of a community (Ashraf et. al 1994). The previous studies have reported when that if compared to other biological material, hair offers a number of advantages; (1) Easy to obtain without injuring the donor. Thus we can collect samples from any population including anthropological survey population, (2) Can be stored for long periods of time before being analyzed without deterioration since the elements in the sample are assumed to be stable, and (3) The concentration of most elements are relatively high in hair as compared to the rest of the body (Suzuki 1988 and Wilhelm et. al. 1980).

The objective of this study was to determine the range of lead (Pb), cadmium (Cd), copper (Cu), and zinc (Zn) content in hair samples taken from inhabitants of Bandarlampung city related to the age groups and automotive pollution levels of each sampling site. Therefore, the data obtained might be of use as a basis of comparison for any further studies.

MATERIALS AND METHODS

A total of 112 hair samples from inhabitants participating ranging in age from 6 –

70 years, were collected and stored in separate clean plastic bags until used. Samples taken from three different sites related to their volume of traffic per hour such as site of; Panjang (651 vehicles/hour), Langkapura (438 vehicles/hour), and Sukarame (31 vehicles/hour). Concerning their volume of traffic per hour, the cite of Panjang, Langkapura, and Sukarame are considered as; heavy, moderate, and light volume of traffic respectively. Those samples were also broken down into the three groups of age such as; children (<14 years), adult (15-44 years), and elderly (>45 years).

Hair samples were washed with acetone, rinsed with deionized water and again with acetone and then dried it in the room temperature. 0.1 Gram of washed sample was put into a test tube and weighed, dried in the oven at 110° C. for 48 hours and weighed again to determine water content. 1.0 ml of concentrated metal free nitric acid (60-70%) was poured on the dried sample and placed at room temperature overnight or longer covered by a sheet of filter paper. They were ashed and ash them on a hot plate until dry. 2.0 ml of 14% nitric acid were then added and the residue at the bottom of the test tube was dissolved. Pb, Cd, Cu, and Zn in the solution were assessed by flame-less atomic absorption spectrophotometry (Hitachi 180-30), with background correction. Each sample was analyzed two or three times by an auto-sampler. The wavelengths of Pb, Cd, Cu, and Zn were; 283.3 nm, 228.8 nm, 324.8 nm, and 308 nm, respectively. Under the same conditions, 0.1 gram of standard material (bovine liver No. 1577) provided by the US National Bureau of Standard was used as a reference to confirm the accuracy.

RESULTS AND DISCUSSION

In order to further evaluate the relationship between volume of traffic and heavy metal content in the hair samples of 112 inhabitants of Bandarlampung city, Pb, Cd, Cu, and Zn concentration in hair samples were analyzed and their arithmetic mean and standard deviation were calculated. Table 1. shows that the highest concentration of Pb and Cd in hair found in the site of Panjang (651 vehicles/hour) were; 40.65 μg/g for Pb and 0.63 μg/g for Cd. In the site of Langkapura (438 vehicles/hour), concentration Pb and Cd in hair were; 29.28 and 0.62 μg/g respectively, indicated lower than that site of heavy volume of traffic. The lowest Pb and Cd concentration in hair were found in cite of Sukarame (31 vehicles/hour) were; 14.65 and 0.39 μg/g respectively. These results may clarify that the relationship might exist between volume of traffic (vechicles/hour) to a concentration Pb and Cd in hair. However, hair Pb and Cd concentration were positively correlated with the automotive pollution, since the rural areas which considered as use little of leaded gasoline are lower than that areas which use greater amount of leaded gasoline. These present data are in agreement with previous reported data of Chattopadhyay et. al. (1990) that the mean cadmium level of hair of urban volunteers in Calcutta (1.4 μg/g was twice higher than that of rural volunteers. Jamall and Allen (1990) also reported that the data of women living in the city of Karachi have approximately 600% higher Pb levels in their hair than their age-matched counterparts living in the rural environment in

Bangladesh. Tugaswati et.al. (1988) also reported that there is a clear relationship between volume of traffic and Pb concentration in blood from the samples collected in Jakarta. Their data show that Pb in blood collected in the area of heavy traffic volume or 6,570 vehicles/ hour was 3.59 μg/m3, and in the area of light traffic volume or 40 vehicles/ hour was 0.31 μg/m3.

Table 1. Heavy metals (Pb, Cd, Cu, and Zn) content in human hair according to the site and volume of traffic in Bandarlampung city (μg/g. dry wt.).

No	Location (freq.of automotive/hour)	Pb (μg/g)	Cd (μg/g)	Cu (μg/g)	Zn (μg/g)
1.	Panjang (651)				
	N	51	36	31	31
	Mean	40.65	0.63	10.40	309.26
	Std. Dev.	39.09	0.41	2.84	160.66
2.	Langkapura(438)				
	N	32	22	20	20
	Mean	29.98	0.62	11.23	498.71
	Std. Dev.	22.64	0.50	3.30	381.70
3.	Sukarame (31)				
	N	29	19	24	24
	Mean	14.65	0.39	10.65	585.51
	Std. Dev.	15.32	0.33	3.42	332.90
	Total				
	N	112	77	75	75
	Mean	30.67	0.57	10.70	406.85
	Std. Dev.	26.40	0.43	3.14	330.71

In contrast, the highest Cu and Zn concentration in hair occurs in the site of light volume of traffic or Sukarame (31 vehicles/hour) were; 10.65 and 585.51 μg/g respectively. The lowest concentration in hair found in the site of heavy volume of traffic or Panjang (651 vehicles/hour) were 209.26 μg/g, and then followed by the site of moderate volume of traffic or Langkapura (438 vehicles/hour) was 498.71 μg/g. Meanwhile, the data in the site of moderate volume of traffic or Langkapura shows that Cu concentration in hair was the lowest one (11.23 μg/g), and then followed by the site of heavy volume of traffic or Panjang (10.40 μg/g). Similar results have been reported in Ghana by Golow and Kwaansa-Ansah (1994) that Zn concentration in hair of pupils Ayaduase School where considered as a small suburb with only one major road running through it, were higher (ranging from 274.08 – 291.99 μg/g) if compared with those of Ayigya, Atonsu-Agogo, and Kwadaso School considered as a larger suburb which have more than one major road (ranging from164.23 - 193.00 μg/g).

The data of overall mean Pb and Cd concentration in hair of this study were 30.67 and 0.57 μg/g, respectively, relatively higher than the data of Ahmed and Elmubarak (1990) that in England, Saudi Arabia, Sudan, and West Germany Pb concentration in hair were 10.2, 6.3, 14.1, and 8.2 μg/g, respectively, and the data of Cd concentration were 0.47, 0.19, 0.18, and 0.42 μg/g, respectively.

Table 2. Heavy metals (Pb, Cd, Cu, and Zn) content in human hair breakdown to the age groups (μg/g. dry wt.).

No	Age Group	Pb (μg/g)	Cd (μg/g)	Cu (μg/g)	Zn (μg/g)
1.	Children (<14 yrs.)				
	N	29	19	17	22
	Mean	38.46	0.54	12.42	119.78
	Std. Dev	35.09	0.41	3.02	85.00
2.	Adult (15 – 44 yrs.)				
	N	69	43	69	69
	Mean	26.16	0.61	11.94	119.03
	Std. Dev	22.54	0.39	3.68	100.00
3.	Elderly (>45 yrs.)				
	N	13	13	13	13
	Mean	23.07	0.52	12.23	88.43
	Std. Dev	20.68	0.59	3.22	97.80

Comparison to the data of Sen and Chaudhuri (1996) Pb and Cu levels in occupationally unexposed population groups in Calcutta were 3.48-6.91 and 8.04-11.34 μg/g, respectively, relatively lower than the data of this study for Pb and Cu were ranging 14.65-40.65 and 10.40-11.23 μg/g, respectively.

The differences of the data obtained in this study from other data reported are often one of the strongest arguments against hair analysis based upon the difficulty of distinguishing endogenous (via blood circulation, sebaceous secretion, exocrine and apocrine sweat) and exogenous (dust, water, shampoo, cosmetic treatment, external medication) source of metal (Wilhelm et. al. 1989). However, they may also be attributed to the possibility that artificial hair treatments such as dyeing, bleaching and waving alter the quality of hair. Thus, they may cause the direct elimination of hair constituents and a change in the elemental absorption into hair (Suzuki, 1988).

The data of heavy metal content according to the age groups (Table 2.) shows that the highest of Pb, Cu, and Zn content in hair were found in group of children or 38.46, 12.42. and 119.78 μg/g, respectively but for Cd was found in the group adult or 0.61 μg/g. The lowest of Pb, Cd, and Zn content in hair were found in the group of elderly or 23.07, 0.52, and 88.43 μg/g, respectively and for Cu was found in the group of adult or 11.94 μg/g. This may indicate that contaminated soil and dust may be ingested either directly or indirectly as a result of hand-to-mouth activity, and because of this it may represent a significant pathway for make metal intake, especially to the young children. Furthermore, this might indicate that the growth rate of hair is altered by nutritional status, and the change of growth rate may not parallel the rate of deposition of trace elements into hair. Hair Zn and Cu concentration have been used to detect nutritional deficiencies of those essential trace element. In children, it has been suggested that Zn levels < 70 μg/g are indicative of a severe Zn deficiency (Jamall and Allen, 1990). According to

Matsubara and Machida (1985), elemental analysis data of human hair can be a first-step approximation of human contamination and this information should then be supplemented by data on other tissues.

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