

Quantification of Toxic Elements in Tail Hair of Cows as an Indicator of Environmental Exposure in Different Areas from Iran

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Abstract. This paper describes a new comparison and determination for demonstrating the levels of Al, Cd and Pb in cow's tail hair between Tehran as a polluted area and Semnan as an area free from pollution. The hair samples were collected from a total 227 apparently healthy lactating cows above 3 years of age. This includes 165 cows reared in industrial and urban area (Tehran) and 62 cows reared in area supposed to be free from pollution (Semnan). Prior to analysis, samples were washed with 0.1M HCl, acetone and deionized water. The hair samples were digested afterward in a mixture of nitric and perchloric acid mixture (HNO₃:HClO₄=4:1 v/v). Concentrations of all metals were assessed by flame and graphite furnace atomic absorption spectrophotometer.

Key words: Toxic Elements, Tail hair, Cow, Environmental exposure

Introduction

The levels of trace elements are an important to increasing environmental pollution and it can result in various deleterious health effects in human and other animals. Lead and cadmium are the two most abundant heavy metals in the environment, often coexist in a polluted environment [1] and are mostly implicated in human and animal poisoning [2]. The common sources of lead and cadmium are diverse in nature including natural and anthropogenic processes such as combustion of coal and mineral oil, smelters, mining, alloy processing units, paint industries, etc.[3]. A variety of exposure routes allow toxic heavy metals predominantly lead and cadmium to enter the food chain of farm animals [4], Chronic exposure to these sulfhydryl reactive metals through various routes results in their higher accumulation in tissues, bones, hair and blood, and monitoring of these toxic metals in biological materials essentially indicates the status of environmental degradation [5-7].

Hair fiber is a metabolically dead material after it leaves the epidermis. However, the fiber in the root during its growth is metabolically very active. This is mainly because of the certain advantages offered by hair over other clinical specimens such as blood or urine, namely; (i) the concentrations of most trace elements are higher in hair than other clinical specimens; (ii) the

stability of hair, as a biological material, which facilitates the storage and transport processes; (iii) unlike other clinical samples, hair is inert and chemically homogeneous, and (iv) trace elements present in the body are incorporated into the hair during its growth[8-10]. Hair samples have been used for noninvasive diagnosis of cadmium toxicity in humans [11]. The frequency of diseases such as autism has been predicted in humans using data on hair concentrations of cadmium and other minerals [12]. Therefore it is hypothesized that increasing hair trace element levels in cows around industrial area, may influence the concentration of trace elements in milk.

In Iran, metal pollution is more than other countries so the status of toxic elements in food and drinking water in Iran is more than any other country. It triggers a lot of investigation. The main goal of this study was to evaluate the use of tail hair as a biomarker of lead, cadmium and aluminum, contents in cows above 3 years of age. The obtained concentration values of tail hair samples of Tehran as a polluted area were compared with Semnan as an area free from pollution. Quantification was performed by flame and electro thermal atomic absorption spectrometry (FAAS and ETAAS).

Methods and Materials

Sample Collection

During 2010 – 2011, respective tail hair samples were collected from a total of 227 lactating cows of above 3 years of age reared in either around different industrial area from Tehran (n=165) and in non-polluted of Semnan province (n=62). Hair samples were taken from the tail switch using a scalpel and stored individually in sealed plastic bags at room temperature.

Instrumentation

A Varian model Spectra AA-220 (Mulgrava, Victoria, Australia), atomic absorption spectrometer equipped with a GTA-100 graphite furnace atomizer and deuterium lamp background correction was used with hollow cathode lamps (Varian). The spectrometer parameters are shown in Table 1.

Table 1. Spectrometer operating conditions and techniques.

Elements	Wavelength (nm)	Spectral bandwidth (nm)	Lamp current (mA)
Cd	228.8	0.5	4.0
Al	309.3	0.5	10
Pb	217.0	1.0	5.0

Reagents and Standard Solutions

Suprapure Merck HNO₃ and HClO₄ was used in the treatment of tail hair samples and preparation of standard solutions. All reagents used in the present study were of analytical grade obtained from E. Merck. Deionized water of high purity (from a Millipore ultra-pure water system) was used. Cd, Al and Pb stock standard solutions at a concentration of 1.000 g. L⁻¹ was prepared from, cadmium nitrate 4-hydrate, aluminum nitrate 9-hydrate and metal strip respectively (Merck).

Glassware, nalgene bottles and sealed plastic bags were all cleaned in 5% (v/v) nitric acid before use.

Washing Procedures

The risk of sample contamination during the sampling and digestion was minimized. Prior to analysis, hair samples were washed with solutions 0.1M HCl, acetone and water [14]. The washing procedure, each hair sample was weighed directly into a conical sample tube, 25 mL of the washing solution was added and the tube capped. The container was shaken on a mechanical shaker for 4h at 20 °C. Then the supernatant was pipetted-off and kept for further analysis. The residue was treated twice, each time with 40 mL of deionized water, shaken for 4h and the water was pipetted-off. The hair sample was oven-dried at 70 °C for 8 hs and then digested the next day.

Hair Digestion Procedures

All washed hair samples were digested by weighing the sample directly (about 1 g) into teflon bombs, and mixture of nitric and perchloric acid mixture (HNO₃:HClO₄=4:1 v/v) was added. The samples were heated on a hot plate (initially at 90 °C for 120 min and then at 130 °C for 100 min). Standard solution of each element was prepared in a mixture of HNO₃, HClO₄ and deionized water. Detections were carried out using AAS and ETAAS.

Analysis of data

The values of the metal concentrations in tail hair of the subjects were presented as arithmetic mean (μg g⁻¹) with standard deviation (±SD). The statistical significance of concentrations of heavy metals between different parameters was determined by ANOVA as appropriate. The level of significance was set at P<0.05. All calculations were performed using statistical packages SPSS (VERSION 14).

Results and Discussion

Hair is a keratin-rich tissue with abundance of cysteine residues, the sulfhydryl group of which binds with divalent cations such as lead and cadmium leading to their persistence in hair for a long period [7, 13]. Table 2 shows the Pb, Cd and Al concentrations in tail hair from cows (n = 227) reared in industrial (Tehran) and unpolluted areas (Semnan). Cows in the vicinity of Tehran had significantly (P< 0.05) higher concentrations of Pb and Cd in tail hair than cows from the Semnan. Cows reared around industrial urban had higher Al levels than control animals (0.37 ± 0.01 mg/mL). However, Al concentrations in tail hair samples from Tehran did not differ significantly from cows reared in Semnan.

Table 2. Pb, Cd and Al residues in hair (mg/g) in cattle reared around industrial and unpolluted areas

Area/Elements	Pb	Cd	Al
Tehran (n=165)	13.09 ± 0.91	3.45 ± 0.38	0.41 ± 0.02
Semnan (n=62)	6.98 ± 0.54	2.78 ± 0.12	0.37 ± 0.01

The values are expressed as mean ±SE. Values with different superscripts between rows in a column vary significantly at (P<0:05). Values in parentheses indicate ranges.

Fig. 1 shows a scatter plot of continuous data from 227 animals and quadratic regression with number of cows on the x axis and hair Pb and Cd in Tehran and Semnan on the y axis. Cows in the Tehran had significantly higher concentrations of Pb and Cd in tail hair than cows from the Semnan.

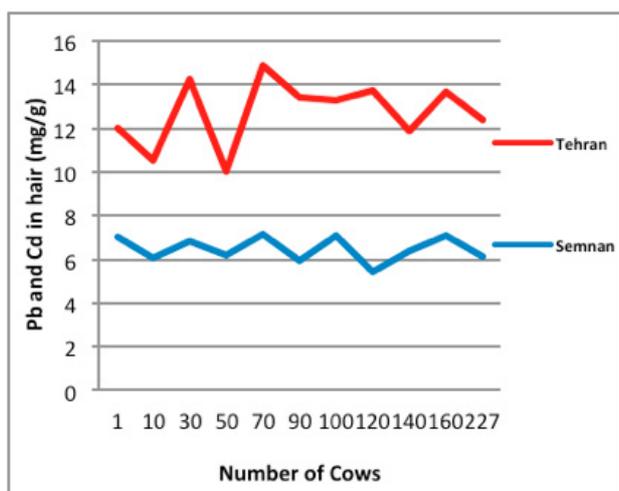


Fig. 1. Scatter plot of continuous data from 227 animals from polluted and unpolluted localities with number of cows on x axis and hair Pb and Cd (mg/g) on y axis.

The scatter plot of continuous data on hair Al concentrations revealed a significant ($P < 0.05$) quadratic regression between these two areas (Fig. 2). However, the hair Al concentration was found to be a poor indicator.

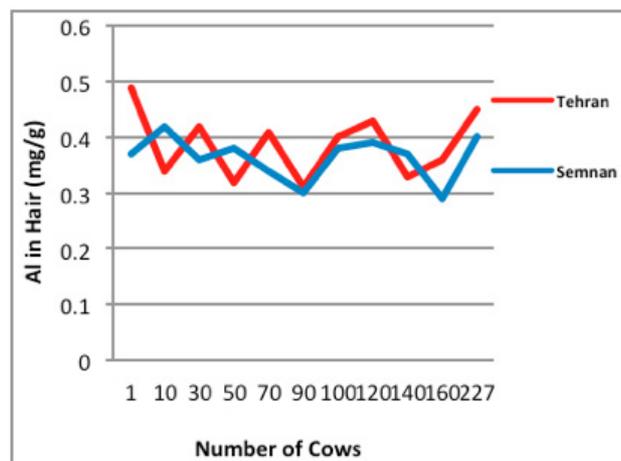


Fig. 2. Scatter plot of continuous data on hair Al (mg/g) concentrations from 227 animals from polluted and unpolluted localities.

Conclusion

It is concluded that Pb and Cd accumulation in hair in the polluted area and unpolluted localities. Also strong positive correlation was between Pb and Cd concentrations from Tehran as a polluted area and Semnan as an area free from pollution. However Al

concentrations in tail hair samples did not differ significantly from two areas.

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