Arsenic in cattle: Evaluation of possible exposure biomarkers

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ABSTRACT: Arsenic pollution is naturally present in groundwater and soils of the main agriculture production areas in Argentina. Arsenic can be taken up and bioaccumulated by forages, and may be bio-transferred to animals, food and humans. Blood and hair are generally used in humans as biomarkers but there is a lack of information in livestock. This study shows that As levels in cattle hair from As affected area were significantly higher than in the control area. In analyzed blood samples no significant differences were found between control and As affected areas. Blood appear not to be an effective biomarker in cattle such as it has been determinate for human but hair may indicate chronic exposure in cattle.

1 INTRODUCTION

Arsenic (As) pollution affects several countries around the world. One of the most affected countries is Argentina, where As is naturally present in groundwater and soils of the main agriculture production areas (Bundschuh *et al.*, 2012). Arsenic can be taken up and bioaccumulated in plants and livestock, which means a potential risk to human health through agri-food.

Presence of toxic substances in blood is a known exposure biomarker (Lowry *et al.*, 1989). On the other hand, in the case of As, its levels in cattle hair might be used as another biomarker exposure. Even though, it is commonly used for humans, there is a severe lack of knowledge for other animal species.

The aim of this study is to assess total arsenic levels in soils and drinking water from cattle farms; and to analyze the relationship with blood and hair As content in cattle.

2 MATERIAL AND METHODS

This study was carried out in the Pampean Plain (Argentina). The study area is one of the most important livestock production regions. The samples zones were located in Buenos Aires province (Control area) and in the southeast of Cordoba province (As affected area).

Soil and drinking water samples were taken up from livestock production systems and dairy farms. Soil samples correspond to surface soil (0 to 20 cm deep). Samples were collected along transect in the field at regular intervals. Arsenic determination was according to ISO 11466 (1995). Soils were digested

using a mixture of nitric and hydrochloric acids (1:3) at 120°C during 2 h with reflux. Water samples correspond to groundwater used for cattle. They were collected in polypropylene tubes, acidified at 20% with HNO₃ and conserved refrigerated at 4°C. Blood and hair samples were collected from adult and female Holando cows. The samples were digested with HNO₃ at hot plate. Arsenic in all samples were determined by inductively coupled plasma optical emission spectrometry (ICP-OES, Optima 2000, Perkin Elmer).

3 RESULTS AND DISCUSSION

Usually, arsenic in soils ranged between 1 to 95 mg kg⁻¹ (Kabata & Pendias, 2001), and in groundwater (main water source for animal drinking in the Pampean Plain) arsenic is documented in the literature up to values of 5000 µg L⁻¹ (Ravenscroft *et al.*, 2009). Maximum total As content for animal drinking water and soil destined to agricultural activities in Argentina are 0.5 mg L⁻¹ and 20 mg kg⁻¹ respectively (Law 24.051), but the international guidelines recommend a maximum level of As in animal drinking water 200 µg L⁻¹ (FAO, 1985) and in agricultural soil 17 mg kg⁻¹ (CCME, 2001). The As levels for all samples analyzed in this study are shown in Table 1.

It is known that drinking water is the main As source for cattle (Perez Carrera *et al.*, 2012, 2016), the levels obtained through forage and fodder or accidental soil take up is relatively low. In the analyzed soil samples, As levels were below the detection limit (LD = 3.5 mg kg⁻¹).

Regarding to As level in hair, in all samples from control area, were below 1000 ng g⁻¹. In affected areas

Table 1. Arsenic levels (min–max.) for water, cattle’s hair and blood in affected and control areas.

Area	Water $\mu\text{g L}^{-1}$	Hair As ng g^{-1}	Blood As $\mu\text{g L}^{-1}$
Affected area	51–268	<LD–1520	<LD–75
Control area	<LD–50	<LD–520	<LD

Figure 1. Relationship between total arsenic ($\mu\text{g L}^{-1}$) in blood and hair with water As concentration. X axis show As levels in water while Y axis shows As levels in blood and hair.

As hair levels were between <LD–1520. In cattle there are no enough data to determine a confident baseline value. These results are according to previous studies (Pérez Carrera & Fernandez Cirelli, 2012).

Arsenic levels in cattle blood were between <LD–75 $\mu\text{g L}^{-1}$. These values are below than those previously reported by Rana *et al.* (2008, 2010) in West Bengal, India, that inform mean levels in blood of 284 $\mu\text{g L}^{-1}$. Relationship between total As level in drinking water and As levels in blood and hair should be of relevance. However, no significant correlation ($p > 0.05$) was observed. Results are shown in Figure 1.

4 CONCLUSIONS

Total As concentration in 50% of water samples exceeded the recommended value for cattle (200 $\mu\text{g L}^{-1}$) in the affected area. Blood appear not to be an effective biomarker for chronic exposure in cattle. Regards hair values in affected area were significantly higher than values determined in the control area and may be used as exposure biomarkers.

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