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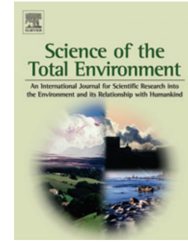

Milk trace elements in lactating cows environmentally exposed to higher level of lead and cadmium around different industrial units

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ABSTRACT

The present investigation was carried out to assess the trace mineral profile of milk from lactating cows reared around different industrial units and to examine the effect of blood and milk concentration of lead and cadmium on copper, cobalt, zinc and iron levels in milk. Respective blood and milk samples were collected from a total of 201 apparently healthy lactating cows above 3 years of age including 52 cows reared in areas supposed to be free from pollution. The highest milk lead (0.85±0.11 μg/ml) and cadmium (0.23±0.02 μg/ml) levels were recorded in lactating cows reared around lead–zinc smelter and steel manufacturing plant, respectively. Significantly ($P<0.05$) higher concentration of milk copper, cobalt, zinc and iron compared to control animals was recorded in cows around closed lead cum operational zinc smelter. Analysis of correlation between lead and other trace elements in milk from lactating cows with the blood lead level>0.20 μg/ml ($n=79$) revealed a significant negative correlations between milk iron and milk lead ($r=-0.273$, $P=0.015$). However, such trend was not recorded with blood lead level<0.20 μg/ml ($n=122$). The milk cobalt concentration was significantly correlated ($r=0.365$, $P<0.001$) with cadmium level in milk and the highest milk cadmium (>0.10 to 0.39 μg/ml) group had significantly ($P<0.05$) increased milk cobalt. It is concluded that increased blood and milk lead or cadmium level as a result of natural exposure of lactating cows to these environmental toxicants significantly influences trace minerals composition of milk and such alterations affect the milk quality and nutritional values.

1. Introduction

Contamination of environment with heavy metals and the insidious nature of their adverse ill health effects have become a matter of growing concern (Scheuhammer, 1987). Lead and cadmium are the two most abundant heavy metals in the environment, often coexist in a polluted environment (Phillips et al., 2003) and are mostly implicated in human and animal poisoning (Ozmen and Mor, 2004). Lead poisoning is one of the most frequently reported causes of poisoning in farm livestock; with cattle being most commonly affected (Blakley, 1984). A variety of exposure routes allow toxic heavy metals predominantly lead and cadmium to enter the food chain of farm animals, the commonest being the contaminated feed and water, lead paint, lead batteries, lead shot, automobile emissions, aluminum paints, textile, metallurgy and petrochemical based industries, combustion of coal and mineral oil, smelting, mining, alloy processing, paint industries,

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aluminum processing, phosphate fertilizer plant, lead–zinc smelter or coal mining areas (Sharma and Street, 1980; Dwivedi et al., 2001).

The chronic lead exposure in farm livestock and tissue lead concentration are receiving increasing attention, due to concern over the sub-clinical effects of elevated blood lead concentration in young children (Underwood and Suttle, 1999). Milk and milk products constitute an important component of diet in human beings especially growing children. Thus, contamination of milk by toxic metals can be a possible health risk to human population (Crout et al., 2004). These toxic chemicals may also influence the quality of milk with respect to its composition, particularly of trace elements essential for normal growth, production and reproduction (Doyle and Younger, 1984) and milk is an important dietary source of these minerals particularly for children. The mother's milk is the only source of nutrients available to neonatal offspring during their early life (Anderson, 1992).

Earlier from our laboratory, we reported higher blood and milk lead and cadmium levels in animals around different industrial areas and their higher levels were associated with higher concentrations of these toxic pollutants in forges and soil (Patra et al., 2005; Swarup et al., 2005). The lead concentration in fodder and soil samples collected from around the lead–zinc smelter was 29.1±11.3 (n=7) μg/g and 232.9±27.6 (n=2) μg/g as compared to 2.08±0.22 (n=8) and 28.66±2.53 (n=3) μg/g, respectively in non-industrialized area (Swarup et al., 2005). Similarly, cadmium concentrations in fodder and soil collected from steel manufacturing plant was 32.0±30.5 (n=3) and 168.9±0.0 (n=1) μg/g as compared to control level of 0.15±0.01 and 1.2±0.01 μg/g, respectably (Patra et al., 2005). Our pervious study also revealed a significant influence of blood lead level on milk lead concentration, and lactating cows with blood lead level>0.2 μg/ml (n=79) had significantly higher lead excretion in milk (Swarup et al., 2005). The cadmium excretion in milk remained relatively constant up to blood cadmium level of 0.02 μg/ml, showed an increasing trend from>0.02 to 0.05 μg/ml, and significantly higher cadmium excretion in milk as compared to that of control animals was recorded with blood cadmium level>0.05 μg/ml (Patra et al., 2005). We also observed that the blood lead (n=201) but not cadmium level had a significant negative correlation with blood copper (r=−0.339), cobalt (r=−0.224) and iron (r=−0.497) concentration (Patra et al., 2006). It was therefore hypothesized that increased blood lead and/or cadmium level in cows around industrial units, and the resultant changes in blood trace elements profile and milk lead and cadmium concentration may influence the concentration of trace elements in milk. Thus, the present work was undertaken to determine the toxic and trace mineral profile in raw milk from animals reared around different industrial units, and to examine the interaction between toxic heavy metals such as lead and cadmium, and trace elements such as copper, cobalt, zinc and iron in milk.

2. Material and methods

2.1. *Animals*

Respective milk and blood samples were collected from a total of 201 lactating cows (Non-descript/ Crossbred) of above 3 years of age reared either around different industrial units (n=149) or in non-polluted areas (n=52). These industrial units located at various parts of the India, were engaged in activities such as steel processing (n=22), aluminum processing (n=25), rock phosphate mining cum phosphate fertilizer production (n=21), lead–zinc smelting (n=21), coal mining (n=46), closed lead but operational zinc smelting (n=14). Cows in almost similar parity (1–3) and stages of lactation (2–3 months of lactation) were selected to rule out possibilities in variation due to stages of lactation and parity of cows. The animals reared since birth, used to graze on pasture within 2 km radial distance from industrial units or fed with the fodder/ grasses grown on those areas were selected for the present study. History regarding recent feeding practices and supplementation regimes (mineral mixture or drugs containing high amount of those mineral and metals under study) was also collected and cows receiving any extra feeding treatment were not included for the study to maintain uniformity in sampling to the maximum possible extent. Cows included in the present study typically had milk yield ranging from 3 to 10 L. Mostly the cows were pasture-dependent with once daily concentrate feeding.

2.2. *Sampling and processing*

Sample collection was executed by door-to-door visit preferably in the morning hours. Raw milk was collected in to clean vials directly from the udder or from milk bucket after morning milking. Milk samples (100 ml) were collected in nitric acid-washed glass vials and a drop of concentrated Hydrochloric acid was added to preserve its oxidation status. The samples were brought in ice packs for further processing in the laboratory, where it was kept in -20 °C till use.

Blood samples were also collected from respective cow by jugular venipuncture with heparin as anticoagulant. Approximately, 5 ml blood or milk sample was wet digested separately with nitric and perchloric acid mixture (HNO3: HCLO3=4:1 v/v) as per Kolmer et al. (1951). Two to three blank samples, where biosample was substituted by de-ionized triple distilled water, were run simultaneously with each batch of the digestion.

2.3. *Analysis of toxic and trace elements*

The toxic heavy metals such as lead and cadmium, and trace elements copper, cobalt, zinc and iron concentrations in the digested samples were estimated using atomic absorption spectrophotometer (Electronic Corporation of India Limited-4141, India) at the wave lengths of 217.0, 229.5, 324.7, 240.7, 213.9, 248.3 with 6, 6, 6, 7, 7, 5 mA current, respectively. The detection limits of lead and cadmium were 0.025 and 0.005 μg/ml respectively. The copper, cobalt, zinc and iron had the detection limits of 0.01, 0.02, 0.003 and 0.012 μg/ml, respectively. The standards procured (Sigma Aldrich Chemicals Corporation, New Delhi and Sisco Research Laboratory, Mumbai, India) for each element were used to calibrate the equipment and to check the analytical quality and accuracy with serial dilutions of test-specific standard solution, and to measure the absorbance of the test samples in reference to that of two fixed concentrations of the standard, and the values were expressed in μg/ml of blood or milk.