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Bioaccumulation of lead in milk of buffaloes from Cooum river belt in Chennai

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Abstract: *Bioaccumulation of heavy metals has been studied in aquatic flora and fauna to a greater extent than in terrestrial animals. Hence, this study was performed to find out whether lead was excreted in the milk of buffaloes reared near the Cooum belt which was fed by contaminated feed and polluted water from the nearby wells. The concentrations of lead in milk of buffaloes fed under farm conditions were also studied. The results have indicated that the ground water (0.32 µg ml^{-1}) and feed (8.62 µg g^{-1}) are the sources of lead in buffalo milk (0.06 µg ml^{-1}). It revealed that one unit increases of lead in water and feed corresponded to an increase of 77.38 and 37.77 units respectively in milk of buffaloes reared near the contaminated watercourse. However, the milk of buffaloes from Central Cattle Breeding Farm is free from lead (0.013 µg ml^{-1}) pollution. The reason for bioaccumulation of lead in the milk of buffaloes reared near the sewage carrying river is due to drinking of contaminated ground water from wells and bore-wells dug near the river.*

Key words: *Buffalo, Milk, Ground water, Feed, Lead*
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Introduction

During the past four decades, chemical fertilizers and pesticides have been used extensively to boost the agricultural production. The dairy animals are fed on agricultural by-products and crop residues. Therefore, the contaminants present in the animal feeds not only have adverse effect on the health of animals, but residues or metabolites of these toxicants get accumulated in the tissues and also excreted in the milk. Contaminants also enter the food chain unintentionally due to environmental conditions in which the animals are reared or due to intake of contaminated water (Varshney, 2004).

In India, heavy metal concentrations in water, feed and milk were studied elaborately (Pandya *et al.*, 1983; Bernice *et al.,* 1987; Bhatia and Choudhri, 1996; Govil, 2001). Ayyadurai *et al.* (1991) reported the range of concentration of lead (ND-0.039 µg ml^{-1}), cadmium (ND-0.020 µg ml^{-1}) and mercury (BDL) in the milk of cow and buffalo in seven agro-climatic zones of Tamil Nadu. It was also reported that the excretion of lead in buffalo milk (0.029 µg ml^{-1}) was slightly higher than that of cow milk (0.024 µg ml^{-1}).

Bioaccumulation of heavy metals has been studied recently in aquatic flora and fauna to a greater extent than in terrestrial animals (Shukla *et al.,* 2007; Saxena *et al.*, 2007). In the present study, samples of ground water from wells and bore-wells near the river, feed and raw milk from buffaloes reared near the Cooum river belt were collected for the estimation of lead to investigate the bioaccumulation of lead in milk through water and feed.

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Materials and Methods

River Cooum, which starts from Sattarai village in Tiruvallur district, flows a distance of 65 Km, passes through the city of Chennai and opens into the bay of Bengal (Fig. 1). Six stations were chosen for the collection of water, feed and milk sample in the stretch of the river within the city. Station 1 was located at Koyambedu; Station 2 at Shenoy Nagar; Station3 at Aminjikarai; Station 4 at Choolaimedu; Station 5 at Chetput and Station 6 was at the estuarine zone, Chintadripet. Monthly samples of water, feed and milk, in six stations were collected (Total 6x12=72) per annum during 2001, 2002 and 2003. However, random samples (12) were collected in each category at different intervals from Central Cattle Breeding Farm (CCBF).

Water: Water sample of 100 ml was treated with 3 ml of concentrated HNO_3, evaporated to dryness and the residue was dissolved in 3 ml of concentration HNO_3 and digested until a clear solution was obtained. The resulting solution was made up to 100 ml (EPA, 1974).

Feed: Feed sample of 2.5 g was treated with 25 ml of concentrated HNO_3 and digested for 30 to 45 minutes. After cooling the solution, 10 ml of $HClO_3$ (72%) was added to the mixture and the digestion was continued till a colourless solution was obtained. The resulting solution was made up to 100 ml (Heckman, 1967).

Table - 1: Range and mean concentration of lead (μg ml^{-1}) in well water, and bore- well water near the Cooum belt and corporation water and bore well water from government farm

Source	Range	Mean ± SE	Safe upper limit concentration (NRC, 1974)
Well water (N=83)	ND-1.73	0.370 ± 0.002	0.10 μg ml^{-1} (NRC and BIS)
Bore well (N=124)	ND-1.62	0.270 ± 0.002	
Corporation water (N=9)	ND-0.04	0.008 ± 0.001	
Bore well water from CCBF (N=12)	ND-0.01	0. 006 ± 0.001	

N = Number of samples, ND = Not detected

Table - 2: Mean concentration of lead in feed (μg g^{-1} dry weight) and milk (μg ml^{-1})

Source	Range	Mean ± SE	Safe upper limit concentration (NRC, 1974)
Feed (N=216)	ND-0.19	8.62 ± 1.60	30 μg g^{-1} (NRC)
Buffalo milk (N=216)	ND-0.09	0.060 ± 0.008	0.02 mg ml^{-1} (IS)
CCBF Feed (N=12)	ND-0.22	7.43 ± 0.79	
Buffalo milk (N=12)	ND-0.01	0.013 ± 0.003	

N = Number of samples, ND = Not detected

Milk: Milk sample of 5 ml was taken in a 100 ml volumetric flask and TCA (25%) was added and made up to the mark with deionized water. The flask was shaken for 15 min and filtered. 5 ml of this aliquot was transferred to 50 ml volumetric flask and 1 ml of 5 per cent lanthanum oxide solution was added. Finally it was made up to 50 ml (Brooks *et al.*, 1970).

Preparation of standard solution for lead: Lead nitrate (1.5980 g) was weighed and dissolved in 1% (V/V) HNO_3 and made up to one liter using the same acid. The concentration of lead in the standard stock solution was 1000 μg ml^{-1}. The linear working range for lead was prepared at 20 μg ml^{-1}. The analysis of lead was carried out by Atomic Absorption Spectrophotometer (Perkin Elmer-Model 3010) at a wavelength of 283.3 nm.

The least significant difference and multiple regression analysis were carried out for 95 and 99% confidence interval (Snedecor and Cochran, 1968).

Results and Discussion

The mean concentration of lead in the bore well water from CCBF was 0.006 μg ml^{-1}, which is well below the safe upper limit for livestock. On the contrary, lead concentration in the well water (0.37 μg ml^{-1}) and bore-well water (0.27μg ml^{-1}) collected near the Cooum has exceeded the safe upper limit of 0.10 μg ml^{-1} for livestock (Table 1). This may be attributed to the seepage of contaminated water of the Cooum into the adjoining wells (Bernice *et al.,* 1987). Presence of fulvic acid and humic acid in the soil /sediment helps the metals to form complexes and leach out the metals to concentrate the ground water resources. A combination of tropical climate and low pH play a major role in transporting the heavy metals to the ground water through soil/sediment (Govil, 2001). It is observed that the dwellers who use well and bore- well water to bathing avoid drinking. However, the buffaloes have an access to the well water through oil cakes and bran mixed with well water. The mean concentration of lead in the corporation water was found to be 0.008 μg ml^{-1} which is far below the NRC(1974) limit. Pandya *et al.* (1983) reported the mean concentration of lead in wells, city water supply, tanks and household taps of Kolkatta city as 0.09 μg ml^{-1} which was nearly twice the permissible level of 0.05 μg ml^{-1} as stipulated by WHO (1984) while the concentration of lead in corporation water and well water from the CCBF, Government farm, was almost negligible. It is interesting to note that the seepage of the Cooum to the adjoining wells contribute to high concentration of lead.

The mean concentration of lead in feed offered to the animals by the breeders and the Government farm was 8.62 and 7.43 μg g^{-1} respectively (Table 2). There was not much of difference since the feed were procured from reputed firms by the Government farms in bulk and in retail by the buffalo owners. Since the feed purchased in the Chennai city market was from different agro climatic zones of Tamil Nadu and nearby states the bioaccumulation of lead in milk through the feed cannot be assessed directly. The lead concentration in feed was less than the upper limit of 30 μg g^{-1} (NRC, 1974). It appears that the exposure of dairy cows to 9.2 μg g^{-1} of lead in feed did not influence the lead concentrations in milk at any time interval (Sharma and Street, 1980).

The buffaloes drink water from the well on the banks and wallow in the river fed with untreated effluents, sewage and domestic wastes. Licking of posters by the animals also contribute to the

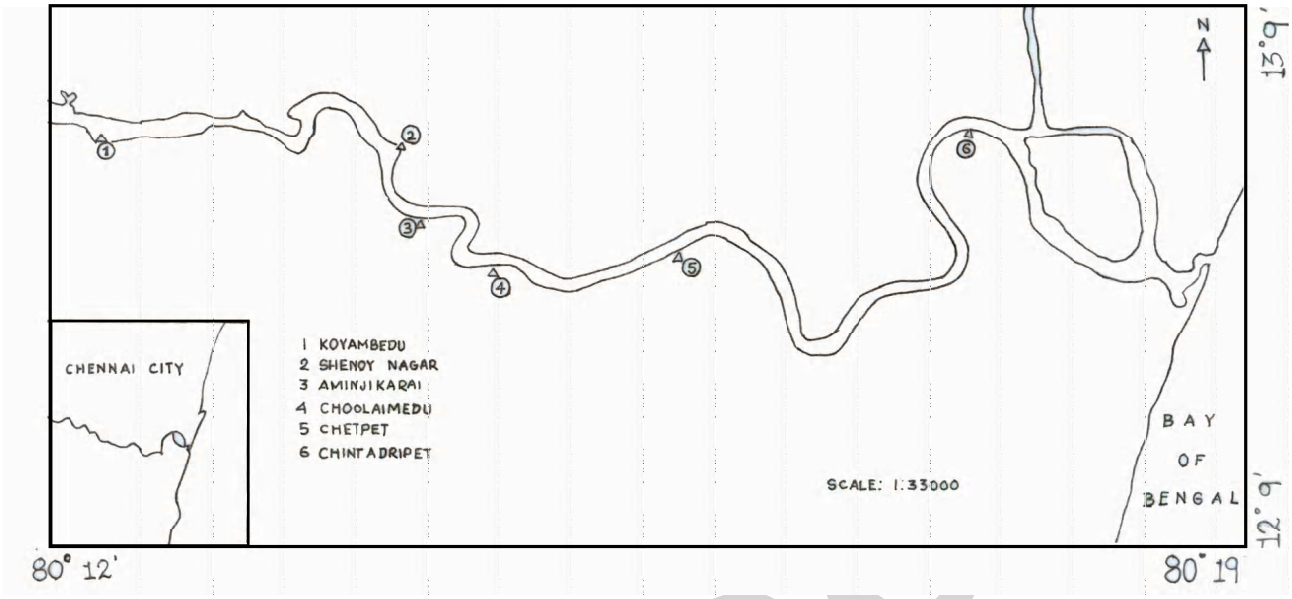

Fig. 1: Course of the river Cooum and collection stations in Chennai city

increased lead concentration in the blood. In the blood, lead binds to erythrocytes and plasma proteins and pass on to the muscle, milk or nervous system and remains in the body for a limited time and excreted in milk, dung, urine and hair (Humphrey, 1991). The mean concentrations of lead excreted in milk of buffaloes in the Cooum belt and CCBF were 0.060 and 0.013 μg ml^{-1} respectively (Table 2). A level of 0.20 μg ml^{-1} of lead in milk is considered safe in India, while the International standards (IS) are fixed at 0.02 μg ml^{-1}(Varshney, 2004). The concentration of lead (0.06 μg ml^{-1}) in milk of buffaloes reared in the Cooum was 3.33 times less than the Indian standards and three times higher than International standards. However, lead concentration in milk (0.013 μg ml^{-1}) from the Government farm was far below the Indian and International safe limits. The buffaloes reared near the Cooum, within the city limits are exposed to the lead contamination primarily through air. A recent study on the lead content of cattle milk at Varanasi showed that the milk collected from an area of heavy traffic contained lead of 0.046-0.072 μg ml^{-1} (Bhatia and Choudhri, 1996).

The multiple linear regression equation was arrived to predict lead in milk: $Y=31.03 + 77.38X1 + 37.77X_2$ where X_1, X_2 and Y denoted as water, feed and milk. A highly significant correlation was obtained between water and milk ($R^2 = 0.092$). It revealed that one unit increase in water and feed corresponded to an increase of 77.38 and 37.77 units in milk respectively.

In Chennai city, milch cattle are reared in the congested areas, especially near the banks of the three water courses traversing the city. Like Mumbai, the milch cattle can be reared in the outskirts of the city. This measure will avoid the entry of lead in cattle through drinking polluted water, consumption of fodder from sewage farms, inhalation of polluted air and licking of paints and posters. It is evident from the observation that the concentration of lead in the ground water as well as the milk of buffaloes reared away from the city was well within safe limits. Till such time, cattle owners are advised to use corporation water for livestock.

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