Original Research

Assessment of Lead and Cadmium Status in Feedstuffs, Milk and Water Samples in Haryana State of India

Vinod Kumar

Dairy Cattle Nutrition Division, National Dairy Research Institute, Karnal-132001, Haryana, INDIA

***Corresponding author:** vinodsidhu@rediffmail.com

Rec. Date:	Aug 07, 2018 11:42
Accept Date:	Dec 08, 2018 16:28
DOI	10.5455/ijlr.20180807114242

Abstract

A survey of feedstuffs, milk and water samples (n=742) from Haryana state of India was conducted by dividing the State in three zones on geographical and agro-climatic basis. Districts of Sirsa, Fatehabad and Hisar were in Zone 1, Rohtak, Bhiwani, Mahendra Garh, Rewari, Jhajjar, Faridabad and Gurgaon in Zone 2 and Ambala, Kurukshetra, Yamuna Nagar, Karnal, Kurukshetra, Panipat, Sonipat, Jind and Kaithal in Zone 3. A significantly higher content of Pb in cereals and green fodder in Zone 2 and green fodder in Zone 3 was observed. The mean Cd content was significantly higher ($P < 0.05$) in oil cakes and dry fodders in Zone 1 and 3, respectively. Milk Pb contents were in range of 0.14 to 0.39 mg kg^{-1}. Per cent transfer factor of Pb from feed to milk ranged from 7.21 to 36.84 in the order of Zone 2>Zone 3>Zone 1. Cd contents of milk in Zone 1, 2 and 3 averaged 0.0127, 0.0140 and 0.0234 µg mL^{-1}, respectively. Transfer factor of Cd from feed to milk was in range of 9.27 to 20.38 with maximum rate in Zone 2, followed by Zone 3 and Zone 1. Water samples analyzed for Pb and Cd content were within the maximum permissible limits for livestock.

Key words: Cadmium, Feeds, Heavy Metals, Lead, Milk, Transfer Factor

How to cite: Kumar, V. (2019). Assessment of Lead and Cadmium Status in Feedstuffs, Milk and Water Samples in Haryana State of India. International Journal of Livestock Research, 9(2), 129-137. doi: 10.5455/ijlr.20180807114242

Introduction

Heavy metals are a serious health concern due to their high levels in soil, water and animal products as reported in various studies from different parts of India (Zopade *et al.*, 2012; Chandrakar *et al.*, 2018). Due to natural and anthropogenic activities, they can get transported over long distances and contaminate drinking water, soil, feeds and fodders. The major sources of heavy metals in agricultural lands include atmospheric deposition, sewage sludge (Singh *et al.*, 2010), animal manures (Zhang *et al.*, 2012), agrochemicals and inorganic fertilizers (Hamid and Jawaid, 2013). A contaminated agricultural land is major source of heavy metals in feeds and fodder grown for animal feeding. Plants have inherent tendency of accumulating heavy metals that are subsequently transferred along the food chain (Aslam *et al*., 2011; Goni *et al*., 2014). The intake of high level of heavy metals affects biological functions, hormone release and growth (Rajaganpathi *et al*., 2011). Accumulation of cadmium (Cd) and lead (Pb) in ruminants not only causes toxic effects in animal, but also affects humans consuming meat and milk from Cd and Pb exposed animals (Govind and Madhuri, 2014). Pb and Cd accumulate in the vital organs and exert adverse effects on endocrine function of domestic animals and human (Doumouchtsis *et al*., 2009). Once Pb and Cd gained entrance in animal system, they persist for several weeks, even after discontinuation of exposure (Hatch, 1988). Physiologically mammary gland is the most active part and therefore the input and output of heavy metals is clearly reflected through milk. Pb readily passes into milk, therefore increasing dietary concentration of Pb results in its increased concentration in milk (Sahayaraj and Ayyadurai, 2009).

There is an urgent need for systematic monitoring for the presence of heavy metals in agricultural regions as well as in natural ecosystems (Kumar and Chopra, 2014). Till now, most of the reports on Pb and Cd were on industrial perspective, which have reported obliviously high levels of heavy metals in food chain. However, studies on farmers' location, rural and with modern agricultural system need to be conducted to access status at non-industrial sites. Present survey was therefore, conducted to access the Pb and Cd content in different feedstuffs, water and milk samples in different districts of Haryana state of India.

Materials and Methods

Survey Location and Sample Collection

The survey was conducted in rural areas of different districts of Haryana state of India. On geographical and agro-climatic basis, Haryana state was divided into three zones namely zone 1, 2 and 3. Districts of Sirsa, Fatehabad and Hisar were in Zone 1, Rohtak, Bhiwani, Mahendra Garh, Rewari, Jhajjar, Faridabad and Gurgaon in Zone 2 and Ambala, Kurukshetra, Yamuna Nagar, Karnal, Kurukshetra, Panipat, Sonipat, Jind and Kaithal in Zone 3.

Samples of feeds (cereals, byproduct, and oil cake/seed), fodders (green and dry), milk and water, collected from different locations were analysed for status of Pb and Cd. From each district, two villages and from each village, three farm households were selected randomly ($1\times2\times3=6$ sampling house hold unit) for collection of feeds, fodder, milk and water samples. A total of 742 samples (cereals and its byproducts, 123; oil cake, 137; green fodders, 84; dry fodders, 122; milk, 181; water, 95) were collected from three zones.

Sample Processing and Analysis of Lead and Cadmium

Feed and fodder samples were dried in oven at 60°C for 48 h and ground to fine powder before storing in polythene sachets for further analysis. The modified method of closed system of digestion was adopted for processing of samples (Method 1631; EPA, 2001). In closed system of digestion, 1 g of sample was taken

  DOI 10.5455/ijlr.20180807114242

in digestion tube and mixed with 30 ml of tri-acid mixture of nitric acid: perchloric acid: conc. sulphuric acid (3:2:1). Samples were digested till all the nitric acid fumes were evaporated and there was no organic matter in the tube. Digested samples were cooled at room temperature and volume was made to 30 ml with triple distilled water. Milk samples were digested in tri-acid mixture same day.

Pb and Cd were determined using flame as well as furnace mode of Atomic absorption spectrophotometer (AAS, Model Z-5000, Hitachi Ltd, Japan) using acetylene as fuel and air as an oxidant. Specific hollow cathode lamps were used for the determination of Pb and Cd. The wavelength for detection of Pb and Cd was set at 283.3 and 228.8 nm, respectively. The concentration of heavy metals was calculated by plotting absorbance values on calibration curves prepared by running standards of known concentrations. The transfer factor is expressed as the concentration of the metal in milk (mg kg^{-1}) divided by the concentration of the compound in animal feed (mg kg^{-1}), in which the concentration in animal products is on wet weight basis, and in feed on dry weight basis (Leeman *et al*., 2007). Composition of feed ingredients offered was assumed to be fed as concentrate (2/3 cereals and 1/3 oil cakes) and fodders (2/3 green and 1/3 dry fodder) in ratio of 1:2.

Statistical Analysis

Data was subjected to analysis of variance in lead and cadmium levels in different zones of Haryana in feed, milk and water samples using statistical software SPSS version 21.0 (IBM SPSS Statistic) and least square difference was applied to compare homogenous subset of different means.

Results and Discussion

The Pb and Cd content of various cereals ingredient, oil cakes, green and dry fodder samples is presented in Table 1 and 2, respectively (Fig. 1).

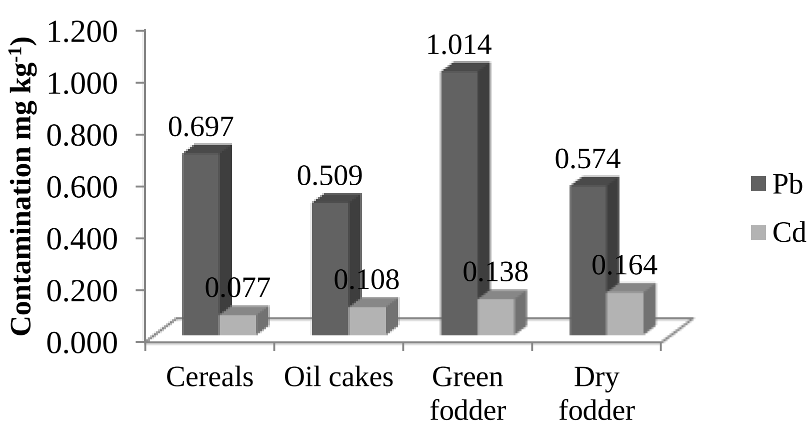

Fig. 1: Lead and cadmium in feeds and fodders in Haryana

 DOI 10.5455/ijlr.20180807114242

Table 1: Average (Mean±SE) content of lead (mg kg^{-1}) in feeds and fodders in three zone of Haryana state of India

Feed	Zone-1[NS]	Zone-2**	Zone-3**	Overall* Mean
Cereals	0.422±0.35	1.112±0.46[a]	0.160±0.05[b]	0.697±0.31[ab]
	(0.00-1.47)	(0.00-8.00)	(0.00-0.56)	(0.00-8.00)
Protein cakes	0.434±0.16	0.277±0.08[b]	0.757±0.21[ab]	0.509±0.10[b]
	(0.00-1.99)	(0.00-2.52)	(0.00-6.21)	(0.00-6.21)
Green fodder	0.779±0.27	1.042±0.27[a]	1.074±0.20[a]	1.014±0.14[a]
	(0.00-3.180)	(0.00-6.031)	(0.00-6.21)	(0.00-6.21)
Dry fodder	0.206±0.12	0.674±0.23[ab]	0.589±0.13[ab]	0.573±0.11[ab]
	(0.00-1.10)	(0.00-4.17)	(0.00-3.39)	(0.00-4.17)

Values (Mean±SE) in a column differed significantly at P<0.05, P<0.10**; NS: Non significant, Data in parentheses are ranges, Zone-1: Hisar, Sirsa, Fatehabad district, Zone-2: Rohtak, Bhiwani, M. Garh, Rewari, Jhajjar, Gurgaon, Faridabad district and Zone-3: Ambala, Kurukshetra, Yamunanagar, Karnal, Panipat, Sonipat, Kaithal, Jind*

Table 2: Average (Mean±SE) content of cadmium (mg kg^{-1}) in feeds and fodder samples in three zone of Haryana state of India

Feed	Zone-1[NS]	Zone-2[NS]	Zone-3*	Overal[NS] Mean
Cereals	0.076±0.037	0.080±0.0.047	0.075±0.05[b]	0.077±0.020
	(0.00-0.72)	(0.00-1.58)	(0.00-0.37)	(0.00-1.58)
Protein cakes	0.148±0.075	0.082±0.020	0.114±0.037[ab]	0.108±0.023
	(0.00-0.97)	(0.00-0.55)	(0.00-1.52)	(0.00-1.52)
Green fodder	0.066±0.021	0.240±0.157	0.086±0.020[b]	0.138±0.056
	(0.00-0.23)	(0.00-4.74)	(0.00-0.57)	(0.00-4.74)
Dry fodder	0.138±0.059	0.074±0.016	0.218±0.070[a]	0.164±0.041
	(0.00-0.70)	(0.00-0.36)	(0.00-2.550)	(0.00-2.55)

Values (Mean±SE) in a column differed significantly at P<0.05; NS: Non significant, Data in parentheses are ranges, Zone-1: Hisar, Sirsa, Fatehabad district, Zone-2: Rohtak, Bhiwani, M. Garh, Rewari, Jhajjar, Gurgaon, Faridabad district and Zone-3: Ambala, Kurukshetra, Yamunanagar, Karnal, Panipat, Sonipat, Kaithal, Jind*

The Pb concentration in green fodder samples was higher ($P < 0.05$) than cereals ingredients, oil seed/cakes and dry fodders. In zone 1, there were no differences in Pb content of various feedstuffs. Zone 2 cereals, green fodders and zone 3 green fodder samples had significantly higher ($p < 0.05$) Pb content. High Pb content in green fodders was due to high Pb levels in berseem samples collected from different district of zone 2 and 3. The levels of Pb were far below the maximum tolerable limits. Percent Pb and Cd contamination of feeds ranges from 48.15-52.0% and 63.9-68.4%, respectively (Fig. 2). Bharathidhasan *et al*. (2008) also reported lower Pb in feeds *i.e.* cottonseed cake, mustard cake, wheat bran, grains, pelleted feed; concentrate mixture and fodders in non-industrial areas. Lower Pb values as reported in this study might be due to the fact that most of the farmers in rural areas use locally available feed ingredients, whereas, in urban areas there can be more chances of Pb contamination due to use of sewage or industrial water for irrigation purposes, which may be contaminated with heavy metals (Kumar and Chopra, 2014). Underwood and Suttle (2001) did not observe any difference in Pb concentration in different categories of feeds and reported less than 5 µg g^{-1} Pb in most of the feeds as also observed in present studies.

  DOI 10.5455/ijlr.20180807114242

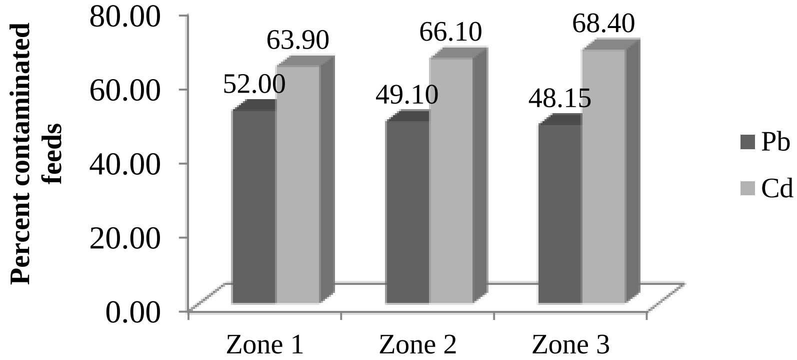

Fig. 2: Percent zonal contamination of feeds with Pb and Cd in Haryana.

In contrast to findings of present study, Kumar and Chopra (2003) reported higher Pb concentrations in berseem, oats, green maize, jowar, wheat straw and paddy straw collected from industrial areas of Karnal, Panipat and Yamunanagar. The Pb concentration in feed was less than the upper limit of 30 mg kg^{-1} (NRC, 1974). Higher Pb content in oil cake, cereals and its byproduct was also reported by Kumar and Chopra (2003). These higher levels may be due to the differences in their morphology and physiology for heavy metal uptake, exclusion, accumulation and retention (Kumar *et al*., 2009).

The mean Cd content was higher ($P < 0.05$) in dry fodder samples than cereals ingredient, oil cakes and green fodder in zone 3. Protein cakes of zone 1 were significantly ($P < 0.05$) higher in Cd content than zone 2 and 3, respectively. Similarly, cottonseed cake, mustard cake, wheat bran, grains, pelleted feed and concentrate mixture samples were found to have similar concentration of Cd in Haryana in earlier study (Bharathidhasan *et al*., 2008). High concentration in dry fodders in present study might be due to higher uptake of Cd by wheat plant (Mahmoud *et al*., 2011). Cd concentration in crops is influenced by a wide range of factors, including crop genotypes, soil characteristics such as texture, pH and salinity, weather, crop sequence, crop management practices and soil Cd^{2+} concentration (Grant *et al*., 1998). Haryana being an intensive agricultural state consumes significant quantity of fertilizers for crop production and that might be a possible reason for higher levels of Cd. It has been shown that application of phosphate fertilizers increases Cd levels in soil, which resulted in higher concentration in all types of crops (Grant, 2011).

Pb and Cd contents in milk and water samples from all the three zones of Haryana have been presented in Table 3. Pb content in milk samples ranges 0.14 to 0.39 µg mL^{-1}. Some of the samples were above the safe limits of 0.20 µg mL^{-1} (European Commission, 1997). Milk Pb content did not difference significantly among three zones. Percent contamination of milk samples for Pb was 55.5, 39.5 and 72.4 in zone 1, 2 and 3, respectively, thereby showing significantly higher ($P < 0.05$) levels in zone 3 (Fig. 4). Higher levels of Pb in Zone 3 may be due to deterioration in ground water quality (Kaushik *et al*., 2000) and use of fertilizers

 DOI 10.5455/ijlr.20180807114242

(Nacke *et al*., 2013). Previous studies also reported similar Pb levels in bovine milk samples from rural Haryana (Bharathidhasan, *et al*., 2008; Roy *et al*., 2009). Contrary to present finding, higher Pb levels were found in bovine milk from urban areas of Ahmedabad, Kolkata, Delhi (Dey *et al*., 1996), Varanasi (Bhatia and Chowdhry, 1996), Kanpur (Swarup *et al*., 1997) and Maharashtra (Zopade *et al*., 2012). Pb levels in bovine milk samples were higher in industrial areas and areas adjacent to highways compared with rural areas (Bhatia and Choudhury, 1996).

Cd content of milk averaged 0.0127, 0.0140 and 0.0234 µg mL^{-1} in Zone 1, 2 and 3, respectively. Percent contamination of Cd in milk samples was 100.0, 76.4 and 92.9 in Zone 1, 2 and 3, respectively (Fig. 3).

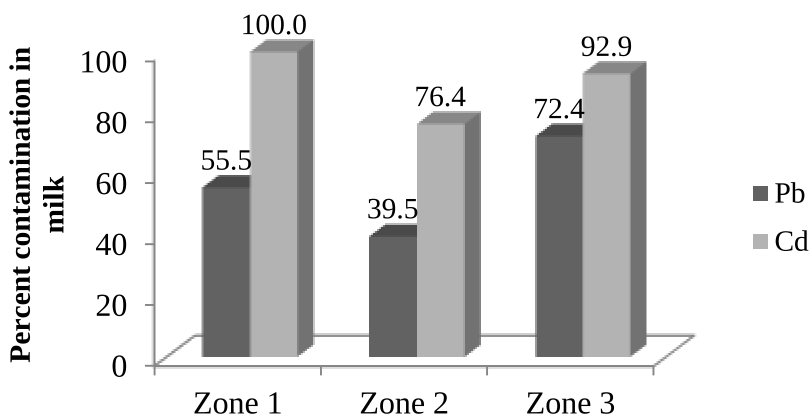

Fig. 3: Percent zonal contamination of Pb and Cd in milk samples of Haryana

Similar to present finding, lower levels of milk Cd in rural area have been reported (Swarup *et al*., 1997; Bharthidhasan *et al*., 2008). Cd clearance in milk averaged 2.0 to 4.9% of blood Cd (Houpert *et al*., 1997). Percent transfer factor of Pb from feed to milk ranges 7.21 to 36.84 and follows the order of Zone 2>Zone 3>Zone 1 (Fig. 4).

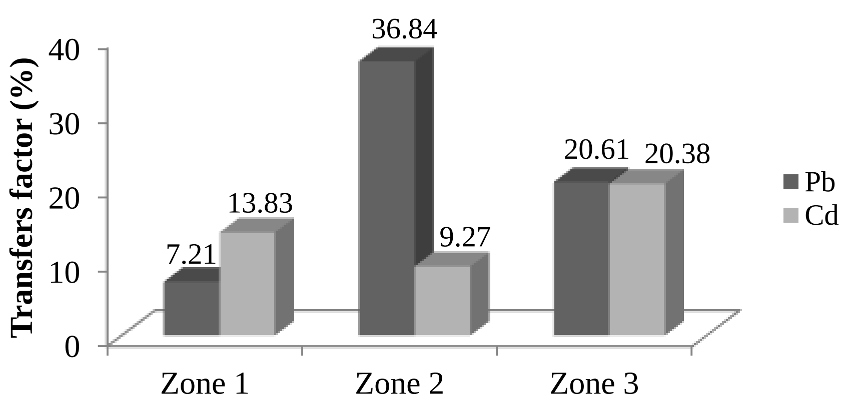

Fig. 4: Transfer factor of Pb and Cd from feed to milk in three zones

DOI 10.5455/ijlr.20180807114242

Similarly, percent transfer factor of Cd from feed to milk ranges from 9.27 to 20.38 and order of transfer factor was zone 2>zone 3>zone 1. This zonal difference is possibly due to differences in morphology and physiology for heavy metal uptake, exclusion, accumulation and retention (Kumar *et al*., 2009). Pb and Cd levels analyzed for water samples from different district of Haryana have been presented in Table 3.

Table 3: Average (Mean±SE) content of lead and cadmium in milk and water samples (µg mL^{-1}) in three zone of Haryana state of India

Feed	Zone-1	Zone-2	Zone-3	Overall Mean
Lead				
Milk	0.039±0.027	0.332±0.174	0.149±0.025	0.209±0.070
	(0.00-0.320)	(0.00-6.530)	(0.00-0.910)	(0.00-6.530)
Water	0.0071±0.003	0.0043±0.0006	0.0053±0.0009	0.0053±0.0007
	(0.0017-0.019)	(0.0016-0.007)	(0.001-0.023)	(0.0012-0.023)
Cadmium				
Milk	0.0127±0.0047	0.014±0.0031	0.023±0.0039	0.026±0.0040
	(0.0005-0.055)	(0.000-0.105)	(0.00-0.127)	(0.00-0.127)
Water	0.0005±0.0002	0.0002±0.00003	0.0008±0.0003	0.0005±0.0002
	(0.0001-0.0001)	(0.0001-0.0005)	(0.000-0.0006)	(0.000-0.0006)

NS: Non significant, Data in parentheses are ranges, Zone-1: Hisar, Sirsa, Fatehabad district, Zone-2: Rohtak, Bhiwani, M. Garh, Rewari, Jhajjar, Gurgaon, Faridabad district and Zone-3: Ambala, Kurukshetra, Yamunanagar, Karnal, Panipat, Sonipat, Kaithal, Jind

Average Pb content in water samples of different zones of Haryana ranged between 0.0043-0.0071 µg mL^{-1}. In the present survey, Pb concentration in all the water samples was within the maximum permissible limit of 0.10 µg mL^{-1} for livestock (EPA, 2004). The maximum permissible level of Pb in water for human consumption is 0.015 µg mL^{-1} (EPA, 2004), which is much lower than the limits set for livestock. On the contrary, there are reports of higher water Pb levels from industrial sites of Haryana (Kumar and Chopra, 2003).

Cd content of water samples was 0.0005, 0.0002 and 0.0008 µg mL^{-1} in Zone 1, 2 and 3, respectively. No sample of water collected in the present study exceeded the Cd levels above maximum permissible limits for livestock (0.05µg mL^{-1}), but 1 sample from canal water near Panipat refinery exceeded the maximum permissible limits of 0.005 µg mL^{-1} for human beings (NRC, 1974; EPA, 2004). Drinking water samples showed levels of Cd within permissible limit demarcated by BIS (0.01 mg/L). Similarly, Datta *et al.* (1999) reported Cd content in the range of 0.001-0.202 µg mL^{-1} in the groundwater of Delhi near industrial sites, which are much higher than the present findings. From the study it was observed that modern agricultural practices are more likely to affect milk quality in rural and semi-urban areas and the high levels of these metals in milk may lead to chronic toxic effects in human beings.

  DOI 10.5455/ijlr.20180807114242

Conclusion

Status of Pb and Cd in feedstuffs, milk and water samples in Haryana showed higher levels of these heavy metals in non-industrial areas. Modern agricultural practices appears to contribute a significant amount of these metals in food chain and being cumulative in nature these metals may pose health hazard in future.

Acknowledgement

The author is thankful to Head, Dairy Cattle Nutrition and Director, National Dairy Research Institute, Karnal, ICAR, New Delhi for providing the necessary facilities. Funds provided as Network Project by Indian Council of Agricultural Research, New Delhi are thankfully acknowledged.

References

1. Aslam, B., Javed, I., Khan F.H. and Rahman, Z. (2011). Uptake of heavy metal residues from sewerage sludge in the milk of goat and cattle during summer season. *Pak. Vet. J.*, 31, 75-77.
2. Bharathidhasan, S., Kaur, H., Mani V. and Kewalramani, N. (2008). Lead and cadmium contents of animal feed resources in Haryana. *Indian J. Anim. Sci*., 11, 1268-1272.
3. Bhatia, I. and Choudhury, G.N. (1996). Lead poisoning of milk – the basic need for the foundation of human civilization. *Indian J. Public Health*, 40, 24-26.
4. Chandrakar, C., Jaiswal, S.K., Chaturvedani, A.K., Sahu, S.S., Monika and Wasist, U. (2018). A review on heavy metal residues in Indian milk and their impact on human health. *Int. J. Curr. Microbiol. App. Sci.*, 7(5), 1260-1268.
5. Datta, P.S., Manjaiah K.M. and Tyagi S.K. (1999). In isotope techniques in water resources development and management. In proceedings of the International Symposium, May, 1999, Vienna, IAEA-SM-361/35. pp. 190-198.
6. Dey, S., Dwivedi, S.K. and Swarup, D. (1996). Lead concentration in blood, milk and feed of lactating buffaloes after acute poisoning. *Vet. Record*, 138, 336.
7. Doumouchtsis, K.K., Doumouchtsis, S.K., Doumouchtsis, E.K. and Perrea, D.N. (2009). The effect of lead intoxication on endocrine functions. *J. Endocrinol. Invest*., 32, 175–183.
8. EPA Method-1631. (2001). *Development of digestion procedures for determination of Mercury in solid and semisolid samples*, Frontier Geosciences, available from EPA sample control centre D Y N Corp I & E T, Alexandria, V A 22304 (703-461-2100).
9. EPA (Environmental Protection Agency, U.S.A.) (2004). Drinking Water Contaminate List. Available at http://www.epa.gov/safewater accessed on April 18, 2014.
10. European Commission Draft (1997). Commission regulation setting maximum limits for certain containments in foodstuffs, amending commission regulation (EC) 194/97 of 31 January 1997 setting maximum limits for certain contaminants in foods-maximum limits for lead and cadmium in foodstuffs." European commission III/5125/95 Rev. 3 (March 1997).
11. Grant, C.A. (2011). Influence of phosphate fertilizer on cadmium in agricultural soils and crops. *Pedologist*, 54(3), 143-155.
12. Grant, C., Buckley, W., Bailey L. and Selles, F. (1998). Cadmium accumulation in crops. *Can. J. Plant Sci.*, 78, 1-17.
13. Govind, P. and Madhuri, S. (2014). Heavy metals causing toxicity in animals and fishes. *Res. J. Anim. Vet. Fishery Sci*., 2, 17-23.
14. Goni, M.A., Ahmad, J.U., Halim, M.A., Mottalib, M.A. and Chowdhury, D.A. (2014). Uptake and translocation of metals in different parts of crop plants irrigated with contaminated water from DEPZ area of Bangladesh. *Bull. Environ. Contam. Toxicol*., 92, 726–732.

  DOI 10.5455/ijlr.20180807114242

15. Hamid N. and Jawaid, F. (2013). Effects of chicken manure and mineral fertilizer on some nutritive parameters and lead accumulation in two vigna species grown in lead contaminated soil. *Pak. J. Chem*., 3, 188-197.
16. Hatch, R.C. (1988). *Poisons causing nervous stimulation or depression*. *In:* Veterinary pharmacology and therapeutics, ed. Booth NH, McDonald LE, 6th ed., pp. 1053-1101. Iowa State University Press, Ames, I.A.
17. Houpert, P., Federspiel, B. and Milhaud G. (1997). Toxicokinetics of cadmium in lactating and non-lactating ewes after oral and intravenous administration. *Environ. Res.*, 72, 140-150.
18. Kaushik, A.K., Sharma H.R. and Bhupindar, M. (2000). Groundwater quality of Ambala and Nilokheri cities in Haryana in relation to land use. *Environ. Ecol*., 18, 616–623.
19. Kumar, A. and Chopra R.C. (2003). Lead concentration in feeds and fodders and its effect on growth, nutrient utilization and certain blood parameters in crossbred calves. *Indian J. Anim. Nutr*., 20, 412-420.
20. Kumar, V. and Chopra, A.K. (2014) Accumulation and translocation of metals in soil and different parts of French bean (*Phaseolus vulgaris* L.) amended with sewage sludge. *Bull. Environ. Contam. Toxicol.*, 92, 103–108.
21. Kumar, A., Sharma, I.K., Sharma, A., Varshney, S. and Verma, P.S. (2009). Heavy metals contamination of vegetable foodstuffs in Jaipur (India). *Electron. J. Environ. Agri. Food. Chem*., 8, 96–101.
22. Leeman, W.R., Van Den Berg, K.J. and Houben, G.F. (2007). Transfer of chemicals from feed to animal products: The use of transfer factors in risk assessment. *Food Addit. Contam*., 24, 1–13.
23. Mahmoud, A.H., Saleh, M.E. and Abdel-Salam, A. (2011). Effect of rice husk biochar on cadmium immobilization in soil and uptake by wheat plant grown on lacustrine soil. *Alex. J. Agric. Res.*, 56, 117-125.
24. Nacke, H., Goncalves Jr, A.C., Schwantes, D., Nava, I.A., Strey, L. and Coelho, G.F. (2013). Availability of heavy metals (Cd, Pb, and Cr) in agriculture from commercial fertilizers. *Arch. Environ. Contam. Toxicol*., 64, 537-544.
25. National Research Council (1974). Effects of fluorides in animals. National Academy of Sciences, Washington, DC (SF757.5.N27).
26. Rajaganapathi, V., Xavier, F., Sreekumar, D. and Mandal, P.K. (2011). Heavy metal contamination in soil, water and fodder and their presence in livestock and products: A review. *J. Env. Sci. Technol*., 4, 234-249.
27. Roy, D., Bharthidasan, S., Mani, V., Kaur H. and Kewalramani, N. (2009). Heavy metal contents in cow and buffalo milk samples from Haryana. *Indian J. Anim. Nutr*., 26, 29-33.
28. Sahayaraj, P.A. and Ayyadurai, K. (2009) Bioaccumulation of lead in milk of buffaloes from Cooum River belt in Chennai. *J. Environ. Biol*., 30, 651-654.
29. Singh, A., Sharma, R.K., Agrawal, M., Marshall, F.M. (2010). Health risk assessment of heavy metals via dietary intake of foodstuffs from the wastewater irrigated site of a dry tropical area of India. *Food Chem. Toxicol*., 48, 611–619.
30. Swarup, D., Dwivedi, S.K. and Dey, S. (1997). Lead and cadmium levels in blood and milk of cows from Kanpur city. *Indian J. Anim. Sci.*, 67, 222-223.
31. Underwood, E.J. and Suttle, N.F. (2001). The Mineral Nutrition of Livestock. 3rd edn. CABI Publishing, Wallingford, UK.
32. Zhang, F., Yanxia, Li, Xiong, X., Yang, M. and Li, W. (2012). Effect of composting on dissolved organic matter in animal manure and its binding with Cu. *The Scientific World J*., 1-9. Article ID 289896, https://doi.org/10.1100/2012/289896.
33. Zopade, G.V., Dhawan, V.L. and Wagh, R.R. (2012) Determination of metals in cow milk collected from Mumbai city, India. *Eco Revolution*, 270-274.

  DOI 10.5455/ijlr.20180807114242