Heavy Metal Contamination in Soil, Water and Fodder and their Presence in Livestock and Products: A Review

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ABSTRACT

Environmental pollution is a global problem for man and animals. Pollutants from industrial waste enter into the livestock production systems and then into food chain. In most developing countries it is often attributed to industrialization with improper waste disposal. In developed countries impact of pollution on domestic and wild animals due to chemical toxicities are reported. Pollution is a serious problem in India, threatening the animal and human health. Heavy metal pollution is becoming a serious health concern in recent years. High levels of heavy metals in soil, water and animals have been reported in different parts of India due to pollution. Heavy metals from industrial waste contaminate drinking water, soil, fodder and food. The toxic heavy metals like Cd, Pb and Hg affect biological functions, affecting hormone system and growth. Many heavy metals accumulate in one or more of the body organs in food animals and are transmitted through food causing serious public health hazard. These toxicants are accumulated in the vital organs including liver and kidney and exert adverse effects on domestic animals. Many surveys involving human population in industrial, mining and urban areas have indicated toxicities due to effluents. Pesticides, heavy metals and other agro-chemicals are some of the major causes of environmental toxicity in farm animals. The impacts of pollution on animals result in serious economic losses. In this review we have tried to concise the information available in literature about the heavy metal pollution in soil, water, fodder and its consequences in livestock (blood, dung) and their presence in livestock products (milk, meat, egg).

Key words: Pollution, contamination, livestock, toxicity, livestock products

INTRODUCTION

Environmental pollution is a major global problem posing serious risk to man and animals. The development of modern technology and the rapid industrialization are among the foremost factors for environmental pollution. The environmental pollutants are spread through different channels, many of which finally enter into food chain of livestock and man (Kaplan et al., 2010). There is increasing concern about environmental pollutants emanating into the livestock production systems (Rajaganapathy, 2006). Pollution of the environment has significant impact on living organisms.
Reports from developed countries have documented adverse impact of pollution on domestic and wild animals in the form of specific chemical toxicities, behavioural changes and population decline. Pesticides, heavy metals and other agro-chemicals are some of the major causes of environmental toxicity in farm animals.

Various anthropogenic activities such as burning of fossil fuel, mining and metallurgy, industries and transport sectors redistribute toxic heavy metals into the environment, which persist for a considerably longer period and are translocated to different components in environment affecting the biota (Kaplan et al., 2010). These toxicants are accumulated in the vital organs including liver and kidney and exert adverse effects on domestic and wild populations (Kotwal et al., 2005). The effluents from livestock systems can affect the micro and macro environment, viz., water, atmosphere and food chain. Number of environmental cum medical surveys mainly involving human population in industrial, mining and urban areas have documented occurrence of toxicities due to effluents.

Heavy metal pollution is posing a serious problem in India, threatening the animal and human health and quality of environment. Environmental pollution in most developing countries is often attributed to negative effect of technological developments, like rapid urbanization and industrialization, with poor planning in waste disposal and management (Swarup and Dwivedi, 1998). Recently, in Kerala there was news about ground water contamination with heavy metals. The global environmental action group urged the state government to close down a bottling plant in Palakkad district for supplying inferior waste from the plant as fertilizer. The government reports say that ground water samples collected contained 65.7 µg of Pb and more than 10 µg of Cd per litre. Heavy mortality in cattle in Maharashtra, Punjab, Rajasthan and Delhi, due to industrial lead poisoning and death of animals due to leakage of MIC gas during Bhopal tragedy are some examples of industrial pollution catastrophe on domestic animals in India. The impacts of pollution on animals result in serious economic losses and economic consequences over and above health hazards. In India, heavy mortality in cattle and buffaloes due to industrial lead toxicity was responsible for decline in dairy animal population and significant financial losses to farmers (Swarup and Dwivedi, 1998).

**Heavy metal toxicity:** Heavy metal toxicity is one of the major current environment health problems and is potentially dangerous because of bio-accumulation through the food chain (Aycicek et al., 2008) and this can cause hazardous effects on livestock and human health (Aschner, 2002). In general, the hazardous effects of these toxic elements depends upon the dietary concentration of the element, absorption of the element by the system, homeostatic control of the body for the element and also the species of the animal involved (Underwood, 1977). Heavy metal pollution has become a serious health concern in recent years, because of industrial and agricultural development. Heavy metals of industrial bio-waste contaminate drinking water, food and air. The toxic heavy metals of great concern are Cd, Pb and Hg which are usually associated with harmful effects in men and animals. It is recognized that heavy metals may exercise a definite influence on the control of biological functions, affecting hormone system and growth of different body tissues (Teresa et al., 1997). Many heavy metals accumulate in one or more of the body organs with differing half-lives. These heavy metals apart from acute or chronic poisoning can be transferred to next generation and have potential toxicity from the viewpoint of public health.

**Heavy metals in water:** About five million people die of diseases caused by drinking impure water and the incidence of water pollution from heavy metals has reached such an alarming level that
environmentalists are finding it difficult to enforce effective control measures (WHO, 1995). The non-essential heavy metals have, directly or indirectly, an adverse effect on biological activities. The presence of these metals in water degrades their quality, which eventually affects human health. Even the essential metals at higher concentration are toxic. The livestock systems are prone to general problems of pollution emanating from industrial activity.

The extent of heavy metal contamination which was higher in untreated sewage water of Musi river near Hyderabad, India was studied by Raj et al. (2006). Sewage water collected all along the Musi river at different sites was contaminated with Cd, Cr, Ni, Pb, Co, Zn, Cu, Fe and Mn with a mean content of 0.025, traces, 0.062, 0.21, 0.053, 0.003, 0.011 ppm, traces and traces, respectively. Samples analyzed had excess amounts of heavy metals than the WHO permissible limits. In the same state, Bhat and Krishnamachari (1980) measured the Pb concentration in well water which contained 0.1 to 1.5 ppm of Pb). The distribution and characterization of heavy metals in water in Jeedimetla industrial area in Andhra Pradesh showed concentration of some of the trace elements as follows: As (1.5- 23.3 ppb), Cu (4.2 -13.7 ppb), Cd (0.60-31.8 ppb) and Pb (0.10- 0.50 ppb). The concentration of these elements was found to be far above the permissible level in water (Govil, 2001). In another study, Fiska et al. (2004) assessed the heavy metal pollution and its toxic effect on ground water quality of Jeedimetla in Andhra Pradesh and found that the concentration of heavy metals were above the permissible limits of WHO. The ground water was highly polluted and was unfit for domestic, irrigation and fishery uses.

The concentration of As from water tube wells in a residential area polluted due to industrial effluent discharge from a chemical factory in Calcutta, India, ranged from 0.05 to 23.08 ppm (Chakraborti et al., 1998), which was above the WHO recommended value of 0.01 ppm. The estimated mean concentration of Zn, Cu, Pb and Cd were 2.500, 0.500, 1.464, 0.006 ppm, respectively in regions around a fertilizer factory in Punjab (Dey et al., 1997). Kataria (1995) examined heavy metals in polluted water of Pipriya town-ship in Madhya Pradesh, India and found that surface water has been contaminated with heavy metals like Cu and Hg. The concentration of Cu, Cd, Fe, Cr, Mn, Pb and Zn in ground water at Dhanbad, Bihar was studied by Prasad and Jaiprakash (1999). The concentration of heavy metals was found to be below the permissible levels although concentration of Fe and Mn was found above the permissible limits at a few stations. The Heavy Metal Pollution Index (HPI) of ground water was found to be far below the index limit of 100 points indicating that the ground water was not polluted with heavy metals in spite of the prolific growth of mining and allied industrial activities near the town. Monitoring and assessing the heavy metals like Fe, Cd, Ni, Zn, Cu and Pb contents in the industrial effluents from Ambarnath area in Maharashtra state, India revealed that Cd concentration varied from 1.0 to 9.1 ppm, Cu varied from 8.0 to 10.2 ppm and Pb content ranged from 0.1 to 10.4 ppm (Lokhande and Sathe, 2001). In Lucknow district of Uttar Pradesh, India, most of the water bodies are being used for the cultivation of edible aquatic plants. It was found to be contaminated with a variety of toxic metals like Fe, Cu, Cr, Mn and Pb. The concentrations of Cr, Pb and Fe in the water were much higher than the recommended permissible limits by WHO (Rai et al., 2001).

Water samples in industrially polluted areas in Bangalore, Karnataka, India had higher Pb (0.17 ppm), Cd (0.05 ppm), Cu (33.63 ppm) and Zn (41.09 ppm) (Gowda et al., 2003). Rani and Reddy (2005) examined the concentration of Cr, Mo, Pb, Co, Cd and Fe in the highly polluted Hussain Sagar lake, Hyderabad, India. The results showed that the concentration of Fe, Zn and Co is high when compared to WHO and ICMR standards. Sinha (2004) analyzed the level of Cu, Pb, Ni, Co, Mn and Zn in water from Sai river at Rae Bareli in Uttar Pradesh, India during different seasons. Moderate concentration of Cu was found in the river water whereas Pb
(0.05-0.1 ppm) and Mn (0.100-2.200 ppm) were present in higher concentrations. In Bhopal, India, the surface water of lower lake had Cu (0.12 to 0.165 ppm), Zn (0.083 to 0.163 ppm), Pb (0.03 to 0.12 ppm) and Cd (0.014 to 0.41 ppm). Concentration of heavy metals like Cd and Pb in surface water was found to be above permissible limits. Heavy metal contamination of the lake water was found to occur due to a high degree of anthropogenic stress including idol immersion activity during religious festivals (Gupta et al., 2005). Haque et al. (2005) estimated the heavy metal concentration in surface water of the rivers and estuaries of Sundarbans mangrove forest in Bangladesh, India. The concentrations of Cu, Pb and Cd seasonally varied from 0.025 to 0.136, 0.205 to 0.598 and 0.0045 to 0.013 ppm, respectively.

In Nigeria, Beavington (1975) analyzed the water samples in different areas of rivulet and in a harbour in Wollongong. The results indicated biologically significant contamination of water by heavy metals. Various sources contributed to the levels of heavy metals in the rivulet and harbour water, the major part came from industrial outfalls. Analyzing water used for irrigating fodder fields near a refinery factory, Li-wenfan et al. (1995) found that the Pb, Cd, Cu and Zn concentration from polluted areas was significantly higher than that of unpolluted controls. Kokhue et al. (2000) evaluated the concentration of heavy metals like Cd, Pb, Cr, Cu and Zn in sea water collected from Istanbul. The concentration ranges of Cr, Cd, Pb, Cu and Zn in sea water were 0.89-3.33, 0.32- 2.00, 1.29- 4.41, 0.60- 35.2 and 0.13-1.38 ppm, respectively. In China, Ping (2005) measured the concentration of heavy metals in water in the vicinity of the Baiyin mining area and found that the waste gases and waste water produced by melting metals in factories caused Pb, Cd, Cu and Zn pollution in the surrounding environment.

**Heavy metals in soil:** The soil contaminants of heavy metals were studied in different parts of India (Parkpian et al., 2003; Singh et al., 2003). Also the micronutrient content of soil in the different villages and their availability to lactating cows were studied by many researchers in different parts of India (Prasad et al., 2005; Yadav and Khirwar, 2005).

Lead concentration examined in soil of Andhra Pradesh was 24 to 183 ppm (Bhat and Krishnamachari, 1980). Fodder plot soil showed 36.8 ppm of lead in industrial area of Punjab (Sidhu et al., 1994). Examination of soil samples in Jeedimetla industrial area of Andhra Pradesh, India by Govil (2001) revealed very high concentrations of Cu (400 ppm), Zn (1000 ppm), Pb (1600 ppm) and Ni (700 ppm). Sujatha et al. (2001) found higher concentrations of heavy metal in soil sample from a lake in Mysore, Karnataka, indicating metal toxicity. Gowda et al. (2003) studied the status of pollutants in soil in industrial area in Bangalore. The average soil pH was acidic (6.54 ppm) in industrial areas as compared to normal areas. The Pb (35.30 ppm), Cu (95.30 ppm), Zn (69.0) and Fe levels in soil of industrial areas was much higher than those of non-industrial areas. Bansal (2004) found that the soils under sewer water irrigation had higher concentrations of Zn, Cu, Pb and Cd when compared to fields irrigated by underground water. Soils irrigated with the effluents had higher contents of micronutrients and heavy metals as compared to the corresponding well irrigated soils (Patel et al., 2004).

Heavy metal accumulation, movement and distribution in the soil profiles near Zn smelter plant in Udaipur, India was studied by Garg and Totawat (2005). They found higher levels of heavy metals in the area which was situated in the close proximity of the effluent discharge point. Anuratha (2006) investigated the heavy metal concentration in soil in the vicinity of industries around Coimbatore city in Tamil Nadu, India. The concentration of Cd in all the industrial areas was found above the normal level. Pb was found above maximum tolerable concentration in all sites.
except in the textile industrial area. The content of heavy metals in soil of Jharia coal field of Jharkhand was estimated by Nikhil (2006) and noticed that the polluted soil was substantially contaminated with metals including Cr, Fe, Ni, Pb, Zn and Cu present in significant level.

Soil samples in the area near a refining factory had higher content of Pb, Cd and Cu (Li-wenfan et al., 1995). Burhenne et al. (1997) found high level of heavy metal concentrations in soil. Pb, Cd, Cu and Hg were 1360, 29.7, 817 and 40.8 ppm of soil dry matter, respectively. Longhurst et al. (2004) measured the concentration of As, Cd, Cu and Pb in New Zealand pastoral topsoil in both farmed and non-farmed sites. Results showed that there was a significant enrichment of Cd in the farmed soils over non-farmed soils.

**Heavy metals in fodder:** Rozso et al. (2003) detected the Pb content of forages and roughages produced in agricultural regions and the neighboring cities, industrial plants and busy highways. Pb contamination of plants from industrial areas and nearby busy roads was higher than that of plants from agricultural areas. Dey et al. (1996) examined the fodder samples in a polluted area and recorded the mean Pb concentration in forages as 706 ppm and the mean Cu, Pb, Cd concentration in forages as 1.116, 46, 1.075 ppm, respectively (Dey et al., 1997). The fodder fed to animals in industrial areas of Punjab, India contained Pb concentration of 102 to 382 mg kg$^{-1}$ (Sidhu et al., 1994). The Pb (2.40-145 ppm), Cd (0.50-10 ppm) and Cu (43-251 ppm), Zn (19-50 ppm) and Iron (338-11600 ppm) content in the vegetation in an industrial area was found higher as compared to normal areas (Gowda et al., 2003).

Plants grown on sewer water irrigation had higher concentration of Zn, Cu, Cd, Cr and Ni as compared to fields irrigated by underground water in Aligarh district of Uttar Pradesh, India (Bansal, 2004). The Cu content in various tree leaves in Akola district of Maharashtra state, India ranged between 106.25 to 220.00 ppm (Dhok et al., 2005). The concentration of Cr, Cu, Zn, Fe and Mn in the green roughage fed to Black Bengal goats had mean values of 0.80±0.01, 49.13, 36.89, 353.71 and 96.58 ppm, respectively (Paul et al., 2005).

The fodder samples fed to the dairy animals in Coimbatore, India was analyzed by Somasundaram et al. (2005) for micronutrient and heavy metal concentration. The mean values of micronutrients were Cu, Zn, Fe and Mn; 15.99, 48.4, 379.60, 47.16 mg kg$^{-1}$ and that of heavy metals were Cr, Ni, Pb, Cd; 134.8, 202.9, 64.02, 15.92 mg kg$^{-1}$, respectively. The concentration of micronutrients was in the normal range and hence no toxicity, whereas the heavy metal concentration fell under toxic level based on the critical level of trace metal in plants. Raj et al. (2006) analyzed plants for Cd, Cr, Ni, Pb, Co, Zn, Cu, Fe and Mn in sewage contaminated area. Plants grown on polluted soil irrigated with sewage water recorded higher level of heavy metals. The average value of Cd in plant was 0.79 mg kg$^{-1}$, Pb 19.22 mg kg$^{-1}$, Cu 12.75 mg kg$^{-1}$, Cr 4.90 mg kg$^{-1}$, Ni 4.34 mg kg$^{-1}$, Co 2.39 mg kg$^{-1}$, Zn 44.88 mg kg$^{-1}$, Fe 459 mg kg$^{-1}$ and Mn 92.86 mg kg$^{-1}$.

Parkpian et al. (2003) monitored Pb and Cd contamination in grazing land located near a highway. Grass had a Pb and Cd content of 0.76 to 6.62 ppm and 0.17 to 0.73 ppm, respectively. They found that plants growing nearer to the highway are usually exposed to more heavy metal accumulations than those away from the highway. Prasad et al. (2005) examined the micronutrient content of feeds in the adopted villages and assessed their availability to lactating cows. The fodder and paddy straw contained more silica and low in Cu content whereas in green fodders Cu, Fe and Mn was present above the critical level. The inter-relationship of soil micro-nutrient with feed stuffs was studied by Yadav and Khirwar (2005) in Jind district of Haryana, India. The concentration
of Cu, Zn, Fe and Mn in sorghum stover samples were in the range of 4.41-41.20, 27.12-40.98, 235.80-442.25 and 27.33-62.02 respectively. Soil Cu content had significant positive correlation with Cu content of green berseeum, sorghum stover and wheat straw. They reported that the Cu and Fe content of soil significantly affected their respective concentrations in feedstuffs.

Dobrzanski et al. (1994) assessed the effect of pollution from Cu industry on heavy metals concentration in green forage used in dairy cattle of Poland. Green forage from different farms within the copper mining area of Legnica-Glogow had twice the content of Cu, Pb and Cd than samples from another area. The influence of Pb, Cd, Cu and Zn pollution of the environment on the health of sheep and goats was studied by Li-wenfan et al. (1995) and found that the concentration in samples of grass from polluted areas was significantly higher than that of unpolluted controls. Saad and Fahmy (1996) investigated the accumulation of Mn, Cu, Zn and Cd in the zooplanktons of Bankalah region in Saudi Arabia. The mean concentration of Cu, Zn, Mn and Cd was 195.92, 179.18, 40.72 and 3.82 mg g⁻¹ dry weight respectively. The Cd level in organic and conventional pig production systems was studied by Linden et al. (2002). The Cd levels in organic and conventional feeds were 39.9 and 51.8 µg kg⁻¹ respectively. Organic feed contained two per cent potato protein which contributed 17% of the Cd content and conventional feed contained 5% beet fibre, which contributed 38% of the total Cd content. Palacios et al. (2004) reported Pb poisoning of horses in the vicinity of a battery recycling plant based on clinical signs and as well as on laboratory findings. Pb levels in the aerial part of herbage samples ranged from 113 to 4741 mg kg⁻¹. Bianu and Nica (2005) measured the Cd, Pb and Zn concentrations in hay, green Lucerne and feed grains fed to horses in Copsa Mica, Romania near a ferrous metal processing plant. It was detected that there were very high Pb and Cd levels in the hay, Lucerne, feed grains and maize stalks. Mor (2005) examined the Pb content in livestock feed taken from four agricultural areas of Bursa, Turkey. Among the live stock feed used, green grass was found to have higher level of Pb than straw. The concentration of heavy metals in forage fed to animals in the vicinity of the Baiyin mining area in China was analyzed by Ping (2005). The contents of Pb and Cd were 9 and 680 times higher in forages and 10 and 35 times higher in grain, respectively, as compared with the control area.

**Heavy metals in livestock (blood):** Rajaganapathy (2009) studied the biomonitoring of pollution in livestock production systems in industrialized area of Palakkad, Kerala, India. Heavy metals (Pb and Cd) in the blood of cows and buffaloes were studied in different parts of India (Dey et al., 1997; Swarup et al., 1993, 1997). Lead toxicity was reported in bovine in an industrial area in Punjab by Sidhu et al. (1994). Blood Pb concentration ranged from 19.5 to 73.1 ppm in ruminants. The Pb content in erythrocytes varied from 23.4 to 42.9 ppm. Normal blood Pb level in ruminants is 5 to 22.5 µg/100 mL. Dwivedi et al. (2001) recorded varying degrees of Pb poisoning in cows and buffaloes near a primary Lead-Zinc smelter in India. Blood level of 1.43 ppm Pb and 0.11 ppm Cd was detected in the vicinity of the smelter. The blood concentration of Pb, Cu, Co and Zn were 1.06 ppm, 0.82 ppm, 0.51 ppm and 4.67 ppm, respectively in 28 days of exposure to Pb. Increase in blood Pb concentration in lead-exposed calves was associated with a decrease in blood Cu and increase in Co concentration (Patra et al., 2001). In an industrial area in Bangalore, India Gowda et al. (2003) analyzed blood of dairy animals for heavy metals which showed comparatively higher Pb (0.09 ppm) and Cd (0.065 ppm), whereas the Cu and Zn levels in the blood plasma were similar to the normal values. Heavy metal presence in equine blood was observed by Dey and Dwivedi (2004) and Bianu (2005).
Swarup et al. (2005) studied the blood Pb level in animals reared in areas around different industrial localities and to find out the correlation between blood and milk Pb level in cows. Significantly (p<0.05) higher blood Pb level was recorded in animals reared around Lead-Zinc smelting factories followed by closed Pb but functional Zn smelter, Al processing unit and steel manufacturing plant, as compared to values recorded for control animals. Similarly, Patra et al. (2005) and Singh et al. (2006) estimated heavy metals in blood profile of cows and sheep in industrial localities. Somasundaram et al. (2005) recorded higher Pb, Cd, Cu serum concentration in Jersey crossbred cattle in Coimbatore, India. High amount of heavy metals is reported in serum samples in animals consuming fodder grown in land irrigated by polluted water with a mean concentration of Cd, Pb, Cu, Cr, Ni, Co, Zn, Fe and Mn as 0.022, 0.385, 0.302, 0.140, 0.029, 0.077, 0.496, 24.18 and 0.04 ppm, respectively (Raj et al., 2006). Vyas (1996) reported the pathological response of Ochratoxin -A, Cd and Hg toxicities in ducks. Field samples of soil, water, feed, biological materials were analyzed for the presence of Hg and Cd.

Dobrzanski et al. (1994) assessed the effect of pollution from Cu industry in bovine blood serum of dairy cattle from 30 farms in Poland. Blood serum from different farms within the copper mining area of Legnica-Glogow had twice the content of Cu, Pb and Cd of samples from another area, 80 km away. In an environmental pollution incidence, Marcal et al. (2004) analyzed water, soil, grass and mineral salt samples to investigate the sources of toxicity in animals. Animals from the vicinity of a factory making batteries for motor vehicles were monitored for the presence of inorganic Pb by clinical examination and haematological analysis. The results showed that animal health was harmed due to environmental pollution. Park et al. (2005) reported the concentrations of Cd, Pb, Hg and Cr in dog serum in Korea as 0.21, 1.10, 0.68 and 0.66 ppm, respectively.

Heavy metals in milk: Varying amounts of heavy metal contamination were detected in milk and dairy products. Higher concentration of Pb (1.13 ppm) was observed in milk from buffaloes reared in polluted areas of Delhi, India, which was higher than the concentration of (0.24 ppm) in milk from rural areas (Dey et al., 1996). Dwivedi et al. (1997) recorded mean Cd level in cows and buffaloes milk from different industrial areas as 0.008, 0.012 and 0.008 μg mL⁻¹, respectively. In Andhra Pradesh, India, Bhat and Krishnamachari (1980) measured the Pb concentration in cow's milk as 0.05 to 0.15 ppm. The Pb concentration in urban milk samples from Kanpur city, India was 0.32 ppm and rural milk sample had a Pb level of 0.24 ppm (Swarup et al., 1997). The Cd level in the milk samples of cows in urban and rural area was 0.013 ppm and 0.04 ppm, respectively. Varying degrees of Pb poisoning in cows and buffaloes near a primary Lead-Zinc smelter in India were reported by Dwivedi et al. (2001). The affected animals revealed considerably high levels of Pb and Cd in milk, 0.75 ppm and 0.05 ppm, respectively.

The status of pollutants and trace elements in dairy animals in an industrial area of Bangalore, India was studied by Gowda et al. (2003). The samples of milk in industrial area contained higher Pb (0.47 ppm) and Cd (0.05 ppm). The metals originated from various sources including grazing land, which naturally contained high levels of these metals or contaminated by industrial or other human activities. Parkpian et al. (2003) assessed milk samples to monitor Pb and Cd contamination from grazing land located at different distances from highway. The analysis revealed that improvements on farm management had significant reduction in elevated levels of Pb and Cd in soil and plants and this minimized the amount of Pb and Cd in milk. Milk from cows in agricultural regions and neighboring cities with industrial plants and busy highways were measured for Pb content. The Pb and microelement content of milk samples from cows grazing
along busy roads was found to be higher than that of milk from agricultural areas (Rozso et al., 2003). Swarup et al. (2005) estimated the level of Pb in milk from cows reared in areas around different industrial localities and found positive correlation between blood and milk Pb levels. The highest milk Pb level (0.84 ppm) was detected in animals reared in the vicinity of lead-zinc smelting unit. The extent of heavy metal contamination in untreated sewage water of Musi river near Hyderabad, India and the impact of irrigation with this water on soil-plant- milk animal continuum was studied. High amount of heavy metals in milk were detected in all the samples collected. All the heavy metals except zinc were in toxic limits to an extent of 100% (Raj et al., 2006).

The mean level of Pb, Cd, Hg and As recorded in milk were 0.02, 0.0015, 0.005 and 0.004 mg kg⁻¹, respectively and the mean levels of Pb, Cd, Hg and As recorded in the dairy product, cheese were 0.08, 0.05, 0.015 and 0.003 mg kg⁻¹ respectively (Strauch, 1983). Milk from different dairy farms in Poland within the copper mining area of Legnica-Glogów had higher content of Cu, Pb and Cd from samples of other areas (Dobrzanski et al., 1994). The heavy metal concentration in milk samples collected from three different regions (an industrial region, a rural and a heavy traffic intensity region) in Turkey was estimated by Simsek et al. (2000). The average content in the samples from the three regions were 0.032, 0.049 and 0.018 mg kg⁻¹ for Pb, 0.05, 0.009 and 0.0002 mg kg⁻¹ for As and 0.58, 0.96 and 0.39 mg kg⁻¹ for Cu, respectively The highest heavy metal content was found in the milk samples collected from industrial region followed by traffic intensive region and rural region.

**Heavy metals in muscle and organs:** The accumulation of metals like Pb, Cd, Cu and Zn in meat was studied by many researchers in India (Sidhu et al., 1994; Avram et al., 2000).

**Cattle:** Rajaganapathy et al. (2008) studied the heavy metal level in beef sample in industrial area of Palakkad, Kerala, India. Heavy metal contents in liver and kidney, especially from older cattle kept in polluted areas as well as from horses, foodstuff derived from such animal showed heavy metals in it (Strauch, 1983). Alonso et al. (2002) examined the effects of low-level environmental contamination on trace metal metabolism in cattle from the rural and relatively uncontaminated region of Galicia (NW Spain). Correlations between toxic Cd, Pb As and essential trace elements Cu and Zn were evaluated in liver, kidney and muscle of cattle from throughout Galicia. There was a significant positive association between renal Cd and Zn residues and a significant negative correlation between kidney Cd and Cu. Alonso et al. (2003) reported heavy metal accumulation in the organs of animals reared under cattle production systems of Spain. Cd and Pb accumulation in kidney, liver and muscle were noted. The heavy metal accumulation in the liver of dairy cattle was related not only to higher dietary intake, but also to the higher hepatic metabolism associated with milk production. Miranda et al. (2005) evaluated the contribution of anthropogenic pollution to toxic metal residues (Cd, Pb and As) in cattle in an industrialized area in Spain. They investigated possible implications of toxic metal exposure for metabolism of essential trace elements (Cu, Zn, Fe and Zn). Samples of kidney, liver and muscle from calves were obtained from an industrialized area and from a rural area. Cd and Pb contents in the liver and kidney were moderately and significantly higher in calves from the industrialized area (Cd: Liver 29.6, Kidney 161; Pb: Liver 38.1, Kidney 38.3 mg kg⁻¹) than in calves from the rural area (Cd: Liver 22.9, Kidney 96.4; Pb: Liver 20.7, Kidney 15.9 mg kg⁻¹). Toxic and essential metals in muscle, bone, liver and kidney of bovines, grazing on the municipal waste water spreading field in Morocco were
observed. Bovines were found to be contaminated by toxic metals. Specific target organs for metal bioaccumulation showed higher heavy metal accumulation (Sedki et al., 2003). Lemos et al. (2004) observed Pb poisoning in cattle, grazing in pasture contaminated by industrial waste. Pb concentration in liver and kidney was very high in cattle grazing in contaminated pasture. Skalicka et al. (2005) reported presence of higher Cu level in muscle, heart, liver and kidney of cows from a polluted area. Doyle and Spaulding (1978) found the concentration of Zn in liver of cattle in the range of 100-300 ppm.

Sheep and goat: Baars et al. (1986) estimated the environmental pollution with heavy metals of marshyland of the Scheldt estuary and its effect on sheep. The content of Cd and Pb in liver was low, but the Cu content was up to 600 mg kg\(^{-1}\) dry matter. In kidney tissue the Cd content was generally low, but Pb averaged 1 mg kg\(^{-1}\) and Cu ranged from 6 to 30 mg kg\(^{-1}\). Sheep fed with commercial concentrate containing Cu showed the signs of chronic Cu poisoning (Möllerka and Ribeiri, 2006). The mean Cu level in the concentrate was 11.37 mg kg\(^{-1}\) and the Cu levels in the liver and kidney were 1641 and 305 mg kg\(^{-1}\), respectively. Robinson (1994) reported copper content in goat kidney as 12.48 to 14.5 ppm which is below toxic level and Pb 29 ppm in goat meat from Chennai city, India, which is at toxic level. In Sophia copper content in fresh liver of sheep and goat was reported in the range of 2.6 to 10.3 mg\% (Tomoff, 1990).

Leita et al. (1991) found higher than toxic level of heavy metals in sheep organs from smelter area in Italy as Pb in muscle 15.3 ppm and kidney 43 ppm and Zn 18-28.8 ppm in muscle. Seven times higher level of Pb in sheep organs and tissues from industrial region in Iraq was observed (Abbas, 1992). Schroeder (1991) reported higher levels of Pb in sheep tissues from mining area in Germany. Zinc level of 14.72 mg/100 g has been reported in goat muscle, kidney and lever from Chennai, India which is at toxic level (Ayyadurai and Krishnasamy, 1986). Langlands et al. (1987) observed Zn level of 57 and 70 ppm in muscle of sheep and cattle, respectively. Doyle and Spaulding (1978) found the concentration of Zn in liver of sheep and chicken in the range of 100-300 ppm. Maximum permissible limit of Zn in meat and meat products is 50 ppm (MPPO, 2004).

Pig: Cd level in organic and conventionally produced pig was 39.9 and 51.8 μg kg\(^{-1}\), respectively (Linden et al., 2002), this might be due to the differences in feed composition and bioavailability of Cd. Samples of muscle tissue, liver and kidney were analyzed and measured by Ulrich et al. (2002) for Hg, Cd and Pb in the swine farms of Hodonin, Czech Republic. The concentration of Hg and Cd were higher in liver, kidney and muscle samples. Doyle and Spaulding (1978) found the concentration of Zn in liver of pig in the range of 100-300 ppm.

Horse: Znamirowska et al. (2005) studied the accumulation of heavy metals in the horse organs. They found that Pb accumulation in meat and in liver averaged 0.048 and 0.205 mg kg\(^{-1}\), respectively. In Romania, Bianu and Nica (2005) measured the Cd, Pb and Zn concentrations in horse tissue near a non-ferrous metal processing plant. Very high levels of Cd (40-100 times higher than normal levels) and high levels of Pb (3-6 times higher than normal levels) were detected in the various organs of the horses.

Wild animals: The content of Pb and Cd in liver and kidney of wild animals in polluted area was 20 and 16 and 30 and 100 mg kg\(^{-1}\), respectively. The content of Pb in liver and kidney of wild animals in low polluted area was 1 to 5 mg kg\(^{-1}\) and that of Cd in liver and kidney was
4 to 10 mg kg⁻¹, respectively (Strauch, 1983). Drozd et al. (2003) observed the level of Cd, Pb and Hg in the skeletal muscles, heart muscle, liver and kidneys of Red deer from three natural forests of Lublin region of Poland. Highest level of Cd and Pb accumulation was found in the skeletal and heart muscles. Venalainen et al. (2005) measured the level of heavy metals in game animals. The concentrations of Pb, Cd and Hg in liver and kidney of brown hare in the west Slovakia was reported to be highest during the winter period (Massanyi et al., 2005).

**Heavy metals in eggs:** The Pb and Cd concentrations in egg samples ranged between 0.142 to 0.936 and 0.030 to 0.180 µg g⁻¹, respectively (Dey and Dwivedi, 2000). In this study in India, the majority of the samples had Pb and Cd concentrations that exceeded 0.020 and 0.005 µg, respectively, which are normal levels for Pb and Cd in eggs. Rajaganapathy (2010) reported levels of heavy metals in egg samples of industrialized area of Palakkad, Kerala, India. The mean Pb concentration recorded in this study was found to be higher than that found in hen’s eggs from Canada, Taiwan, China, Finland and Hungary. In a study in the United States (Vodela et al., 1997), broiler breeder hens were used to determine the effect of drinking water containing a low concentration of a chemical mixture (As 0.8 ppm, benzene 1.3 ppm, Cd 5.1 ppm, Pb 6.7 ppm and Trichloroethylene 0.65 ppm) and a high (10 times greater than the low concentration of the chemical mixture) level of the chemical mixture. These chemicals were present in ground water near hazardous waste sites. Water consumption and body weight decreased in hens provided with high concentration of the chemical mixture. The low concentration of the chemical mixture significantly decreased egg production and egg weight.

**Heavy metals in dung:** Dung samples of the cattle of Andhra Pradesh, India contained 4.7 to 38 ppm of Pb (Bhat and Krishnamachari, 1980). Sidhu et al. (1994) found that Pb concentration in dung of ruminants due to industrial pollution in Punjab varied from 48.7 to 146.1 ppm. Gowda et al. (2003) reported that the samples of dung examined from dairy cattle in the industrial areas contained higher Pb (0.55 ppm) and Cd (0.032) than the samples from the control area. Higher concentrations of Cd were reported by Nisha (2000) in all the dung samples from cattle examined in Eloor industrial area in Kerala state, South India.

In pigs, Linden et al. (2002) evaluated the Cd level in the manure of organic and conventionally raised pigs as 39.9 and 51.8 µg kg⁻¹, respectively and they concluded that organic pigs had a higher Cd level in manure indicating a higher Cd exposure from the environment, such as ingestion of soil. Parkpian et al. (2003) investigated lead and Cd contamination in grazing land located near a highway. Analysis of the manure showed considerable amounts of Pb and Cd content of 2.55-8.34 and 0.14-0.31 ppm, respectively. Long term simultaneous application of fertilizer and manure on the commercial farm showed higher metal accumulation in the soil and plants than that of other farms.

It was found that Cu, Pb, Cd and Cr concentrations in animal manures were high in China. The copper concentration in manure sample reached as much as 1726.3 mg kg⁻¹ (Cang et al., 2004). Mor (2005) estimated the Cd and Pb contents in cattle manure taken from four agricultural areas exposed to different degrees of environmental pollution. The levels of Cd and Pb contamination in the manures of the cattle, in the areas far from industries, traffic or urbanization, were less than those that were closer to heavy traffic and industrial activities. The highest heavy metal content was found in cattle manure collected from the region with heavy traffic, followed by industrial and rural region.
CONCLUSION

High levels of heavy metals are found in water, soil, fodder particularly near the industrial areas in India and many other countries has the influence to reach and accumulate in the livestock which may cause severe human health hazards. Higher levels of heavy metals found in the organs and tissue of livestock in different countries is a serious concern. Presence of heavy metals at toxic levels has been reported from India and other countries in livestock especially in muscle and other tissues used as meat. The higher level of heavy metal content was found in cattle manure collected from industrial areas indicated the effect of pollution in the livestock. The overall situation of heavy metal pollution in the environment and in livestock and products are alarming. This is high time for international agencies to be concern about the heavy metal pollution and its consequences on the livestock and human health for necessary control measures.

REFERENCES


MFPO, 2004. Meat food products order: The gazette of India. Ministry of Agriculture and Rural development, Govt. of India.


Rajaganapathy, V., 2010. A study of heavy metals on egg samples of industrialized area of Palakkad, Kerala, India. Proceedings of International Conference on Technological Advances in Poultry Production, Health and Management, Jan. 8-10, Veterinary College and Research Institute, Namakkal, Tamil Nadu, India, pp: 64-64.


