



Assessment of Heavy Metal Pollution and Contaminants of River Palar

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ABSTRACT

The present study was conducted to quantitatively measure the levels of Cr, Pb, Cd, As, Ni and Hg in soil, fodder and meat samples. The study area chosen for the present study is sewage polluted River Palar flowing sites. Two sites were chosen for this work, Site 1 (Palar, Ambur) and Site 2 (Palar, Vaniyambadi). Fresh samples were collected from the study area. Heavy metals like Cr, Cd, Pb, As, Ni and Hg were analysed using atomic absorption spectrophotometer (AAS). In the present study Pb, Cr, Cd, Ni and Hg concentration in Site 1 was high when compare with Site 2, except As which shows high concentration in Site 2. This result indicates Site 1 in heavily polluted than Site 2. Results of meat sample shows that Pb, Cd, Cr and Hg values are higher than the permissible limit, especially Ni. In the same way the results of soil sample shows Cd, Pb, Cr, Hg and Ni levels were higher than the allowed limits. Pb concentration was very higher than other metals. In fodder sample the levels of Cd, As and Hg are higher than the permissible limit.

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Introduction

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 often have direct physiologically toxic effects and are stored or incorporated in living tissues (Baykov et al., 1996). A study carried out by John and Jeanne (1994) showed that levels of arsenic, cadmium, mercury and lead were detected in several tissues of goats; the results showed that the levels of the above metals were found to be very high and generally above the permissible level Toxic effects of lead are seen on haemopoietic, nervous, gastrointestinal and renal systems (Baykov et al., 1996). Food is one of the principle environmental sources of cadmium (Baykov et al., 1996).

Some heavy metals especially lead, cadmium are associated with automobile related pollution. They are often used as minor additives to gasoline and various

autolubrication, and are released during combustion and spillage (Lytle et al., 1995). Most zinc enters the environment as the result of mining, purifying of zinc, lead, and cadmium ores, steel production, coal burning, and burning of wastes.

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).

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).

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 Cr 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. Sheep fed with commercial concentrate containing Cr showed the signs of chronic Cr poisoning (Mollerka and Ribeiri, 2006).

The mean Cr level in the concentrate was 11.37 mg kg⁻¹ and the Cr levels in the liver and kidney were 1641 and 305 mg kg⁻¹, respectively. Robinson (1994) reported copper content in goat kidney as 12.43-14.5 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 2.6-10.3 mg% (Tomoff, 1960).

Environmental pollution with heavy metals like lead, cadmium, nickel and mercury cause various toxic effects in living organisms. Including cancer, bioaccumulation, biomagnifications and biomethylation are some of the characteristic features of heavy metal pollution. As the living organisms including man and plants are constantly exposed to metals, they accumulate by a process referred to as bioaccumulation. Continuous exposure and accumulation of a given metal in the organism results in its increased concentration, a phenomenon referred to as biomagnifications. Biomagnifications usually occurs through food chain and man is the ultimate victim.

Meat is containing rich amount of microelements. Chemical composition of meat depends on both the types and quantity of feeding. Heavy metals pollution made by man which are affected into the aquatic and terrestrial habitats. Metals like iron, copper, zinc and manganese, are essential metals since they play important role in biological systems, whereas mercury, lead and cadmium are toxic, even in trace amounts. The existence of toxic substances residues in food represents a major problem for food hygiene, because these can modify the state of health of all age consumers. 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.

Objectives

To quantitatively measure the levels of Cr, Pb, Cd, As, Ni and Hg of meat sample.

To compare the levels of above mentioned heavy metals to the acceptable limits of heavy metals for food.

To identify the heavy metal contamination in soil and fodder in the study site.

Materials and Method

Study Area and Sampling Locations

The study area chosen for study is sewage polluted River Palar flowing sites. Two sites were chosen for this work, Site 1 (Palar Ambur) and Site 2 (Palar Vaniyambadi).

Sample Collection

Fresh samples of meat of sheep were collected from the study area. The samples were collected in polyethylene bags. The fat was removed while collecting the meat. The samples were kept frozen at -4°C until analysis. Topsoil samples (0-20 cm) were taken from two sites. The soil samples were collected in a plastic bag and transported to the laboratory. Freshly harvested fodder samples were put in clean plastic bags and transported to the laboratory for analysis.

Sample Preparation of Meat

The collected samples were decomposed by wet digestion method for the determination of various metals.

Sampling and Analysis of Soils

The soil samples were dried in an oven at 10F0°C for 24 hrs. Large lumps and rocky granules were removed and the remainder sieved to a particle size of less than 80 mesh.

Digestion of Samples

1 gm of soil was taken into an Erlenmeyer flask and 10 ml of HNO₃: HCl (1:3) was added.

The flask was heated on a hot plate at 95°C for the appropriate time periods. The sample was filtered through Whatman filter paper (No.41) and the volume was made up to 50 ml in a volumetric flask and then analyzed by atomic absorption spectrophotometer (AAS) Model Elico SL-173.

Fodder Crop Sampling and Analysis

Samples were washed with 1% HCl followed by three to four washing with distilled water to remove the foreign material then spread on a clean paper for drying. These sample were then oven dried at 60-70°C. The dried samples were digested in diacid mixture of Nitric acid (HNO₃) and Perchloric acid.

Table 1. Table Type (HClO₄). Heavy metal concentration in the prepared samples was determined by using Atomic Absorption Spectrophotometer Model Elico SL-173 (Table 1 and Table 2).

| Samples | Pb | Cd | Cr | As | Hg | Ni |
|--------------|-----------|-----------|----------|----------|----------|----------|
| Meat | 4.6±0.2 | 6.6±1.6 | 9.5±0.5 | 3.7±1.1 | 2.5±0.3 | 22.1±0.2 |
| Fodder mg/kg | 28.3±0.06 | 0.88±0.02 | 39.5±0.7 | 3.5±0.7 | 0.05±0.9 | 31.5±0.5 |
| Soil mg/kg | 176.5±3.2 | 10.2±0.5 | 122±0.8 | 15.6±1.3 | 0.10±0.1 | 34±0.06 |

Table 2. Heavy metal concentration in different samples collected from Site 2.

| Samples | Pb | Cd | Cr | As | Hg | Ni |
|--------------|-----------|-----------|----------|----------|----------|----------|
| Meat | 2.4±0.3 | 5.1±1.2 | 8.6±0.3 | 5.6±1.7 | 1.5±0.5 | 9.8±0.4 |
| Fodder mg/kg | 25.3±0.03 | 0.85±0.01 | 37.2±1.2 | 2.9±0.8 | 0.03±0.7 | 24.3±0.7 |
| Soil mg/kg | 170.5±4.2 | 9.4±0.2 | 116±0.7 | 13.2±0.6 | 0.09±0.9 | 32±0.03 |

Statistical Analysis

After analysis of all the samples, mean ± SE values were calculated and the data was subjected to analysis (PAST).

Result and Discussion

Toxicity of ingested heavy metals has been an important human health issue for decades. The prevalence of contamination from both natural and anthropogenic sources has increased concern about the health effects of chronic low-level exposures. Some of heavy metals are required by most living organisms in small but critical concentration for normally healthy growth but excess concentration causes toxicity. The samples of meat, fodder and soil were collected from two different sites near Palar river in order to determine the heavy metals concentration in these areas.

Heavy Metal Concentration in Meat

The results of lead in meat samples of present study showed maximum concentration in site 1 (4.6 mg/kg) than in site 2 (2.4 mg/kg). The Lead concentrations in both the sites are above the permissible limit of 0.1 mg/ kg set by WHO. Cadmium found in the Site 1 is 6.6 mg/ kg and in Site 2 it is 5.1 mg/kg). The obtained Cd values are above the FAO limits of 0.1 mg/kg (FAO, 1983).

Heavy Metal Concentration in Soil

Natural and anthropogenic sources of soil contamination are widespread and variable. The Lead concentration in Site 1 is 176.5 mg/kg and Site 2 is 170.5 mg/kg. This result shows high concentration of Lead in both the sites where the permissible limit was found to be 50 mg/kg.

Concentration of Heavy Metals in Fodder

Certain plants can accumulate heavy metals in their tissues. Uptake is generally increased in plants that are grown in areas with increased soil concentrations. The lead concentration in fodder was found to be 28.3 mg/kg and 25.3 mg/kg in Site 1 and Site 2. The maximum tolerable level of Pb

in cattle's diet is 30 mg Kg⁻¹, the observed level is little less than the tolerable level.

The cadmium concentration in fodder was found to be 0.88 mg/kg in Site 1 and 0.85 mg/kg in Site 2. It is slightly above the tolerable limit of 0.5 mg/kg. In the present study the Chromium concentration was observed in Site 1 as 39.5 mg/kg and 37.2 mg/kg. There is no recommended level of Cr in animals' diet.

Environmental pollution is a major global problem posing serious risk to man and animals. The development of modern technology and the rapid industrialization are the main 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., 2011).

Transport of heavy metals from the atmosphere to the soil and vegetation takes place by dust fall, bulk precipitation and gas or aerosol adsorption processes. Heavy metals from distant sources gradually increase the level of toxic metals in natural environments and these will be increasingly taken up by the plants and transferred further up the food chain. Plants have a key function in the biotransformation of chemical elements from soil, water and air, however green plants are unable to take up much mercury from contaminated soil.

Heavy metals in fodder followed hierarchy, order: Cr > Ni > Pb > As > Cd > Hg (Fig 1). The magnitude of different heavy metals in meat followed hierarchy, order: Ni > Cr > Cd > As > Pb > Hg (Fig 2). Heavy metals in soil followed hierarchy, order: Pb > Cr > Ni > As > Cd > Hg (Fig 3).

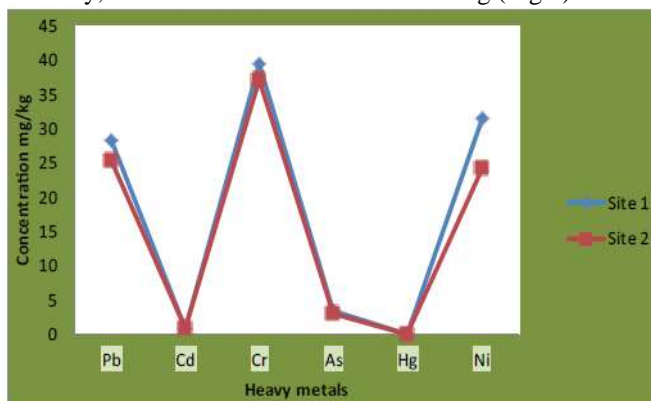


Figure 1. Comparison of heavy metals in fodder collected from two sites.

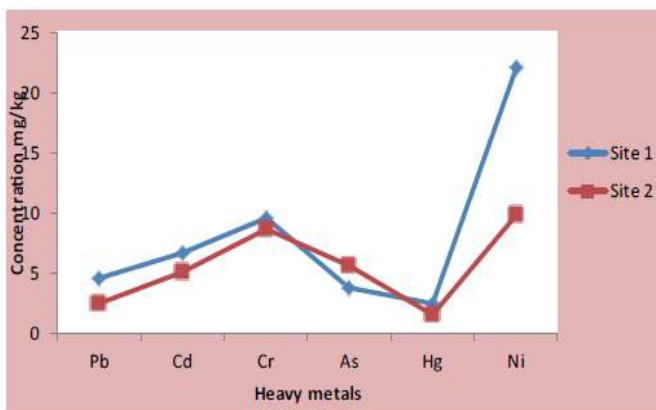


Figure 2. Comparison of heavy metals in meat sample collected from two sites.

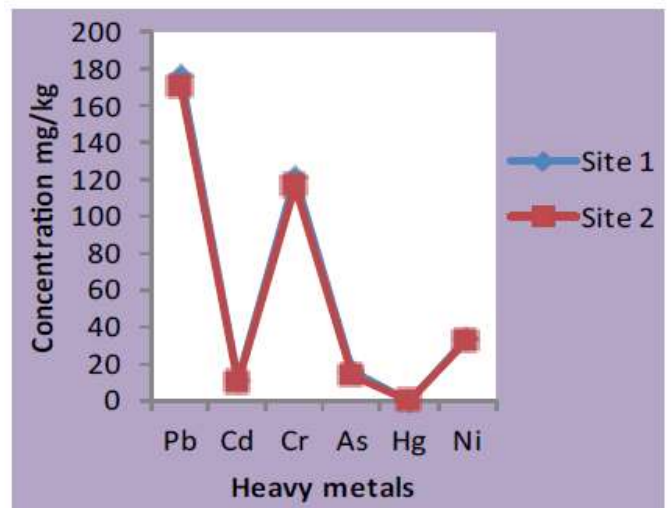


Figure 3. Comparison of heavy metals in soil sample collected from two sites.

Mariam et al. (2006) reported that beef, mutton and poultry contained a range 2.02–4.25 mg/kg of lead concentration. Our result also supports the same, so it appears that values of lead in meat samples of this study were above the permissible limits. This may be due to increased industrialization and urbanization that result in increased bio-availability of lead in meat investigated in present study. Lead is a toxic element and can cause severe health risks such as reduced haemoglobin formation, thus leading to anemia, liver infections, abdominal pain, allergies, cardiovascular disease, depression and kidney disorder etc. The present study results showed that lead concentration in fodder is less than the permissible limit. Excessive levels can cause Pb poisoning. Symptoms of Pb poisoning in cattle include dullness, loss of appetite, abdominal pain with constipation, sometimes followed by diarrhoea and after two or three days bellowing, staggering, snapping of eyelids, muscular twitching, frothing at the mouth and convulsive seizures.

Lead concentration in meat was higher than the permissible limit set internationally. This higher trend was supported by the results of (Sabir et al., 2003). Pb concentration in different organs and muscles of cow ranged from non-detectable to 1.22 mg/kg (Nwude et al., 2011).

The values of chromium recorded in this study were supporting the result reported by Asebeloyin et al. (2010). Excess quantity of chromium damages kidney, liver, skin etc.

Mercury is a liquid volatile metal, found in rocks, soils and also is present in air as a result of human activities as the use of mercury compounds in production of fungicides, paints, cosmetics, papers pulp etc. However, inhalation of 1 mg/m³ of air for three months may lead to death. Nervous system, liver, eyes are damaged. Infant may be deformed. Other symptoms of mercury toxicity are headache, fatigue, anxiety, lethargy, loss of appetite etc. The average mercury content of surface soils from a number of countries ranged from 20 µg/kg to 625 µg/kg. The highest concentrations were found in soils from urban locations. The mercury levels in both the sites are higher than the permissible limits.

Cadmium occurs in air, water and soil due to industries and human activities. The maximum tolerable level of Cd in cattle's diet is 0.5 mg/kg, whereas the excessive level of Cd can cause cattle poisoning. The observed values are quite higher and could be potentially dangerous to animals' health as corroborated by poor appetite and slower growth in some of the animals of the study area.

Higher concentration of arsenic in the livers and kidneys of cattle and goats has also been reported by Krupa and Swida (1997). The permissible limit of arsenic in the livers of chickens has been reported as 2.0 ppm (ANZFA, 2001). Arsenic is also very toxic to animals and affects the gastrointestinal tract and the cardiovascular system. Symptoms of arsenic poisoning in animals include watery diarrhoea, severe colic, dehydration and cardiovascular collapse.

It is obvious from the results that samples contain higher amount of Ni. In humans, it regulates prolactin and stabilization of RNA and DNA structures. In contrast, excessive intake of Ni can cause severe allergic reaction. Applying food safety standards on a product is very important because it relates closely to human's health. Ni concentration also exceeds the allowed limit.

The elevated metallic levels in the samples could also be due to the addition of agrochemicals in agricultural soil and rain water washing (precipitation) on the plants. The metallic levels observed in grasses could be as a result of the heavy metals absorbed from the soil. Present study results also support the same because in fodder samples the heavy metals were found to be high.

The heavy metals accumulated in the higher levels of soil have significant chemical affinity with the organic substances which are widely present on this level. As a consequence, destruction of the organic matter slows down, what increase their availability. An analysis of several dozens of the species and types of fodder plants (mostly grasses) revealed that there is various selectivity of absorbing heavy metals from soil.

According to the result, Site 1 is highly polluted than Site 2. This may be due to the presence of dying industries nearby the Site releasing their effluent directly into the river Palar. At present the river is in dried condition with minimum water stagnated here and there. Though it is not in flowing condition the contaminants got concentrated and the area is heavily polluted.

Conclusion

Heavy metals, such as cadmium (Cd), chromium (Cr), arsenic (As), nickel (Ni), mercury (Hg) and lead (Pb), are a group of potentially toxic compounds (PTC) that are of concern when dealing with the quality of animal feedstuffs. The supply of safe feed products to animals is crucial not only to safeguard animal health and welfare but also to reduce human exposure to heavy metals and organic contaminants.

The study reveals that sewage is the main source of pollution of this water body and fodder that grows along with sewage-contaminated water containing variable amounts of heavy metals leads to increase in concentration of metals in the soil and vegetation. When the cattle feed this fodder or the soil or drink the sewage water the contaminants enter into the food chain. In conclusion, it is agreed that meat is basic ring in human food chain so possible suspicions about aggravated risk should be investigated. The relations between soil, fodder, livestock production and health are very complex and multifaceted, raising serious policy concerns at national and international levels.

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