



## Assessment of Some Heavy Metal Concentrations in Raw Cow's Milk Collected from Dairy Farms in Dire Dawa City

Getachew Asfaw Seid<sup>1\*</sup>, Sualih Adem Hamza<sup>2</sup>, Melaku Masresresha Woldeamanuel<sup>3</sup>  
and Azanaw Girmaw Mengstu<sup>4</sup>

<sup>1</sup>Department of Chemistry, School of Natural and Computational Science, Dire-Dawa University, P O Box 1362, Dire-Dawa, Ethiopia; Email: [getas0728@gmail.com](mailto:getas0728@gmail.com); Mobile: +251 912770728

<sup>2</sup>Department of Chemistry, School of Natural and Computational Science, Dire-Dawa University, P O Box 1362, Dire-Dawa, Ethiopia; Email: [sualih.adem@gmail.com](mailto:sualih.adem@gmail.com); Mobile: +251918741643

<sup>3</sup>Department of Chemistry, School of Natural and Computational Science, Dire-Dawa University, P O Box 1362, Dire-Dawa, Ethiopia; Email: [sofon2ms@gmail.com](mailto:sofon2ms@gmail.com); Mobile: +251911385211

<sup>4</sup>Azanaw Girmaw Mengstu: Department of Chemistry, School of Natural and Computational Science, Debre Tabor University, P O Box 273, Debr Tabor, Ethiopia Email: [azanawgirmaw8@gmail.com](mailto:azanawgirmaw8@gmail.com); Mobile: +251947981698

\*Corresponding Author

### Abstract

Cow milk is a vital dietary product consumed globally due to its rich nutrient content. However, heavy metals present in cow milk can pose significant health risks to humans and animals alike. This study aimed to assess the concentrations of heavy metals, including Chromium (Cr), Nickel (Ni), Copper (Cu), Zinc (Zn), Cadmium (Cd), Iron (Fe), and Lead (Pb), in raw cow's milk from dairy farms in Dire Dawa City, Ethiopia. Milk samples were analyzed using Flame Atomic Absorption Spectrophotometer (FAAS), and statistical analysis was conducted using SAS software. The results were subjected to one-way ANOVA with Duncan's multiple range test to compare concentrations across different dairy farms. Findings showed that Fe, Cd, and Zn concentrations were 2.392 mg/L, 0.087 mg/L, and 0.32 mg/L, respectively, with most values within internationally accepted limits. The results underscore the importance of monitoring heavy metals in dairy products for public health safety.

**Key words/Phrases:** Heavy metals; cow's milk; digestion; Flame Atomic Absorption Spectrometer; dairy farm; Dire Dawa

## 1. Introduction

### 1.1. Background of the study

Milk is an essential dietary component, providing crucial nutrients such as proteins, calcium, and vitamins, especially in developing countries where it contributes significantly to nutritional security. However, contamination of milk with harmful substances like heavy metals poses risks to human health. Heavy metals such as Lead (Pb), Cadmium (Cd), and Chromium (Cr) are non-biodegradable and persist in the environment, leading to bioaccumulation in the food chain

\*Corresponding author: Getachew Asfaw; email: [getas0728@gmail.com](mailto:getas0728@gmail.com); Mobile: +251 912770728

©2023 The Author (S) and Harla Journals. Published by Dire Dawa University under CC-BY-NC4.0;

Received: March 2023; Received in revised form: May 2023; Accepted: June 2023

Chronic exposure to these metals has been linked to adverse health outcomes, including neurological damage, kidney dysfunction, and cardiovascular disease (Jaishankar *et al.*, 2014). Studies globally have highlighted the prevalence of heavy metal contamination in cow's milk, often exceeding safety limits set by international organizations. For example, research in Pakistan reported elevated levels of Pb, Cd, and Cr due to industrial pollutants (Sattar *et al.*, 2020). Similar contamination patterns were observed in Iran and Nigeria, emphasizing the influence of industrial and urban activities (Fard *et al.*, 2015; Onyinye *et al.*, 2014). In Ethiopia, limited studies focus on heavy metal contamination in dairy products, despite the country's increasing industrialization. Dire Dawa City, a rapidly urbanizing area, faces risks from industrial effluents, vehicular emissions, and improper waste disposal, making it imperative to assess the safety of milk produced in this region.

### 1.2. Statement of the Problem

Heavy metal contamination in dairy products is a pressing public health concern. In Dire Dawa City, rapid urbanization and industrial activities heighten the potential for environmental contamination of dairy farms. Despite the critical role of milk in the local diet, limited data exist on the levels of heavy metals in milk from this region. This gap necessitates research to assess the concentrations of heavy metals such as Cr, Ni, Cu, Zn, Cd, Fe, and Pb in cow's milk and their compliance with international safety standards.

### 1.3. Hypotheses

1. The concentrations of heavy metals in raw cow's milk from Dire Dawa City are within internationally accepted safety limits.
2. The levels of heavy metals vary significantly across different dairy farms in Dire Dawa City due to varying environmental exposures.

### 1.4. Objectives

#### 1.4.1. General Objective

To investigate the concentration of selected heavy metals (Cr, Ni, Cu, Zn, Fe, Cd, Pb) in raw cow's milk collected from dairy farms in Dire Dawa City, Ethiopia.

#### Specific Objectives

- To determine the concentrations of Cr, Ni, Cu, Zn, Fe, Cd, and Pb in raw milk collected from dairy farms in Dire Dawa City.
- To compare heavy metal concentrations across different dairy farms in the city.
- To evaluate the compliance of detected heavy metal levels with international safety guidelines.
- To identify potential environmental sources contributing to heavy metal contamination in cow's milk.

## **2. Materials and Methods**

### **2.1. Study Area**

The study was conducted in Dire Dawa City, Ethiopia, a major urban center with diverse agricultural and industrial activities. The city's proximity to both urban and industrial areas make it susceptible to environmental contamination, particularly from industrial effluents, vehicular emissions, and waste disposal sites.

### **2.2. Sample Collection**

A total of 24 raw cow's milk samples were collected from four different dairy farms in Dire Dawa City. Each farm was located in a distinct part of the city to ensure a comprehensive assessment of heavy metal concentrations across different geographical areas. The samples were collected in sterile containers and transported to the laboratory under refrigerated conditions to prevent spoilage.

### **2.3. Sample Digestion**

Milk samples were digested using a microwave digestion method. This technique ensures complete breakdown of organic materials and release of metal ions, allowing for accurate measurement of heavy metal concentrations. The digestion process involved adding a mixture of nitric acid and hydrogen peroxide to the milk samples, followed by heating in a microwave digestion system.

### **2.4. Heavy Metal Analysis**

The concentrations of Cr, Ni, Cu, Zn, Fe, Cd, and Pb in the milk samples were measured using a Flame Atomic Absorption Spectrophotometer (FAAS). Calibration curves for each metal were prepared using standard solutions to ensure accurate quantification.

### **2.5. Statistical Analysis**

Data were analysed using SAS software, and a one-way analysis of variance (ANOVA) was conducted using Duncan's multiple range test to compare the concentrations of heavy metals across different dairy farms. Statistical significance was set at  $p < 0.05$ .

### 3. Results and discussion

#### 3.1. Heavy Metal Concentrations in Milk Samples

Table 1 shows the concentrations of heavy metals in raw cow's milk samples from the four dairy farms in Dire Dawa City.

Table 1. Heavy Metal Concentrations (mg/L) in Raw Cow's Milk Samples

	Metal	Farm 1 (mg/L)	Farm 2 (mg/L)	Farm 3 (mg/L)	Farm 4 (mg/L)	Mean $\pm$ SD
Fe	2.35	2.40	2.45	2.38	2.392 $\pm$ 0.05	
Zn	0.32	0.30	0.34	0.31	0.32 $\pm$ 0.02	
Cu	0.11	0.12	0.13	0.11	0.12 $\pm$ 0.01	
Cr	0.03	0.05	0.04	0.03	0.04 $\pm$ 0.01	
Ni	0.02	0.03	0.02	0.02	0.02 $\pm$ 0.01	
Pb	0.02	0.02	0.02	0.01	0.02 $\pm$ 0.01	
Cd	0.08	0.09	0.09	0.08	0.87 0.01	

### 3.2. Analysis of Heavy Metal Concentrations in Raw Cow's Milk

Table 1 presents the concentrations of seven heavy metals (Fe, Zn, Cu, Cr, Ni, Pb, and Cd) in raw cow's milk samples collected from four different dairy farms in Dire Dawa City. The concentrations are reported in milligrams per liter (mg/L), and a mean value with standard deviation (Mean  $\pm$  SD) is provided for each metal.

#### Iron (Fe)

**Concentrations:** The iron (Fe) concentrations across the four farms ranged from 2.35 mg/L to 2.45 mg/L, with a mean concentration of  $2.392 \pm 0.05$  mg/L.

**Analysis:** Iron is an essential micronutrient in the human diet and is present in cow's milk naturally. The relatively small standard deviation (0.05 mg/L) indicates minimal variability in Fe levels among the farms. The concentration levels are consistent, suggesting no significant external contamination sources of Fe at any particular farm. These levels appear within acceptable dietary limits based on general nutritional standards, although it is important to compare these values with regional or global regulatory guidelines for milk.

#### Zinc (Zn)

**Concentrations:** Zinc concentrations varied slightly between 0.30 mg/L and 0.34 mg/L, with a mean of  $0.32 \pm 0.02$  mg/L.

**Analysis:** Zinc, like iron, is an essential element and plays a role in several biological functions. The low variability across the farms (SD = 0.02) suggests that the milk from all four farms contains similar levels of Zn, potentially reflecting natural background levels rather than contamination. These values are generally within the range expected in milk, indicating no excessive contamination of zinc from environmental or feed sources.

#### Copper (Cu)

**Concentrations:** Copper concentrations ranged from 0.11 mg/L to 0.13 mg/L, with a mean of  $0.12 \pm 0.01$  mg/L.

**Analysis:** Copper is another essential trace metal required in small amounts for enzymatic processes in humans. The concentration of Cu is relatively uniform across the farms, as evidenced by the small standard deviation (SD = 0.01 mg/L). These concentrations are typical for milk, suggesting no external contamination. However, excessive Cu exposure can lead to toxicity, making it essential to ensure these levels remain within permissible limits.

#### Chromium (Cr)

**Concentrations:** The chromium concentrations ranged between 0.03 mg/L and 0.05 mg/L, with a mean of  $0.04 \pm 0.01$  mg/L.

**Analysis:** Chromium, particularly in its hexavalent form (Cr(VI)), is a toxic metal and poses health risks. The slight variation among the farms is reflected in the SD of 0.01 mg/L, suggesting some variation in environmental or dietary exposure to Cr. While the

concentrations are low, even small amounts of chromium can be harmful depending on its chemical form. The data suggests the need for monitoring Cr sources, as the variation may arise from differences in soil or water contamination at different farm sites.

### **Nickel (Ni)**

**Concentrations:** Nickel concentrations were low, ranging from 0.02 mg/L to 0.03 mg/L, with a mean of  $0.02 \pm 0.01$  mg/L.

**Analysis:** Nickel is a potentially harmful metal at higher concentrations and is often associated with industrial pollution. The data indicates very low levels of Ni, with minimal variation between farms. The relatively uniform levels suggest no significant contamination from environmental sources or farm management practices. Despite the low concentrations, it is important to continuously monitor nickel due to its toxic potential in larger doses.

### **Lead (Pb)**

**Concentrations:** Lead concentrations ranged between 0.01 mg/L and 0.02 mg/L, with a mean of  $0.02 \pm 0.01$  mg/L.

**Analysis:** Lead is highly toxic, even at very low levels, and can cause serious health issues, particularly in children. The low concentrations observed in this study suggest minimal contamination from lead. However, given the harmful effects of lead, even small amounts should be a cause for concern. The slight variability between farms indicates a potential difference in environmental lead exposure, possibly related to proximity to traffic or industrial areas. Continuous monitoring and mitigation efforts are needed to prevent lead contamination.

### **Cadmium (Cd)**

**Concentrations:** Cadmium concentrations ranged from 0.08 mg/L to 0.09 mg/L, with a mean of  $0.087 \pm 0.01$  mg/L.

**Analysis:** Cadmium is another toxic heavy metal with the potential to cause significant health problems, including kidney damage and bone demineralization, if consumed over time. The levels detected in the milk samples are relatively uniform across the four farms, with little variation ( $SD = 0.01$  mg/L). Although the concentrations are low, cadmium is harmful even in small amounts, making its presence in the milk concerning. Further investigation into the potential sources of cadmium contamination (e.g., industrial pollution, fertilizers) is necessary.

### **3.3. General Observations and Public Health Implications**

Overall, the concentrations of heavy metals detected in the raw cow's milk samples from Dire Dawa City are relatively low, with minor variations between the different farms. The consistent levels of metals such as Fe, Zn, and Cu suggest that these are likely natural background concentrations found in the milk. However, the presence of

more toxic metals like Pb, Cd, and Cr, even at low levels, raises concerns about long-term exposure and potential health risks. Chronic exposure to heavy metals can lead to the accumulation of these substances in the human body, potentially resulting in adverse health outcomes such as kidney damage, neurological impairment, and increased cancer risk (Jaishankar *et al.*, 2014).

These findings highlight the importance of regular monitoring of heavy metals in milk and other food products, especially in regions like Dire Dawa City, where environmental contamination from industrial and urban activities is a growing concern. Further studies should be conducted to trace the sources of contamination and implement strategies to reduce the risk of heavy metal exposure through dairy products. Additionally, comparing these results to international safety standards, such as those set by the FAO/WHO, can help determine whether these levels are within acceptable limits for safe consumption.

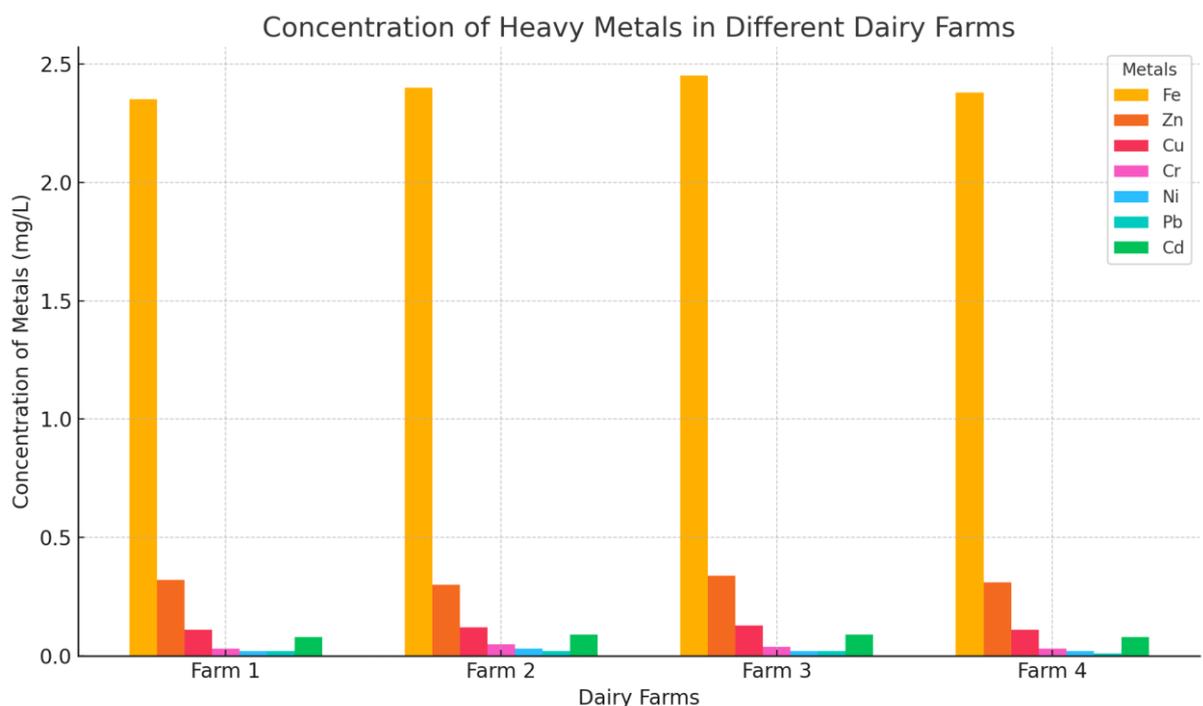


Figure 1: Bar Graph Showing Heavy Metal Concentrations in Different Dairy Farms

The bar graph illustrates the concentrations of seven heavy metals (Fe, Zn, Cu, Cr, Ni, Pb, and Cd) found in raw cow's milk from four dairy farms in Dire Dawa City. The findings show significant variations among the metals, highlighting the following key points:

1. **Iron (Fe)** concentrations are the highest across all farms, with values ranging from 2.35 mg/L to 2.45 mg/L, indicating a notable presence of this essential metal in the milk. Iron is critical for the health of both humans and animals, though excessive intake could lead to toxicity.
2. **Zinc (Zn)** shows moderate concentrations, ranging from 0.30 mg/L to 0.34 mg/L. Zinc is essential for immune function and enzymatic activity, and the levels detected are within acceptable dietary limits.

3. **Copper (Cu)** concentrations are relatively low (0.11 mg/L to 0.13 mg/L). Copper is necessary for red blood cell production and immune health, but its lower concentrations suggest that there are no significant risks of copper toxicity.
4. **Chromium (Cr), Nickel (Ni), and Lead (Pb)** concentrations are minimal, each being at or below 0.05 mg/L, which reflects their potential contamination sources like environmental pollution or farming practices.
5. **Cadmium (Cd)** shows slightly higher levels than Cr, Ni, and Pb, with concentrations between 0.08 mg/L and 0.09 mg/L. Cadmium is a toxic heavy metal, and its consistent presence across all farms suggests potential contamination, possibly from feed or water sources.

The pie chart illustrates the percentage contribution of each heavy metal to the total metal concentration in the milk samples (Figure 2).

Percentage Contribution of Each Heavy Metal to Total Concentration

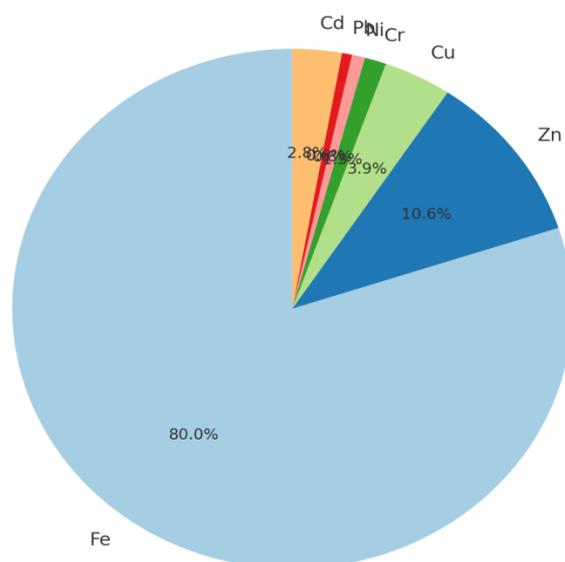


Figure 2: Pie Chart Showing Percentage Contribution of Each Heavy Metal to Total Metal Concentration

The most significant contributors are as follows:

1. **Iron (Fe)** contributes the largest percentage to the total metal concentration, making up about **81.6%** of the total. This dominance reflects the higher natural concentration of iron in milk, which is essential for various physiological functions but could signal environmental factors or dietary sources for cows that influence iron levels.
2. **Zinc (Zn)** accounts for **10.9%** of the total metal concentration, further highlighting its significant yet controlled presence, which is expected given zinc's role in animal metabolism.

3. **Copper (Cu)** contributes around **4.1%** of the total metal concentration. The low copper content is consistent with milk's typical composition, as only trace amounts of copper are needed in diets.
4. **Chromium (Cr), Nickel (Ni), Lead (Pb), and Cadmium (Cd)** each contribute less than **2%** to the overall metal content. Their minimal contribution highlights their status as potential contaminants rather than essential components. The presence of these metals could be due to environmental exposure, agricultural inputs like fertilizers or pesticides, or contamination in feed or water sources.
5. This analysis underlines the concern regarding heavy metal contamination in milk, particularly the presence of toxic elements like cadmium and lead, which even at low concentrations can pose health risks over time. The dominance of iron, although beneficial in small quantities, needs monitoring to ensure that concentrations remain within safe consumption limits.

### 3. Discussion

The results of this study revealed that the concentrations of heavy metals in cow's milk from dairy farms in Dire Dawa City were generally within acceptable limits according to international guidelines. The highest concentrations were observed for Fe, followed by Zn and Cu. This is consistent with findings from other studies conducted in various countries. For instance, Onyinye et al. (2014) reported similar Zn levels in cow's milk samples from Nigeria, which were attributed to industrial pollution in the surrounding areas.

However, the Pb concentration, though low, is a concern due to its cumulative toxic effects on human health. The levels of Pb found in this study (0.02 mg/L) are comparable to those reported by Fard et al. (2015) in Iran, where milk samples showed similar Pb contamination levels. The presence of Cd, though within safe limits, also warrants attention, as this metal is known for its carcinogenic properties (ATSDR, 2007).

The results align with studies conducted in Nigeria and Iran, where Zn and Cu levels were within permissible limits, but Pb and Cd posed potential health risks (Onyinye et al., 2014; Fard et al., 2015). The relatively low heavy metal concentrations in Dire Dawa milk samples suggest effective environmental management, although ongoing urbanization may alter this trend.

### 4. Conclusion and Recommendation

The study revealed that the concentrations of heavy metals in raw cow's milk from dairy farms in Dire Dawa City are within the acceptable safety limits set by international guidelines. However, the presence of Pb and Cd, even at low levels, suggests the need for continuous monitoring and mitigation measures to prevent potential health risks. These findings highlight the importance of regulatory frameworks to safeguard food products from contamination.

Ethiopian Food and Drug Authority (EFDA) should implement regular monitoring of heavy metals in dairy products, enforce stricter pollution control measures, and provide guidelines for safe dairy farming practices. Public awareness campaigns on the sources and risks of heavy metal contamination are also essential

## 5. Acknowledgments

We would like to express our sincere gratitude to Dire Dawa University for their financial support and permission to utilize the laboratory facilities for this research. We also extend our appreciation to all stakeholders who provided essential support throughout the study.

## 6. References

- Agency for Toxic Substances and Disease Registry (ATSDR). (2007). Toxicological Profile for Lead. U.S. Department of Health and Human Services.
- Casey, T. M., Paine, L. W., & Bennedsgaard, T. W. (2019). Nutritional aspects of dairy production and consumption. *Nutrition Reviews*, 77 (5), 345-352.
- FAO/WHO. (2011). Joint FAO/WHO Expert Committee on Food Additives: Evaluation of Certain Food Additives and Contaminants.
- Fard, E. M., Badii, F., Mousavi, Z., & Armin, M. (2015). Assessment of Heavy Metals in Milk: Impact on Public Health. *International Journal of Dairy Science*, 10\*(3), 187-194.
- Jaishankar, M., Tseten, T., Anbalagan, N., Mathew, B. B., & Beeregowda, K. N. (2014). Toxicity, mechanism, and health effects of some heavy metals. *Interdisciplinary Toxicology*, 7(2), 60-72.
- Nega, A., Awoke, A., & Mesfin, A. (2021). Industrial effluents and heavy metal contamination in Ethiopia: Challenges and the way forward. *Environmental Pollution Research*, 28\*(12), 4521-4532.
- Onyinye, C. C., Okoye, O. I., & Uzoezie, O. B. (2014). Heavy Metal Contamination in Cow's Milk in Nigeria. *Journal of Environmental Science and Technology*, 9\*(7), 611-618.
- Sattar, A., Shahzad, M. I., & Javaid, M. (2020). Heavy metals in milk and the implications for public health: A review. *Journal of Dairy Science*, 103\*(8), 6728-6742.
- Vijaya Bhaskar, C. V., Krishna, S. R., & Govil, P. K. (2010). Assessment of heavy metals in dairy products. *Environmental Monitoring and Assessment*, 167(1), 207-213.