e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:07/Issue:01/January-2025 Impact Factor- 8.187 www.irjmets.com

ASSESSMENT OF COW MILK FROM COWS GRAZING AROUND NAKAMBALA SUGAR ESTATE, MAZABUKA, ZAMBIA

Hamusonde Brighton[*1], Mulenga Evelyn[*2], Sinzala Mwape[*3], Mbule Manfred[*4], Hajoke Jolezya[*5]

[*1,5]Chalimbana University, Department Of Chemistry, School Of Technology, Science And Mathematics, Chongwe, Zambia.

[*2]Chalimbana University, Department Of Biological Sciences, School Of Technology, Science And Mathematics, Chongwe, Zambia.

[*3,4]Chalimbana University, Department Of Mathematics, School Of Technology, Science And Mathematics, Chongwe, Zambia.

DOI : https://www.doi.org/10.56726/IRJMETS65981

ABSTRACT

The study was an experimental design that sampled cow milk around Nakambala Sugar estate in order to investigated the concentration of cadmium, chromium, lead and copper in milk samples from cows grazing around Nakambala Sugar Estate. Results indicated that milk was polluted with Cu (sample A= 0.0388, B = 0.0379) with Cd having the highest concentration (A = 0.078, B =0.0799). The concentrations of Pb (A = 0.0019, B= 0.002) and Cr (A = 0.0055, B = 0.0061) were much lower than the WHO permissible thresholds. The study also intended to assess the potential human health risks posed to consumers through the consumption of milk from cows grazing around Nakambala Sugar Estate. Results indicate that consumers of the milk are potentially in danger of copper and cadmium poisoning or may develop illnesses related to effects of these metals since concentrations of some metals were beyond the permissible limits. Finally, the study intended to suggest some recommendations for mitigating heavy metal pollution in milk from cows grazing around Nakambala Sugar Estate. Mitigation of heavy metal pollution could not be brought forth because the source of heavy metal contamination in milk could not be established; is it from the estate or from the polluted water from kafue river?

Keywords: Heavy Metals, Pollution, Concentration, Threshold, Nakambala Sugar Estate.

I. INTRODUCTION

In today's world, pollution is among the topical issues because of the impact it has on the quality of human and environmental health. Heavy metals are among the pollutants detested by man. These pollute the air, water and land. Eventually, they contaminate the food. The level of heavy metals in milk is higher in developing countries than in developed countries. This is due to fewer regulations and poor enforcement by law enforcement agencies in developing countries. Zambia, being a third world country, may not be an exception. Heavy metals come from different sources such as inorganic fertilizer, lime, insecticides and herbicides (Omwoma, 2010, Akpoveta & Osakwe, 2017). Nakambala Sugar Estate uses these agro-products products for its farming activities (Zambia Sugar Annual Report, 2015). The estate is surrounded by both commercial and subsistence farmers who keep cattle for daily products. Several studies have shown that cows grazing near industrial or agricultural areas may accumulate heavy metals in their milk due to contamination in their feed and water. It is from this view that researchers were prompted to study the topic at hand.

On the other hand, Kafue River is polluted with heavy metals (Kapungwe, 2013; Singh & Musonda, 2017; Mbewe & Mkandawire et al., 2017), such that the WHO declared the water unsuitable for human use (National Academy of Sciences, as cited by Manikandan, 2005), because concentrations of heavy metals (Cu, Co, Cr, Cd and Ni) are way beyond the permissible limits. This water flows beyond the boundaries of the estate, exposing the suspected heavy metals to the surrounding community. Again, this signals a red flag. Cattle may get the heavy metals through grazing and water. In turn people take the milk from the same animals, putting the life of consumers at risk.

This research aimed at investigating the concentration of heavy metals in milk of cows grazing around Nakambala Sugar Estate in order to assess potential human health risks.

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:07/Issue:01/January-2025 Impact Factor- 8.187 www.irjmets.com

Many studies have been conducted in several parts of the world to ascertain the quality of milk consumers take. Sharma, Gupta, Shrivas, Chakradhari, Pervez, and De (2023), investigated heavy metal contamination in cow and buffalo milk from industrial and residential areas of Raipur, India. Milk samples were collected from seven sites and analyzed for Zn, Ni, Fe, Mn, Cu, Cr, Cd, Pb, and As. The inductively coupled plasma-optical emission spectroscopy (ICP-OES) and atomic absorption spectroscopy (AAS) were used for analysis and results revealed higher contamination in industrial areas. The concentrations of Zn, Ni, Fe, Mn, Cu, Cr, Cd, Pb, and As in milk samples ranged from 1.708 to 3.243, 0.078–0.295, 1.480–4.450, 0.119–0.472, 0.032–0.461, 0.007–0.040, 0.006–0.032, 0.040–0.204, and 0.006–0.023 mg/kg, respectively. The primary objective was to evaluate potential health risks associated with the consumption of contaminated milk, by using three key indicators; EDI, THQ, and CR. These indicators provided a comprehensive assessment of both non-carcinogenic and carcinogenic health risks, offering valuable insights into the potential impact of heavy metal exposure on Meshref and Moselhy (2014) describe milk is an important and complete diet in the human diet because it contains vital nutrients and minerals in balanced proportions. They collected a total of 22 raw milk samples to determine the concentrations of Pb, Cd, Zn, Cu and Fe. Concentrations ranged from 0.044–0.751, 0.008–0.179, 0.888–18.316, 0.002–1.692 and 1.3208–45.6198 ppm respectively. Pb concentration in all samples exceeded the maximum permissible limit (0.02 mg/kg) established by codex standard. Pd and Cd intake through milk and dairy products consumption were 1.27g/kg which represent 35.3 % of the tolerable daily intake.

In Tanzania, Ali, Ame, Sheilkh & Bakari (2023), analyzed milk samples for heavy metals and results show that the concentration of Co ranged from non-detected to a maximum of 0.004 mg/L with mean concentration of 0.020 ± 0.003 mg/L for all sites. Concentration of Pb ranged between 0.05 - 0.51 mg/L, with mean concentration of 0.263 ± 0.031 mg/L for all sites. However, Cd was only detected in one sample with a concentration of 0.001 mg/L. The results revealed that cow's milk was contaminated with Pb which exceeded the WHO maximum permissible level of 0.02 mg/L.

In Zambia, a study was conducted to compare the concentration of uranium in cow-milk reared in mining and non-mining areas. Although uranium concentration was higher in milk from cows from mining area than from non-mining, the concentration of uranium was within permissible limits of the Health Organization and the United States Environmental Protection Agency's permissible (Haakonde, Yabe, Choongo, Nchima & Islam, 2021). Another study conducted in zambia (Zyambo, Yabe, Muzandu, Mkandawire, Choongo, et al., 2022) shows that lead contamination in cow milk from animals grazing around mining area had elevated levels of lead than animals in far flung areas, though the concentration of lead in animals grazing around mining areas where within safe limits.

II. STATEMENT OF THE PROBLEM

Milk from cattle grazing around Nakambala Sugar estate may be at risk of heavy metal contamination. Despite the potential risk, there is no known published study regarding the concentration of heavy metals in milk from cows grazing around Nakambala Sugar Estate. Therefore, this study assessed the suspected contamination of milk from cows grazing around Nakambala sugar estate.

Purpose of the Study

This study investigated the concentration of heavy metals in milk obtained from cows grazing around Nakambala Sugar estate. This is important because the study has informed relevant authority about the safety of the cattle products around Nakambala sugar estate. This would in turn call for action to alleviate the problem

Objectives of the study

1. To determine the concentration of cadmium, chromium, lead and copper in milk samples from cows grazing around Nakambala Sugar Estate.
2. To assess the potential health risks posed to consumers through the consumption of milk from cows grazing around Nakambala Sugar Estate.
3. To suggest recommendations for mitigating heavy metal pollution in milk from cows grazing around Nakambala Sugar Estate

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:07/Issue:01/January-2025 Impact Factor- 8.187 www.irjmets.com

Research questions

1. What is the concentration of cadmium, chromium, lead and copper in milk from cows grazing around Nakambala Sugar Estate?
2. What are the potential health risks posed to consumers through the consumption of contaminated milk from cows grazing around Nakambala Sugar Estate?
3. What are the recommendations for mitigating heavy metal pollution in milk from cows grazing around Nakambala Sugar Estate?

Significance of the Study

This research is crucial for understanding the environmental impact of farming activities on local ecosystems and evaluating the potential health risks faced by communities consuming dairy products sourced from these areas. The findings will contribute valuable information for policymakers, environmental agencies, and local communities to implement effective strategies for mitigating heavy metal pollution and ensuring the safety of milk.

III. METHODOLOGY

Location of study area and study design

The study was conducted at Nakambala Sugar Estate, in Mazabuka district, Southern province of Zambia. The estate lays at15.78^{0}S and 27.83^{0}E and about 50km southwest of the capital city, Lusaka. It is among the largest sugar estates in Africa, measuring about 15, 0000 hectares of farmland.

Sampling locations were the Western (W) and Eastern (E) parts of the estate because the regions have herdsmen nearby while the Southern and the Northern parts do not have animals nearby due the fact that they are residential areas of the town. Samples from the same region were labelled the initial letter of the name of the region it was collected from, example W1, W2, W3, W4, W5, E1, E2, etc. A total of 5 farmers from each region were purposefully selected because their farms were closer to the estate, hence, their animals had higher chance of interacting with the estate environment. 50mL of milk was collected from each farmer. The samples from each area were thoroughly mixed to come up with one homogeneous sample per region so that the number of samples could be reduced to minimize on laboratory tests cost. This resulted in two samples which were taken for analysis at the laboratory.

IV. MODELING AND ANALYSIS

Sample extraction

Two mL of each sample was digested with nitric and perchloric acid mixture (HNO3:HClO3 = 4:1 v/v) until a transparent solution was obtained. After digestion, samples were filtered diluted to a suitable concentration. Working standard solutions of Pb, Cd, Cu, Zn and Fe were prepared by dilution of certified standard solutions to desired concentration. All reagents used were of analytical reagent grade. Ultra-high purity water was used for all dilutions. All glass and plastic wares were washed and kept overnight in 10 % (v/v) nitric acid solution. Afterwards, it was rinsed thoroughly with ultra-pure water and dried.

Sample analysis

The heavy metals concentrations in the digested samples were measured using the flame Atomic Absorption Spectrophotometer and results are shown in table1.

V. RESULTS AND DISCUSSION

From the results in table 1, Cu was above the WHO permissible limit (0.01) in both sample A (0.0388) and B (0.0379) by about 0. 02 units. Cd was even way beyond the WHO maximum residue limit (0.0026) in both samples A (0.0789) and B (0.0799). This means that consumers of this milk at risk of suffering from diseases related to cadmium pollution because the difference between the threshold and the present concentration is too wide (0.0773). As for Pb and Cr, the concentrations in both samples were quite negligible. This means that the milk was within the safe limits. The source of Cu and Cd remains to be investigated whether its from polluted water from Kafue River water or from Nakambala Sugar Estate.

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:07/Issue:01/January-2025 Impact Factor- 8.187 www.irjmets.com

Table 1: concentration of heavy metals in milk samples

S/N0	Heavy metal	unit	Milk A	Milk B	WHO standard (MRL)
1	Copper	ppm	0.0388	0.0379	0.01
2	Lead	ppm	0.0019	0.002	0.02
3	Cadmium	ppm	0.0789	0.0799	0.0026
4	Chromium	ppm	0.0055	0.0061	0.01

VI. CONCLUSION

This study investigated the concentration of cadmium, chromium, lead and copper in milk samples from cows grazing around Nakambala Sugar Estate. The results indicated that milk is polluted with Cu and Cd. Cd has the highest concentration in both milk samples, while the concentrations of Pb and Cr are way below the WHO permissible thresholds. The study also intended to assess the potential health risks posed to consumers through the consumption of milk from cows grazing around Nakambala Sugar Estate. Results indicate that consumers of the milk are potentially in danger of copper and cadmium poisoning or may develop illnesses related to effects of these metals. Finally, the study intended to suggest some recommendations for mitigating heavy metal pollution in milk from cows grazing around Nakambala Sugar Estate. Further studies must be carried out to investigate the source of milk pollution so that relevant authorities may put some measures to mitigate milk contamination.

ACKNOWLEDGEMENTS

Researchers wish to thank Chalimbana University administration and the Dean for School of Technology, Science and Mathematics for financial, moral and material support rendered during this study. The student had first hands on experience in sample collection, sample management, sample preparation and finally the who process involved in scientific study.

VII. REFERENCES

[1] Ali, H.R., Ame, M.M., Sheikh, M.A. and Bakari, S.S. (2023) Levels of Lead (Pb), Cadmium (Cd) and Cobalt (Co) in Cow Milk from Selected Areas of Zanzibar Island, Tanzania. American Journal of Analytical Chemistry, 14, 287-304. https://doi.org/10.4236/ajac.2023.147016

[2] Zyambo, G.; Yabe, J.; Muzandu, K.; M'kandawire, E.; Choongo, K.; Kataba, A.; Chawinga, K.; Liazambi, A.; Nakayama, S.M.M.; Nakata, H.; et al. Human Health Risk Assessment from Lead Exposure through Consumption of Raw Cow Milk from Free-Range Cattle Reared in the Vicinity of a Lead–Zinc Mine in Kabwe. Int. J. Environ. Res. Public Health 2022, 19, 4757. https:// doi.org/10.3390/ijerph19084757 Academic Editor: Darryl B. Ho

[3] Abdelkhalek A, Elsherbini M & Gunbaej E. (2015). Assessment of heavy metals residues in milk and infant milk formula sold in Mansoura City, Egypt.

[4] Kumar, S., U. J. Mehta1, & S. Hazra L (2008). Accumulation of cadmium in growing peanut (Arachis hypogaea L.) seedlings—its effect on lipid per oxidation and on the ant oxidative Enzyme's catalase and guaiacol peroxidase. J. Plant Nutr. Soil Sci.171: 440–447.

[5] Yahaya M. Ezor, Y. F. Musa and Muhamad. (2010). Analysis of heavy metals concentration in road side soils in Yauri, Nigeria. African journ. Of pure and applied chem. vol 4: 3.

[6] WHO, (2015). Evaluation of certain food additives and contaminant: Hg, Pb, Cd. 30th Report of Expert committee, WHO Technical Report Series. No 51.

[7] S. Khan et al. Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China. Environmental pollution, 152(3):2018, 686-692

[8] World Health Organization, enhancing participation in Codex Activities: An FAO/WHO Training Package, (2005): Food & Agriculture Org.

[9] Morshed S, Alam, Matin A & Kobra T. (2016). Contamination of raw milk, market pasteurized milk and powdered milk by toxic heavy metals in Bangladesh. Scientific Research Journal, 4: 19

[10] Ahuja A, Threja H, Singh P & Sahota H (2015). Analytical techniques for trace element analysis an overview.

[11] Belete T, Hussen A & Rao M (2014). Determination of concentrations of selected heavy metals in cow's milk: Borena Zone, Ethiopia. Journal of Health Science, 4: 105-112.

[12] Agency for Toxic Substances and Disease Registry [ATSDR] (2013) CB Search — Web Search. Agency Toxic Subst Dis Regist ATSDR 2013 - CB Search.

[13] Haakonde T, Yabe J, Choongo K et al (2020) Preliminary assessment of uranium contamination in drinking water sources near a uranium mine in the Siavonga District, Zambia, and Associated Health Risks. Mine Water Environ 39:735–745

[14] Hashemi SE, Arfaeinia H, Ardashiri S, Karimyan K (2017) Health risk assessment of exposure to heavy metals in milk collected from Bushehr, Iran. Ann Trop Med Public Health 10:632

[15] Boudebbouz A, Boudalia S, Bousbia A, Habila S, Boussadia MI, Gueroui Y (2020): Heavy metals levels in raw cow milk and health risk assessment across the globe: a systematic review. Sci Total Environ 141830.