Ba-abbad, et al., Yemeni J Med Sci. 2024; 18: 9-19
https://doi.org/10.20428/yjms.v18i1.2322
https://journals.ust.edu/index.php/yjms

ORIGINAL ARTICLE OPEN ACCESS

Detection of milk's sheep quality indicators by studying the contamination of milk with some heavy metals in some areas of Hadramout Coast – Yemen

Ali Mohammed Abdel-bari Ba-abbad[1, 2*], Alwi Ahmad Alwi Maknoon[3], and Yaslam Khaled Yaslam Bin-Zaidan[3]

[1] *Food Science and Technology Department, Faculty of Environmental science and Marine Biology, Hadhramaut University, Hadhramaut, Yemen.*
[2] *Clinical Nutrition and Dietetic Program, Faculty of Medicine and Health Sciences, University of Science and Technology- Aden.*
[3] *Department of Zoology, Faculty of science, Hadhramaut University Hadhramaut, Yemen.*

ABSTRACT

An experimental study was conducted with the aim of using sheep milk as bioindicators of environmental pollution for cadmium, lead and arsenic in some areas of Hadhramout coast in the period from November 2021 to March 2022, 45 samples of milk were collected from five areas of the Hadhramaut coast (Fowah, Al-Ghaleelah Thelah, Shaheer and Al-Khareebah). Cadmium and lead concentrations were measured by (FAAS), while arsenic concentrations were measured by (AAS- MHS 15). The results of study showed that the mean concentrations of cadmium, lead and arsenic in milk samples are 0.0087 ppm, 0.055 ppm and 0.105 ppm; respectively. Concentration of cadmium were higher than the permissible limit according to Europe Union and Codex Alimentarius milk 0.01 ppm in urban areas (Fowah, Al- Ghaleelah, and Shaheer). Lead concentration was found higher than the maximum permissible limit for Europe Union and Codex Alimentarius of lead in milk 0.02 ppm in areas (Fowah, Al- Ghaleelah, and Shaheer). Arsenic concentration was found higher than the maximum permissible limit for Europe Union and of arsenic in milk 0.1 ppm in Thelah area, While Al-Khareebah area was in maximum permissible limit Europe Union. The statistical results showed that there were significant differences between the average concentrations of cadmium, lead and arsenic at a significant level ($p<0.05$) in milk samples in the different study areas. This study confirmed that sheep milk are good bioindicators for detecting environmental pollution with heavy metals. The study concluded that the main reason for the high concentrations of cadmium and lead in urban areas are human industrial activities, all process of combustion and industrial and agricultural wastes. The study recommends periodic monitoring and examination of heavy metals in the environment using bioindicators and identifying the main sources of their spread in the environment.

Keywords: Bioindicator, Cadmium, Lead, Arsenic, Sheep milk, Pollution, Hadhramaut Coast.

*__Corresponding author:__ Ali Mohammed Abdel-bari Ba-abbad - E-mail:alabbady72@gmail.com

Introduction

Pollution is the addition (or addition in high concentration) of certain substances to the environment (water, air, and soil), making it less suitable or uninhabitable for life (1). Atomic weights and densities of heavy metals exceed 5 g/cm3 (2, 3) Thus, they (heavy metals) are characterized by their ability to bioaccumulate in food (4). The type of effect caused by toxic substances, and the effectiveness of that effect, determine the toxicity of the substance. The effect occurs when exposed to this toxic substance through inhalation, ingestion, or direct contact. They cause health effects that appear immediately or appear delayed later in life, as a result of long-term (chronic) and short-term (acute) exposure to these substances (5).

Cadmium (Cd) is non-essential element, is toxic at very low doses, and non-biodegradable, one of the most common and harmful transition metals presents in our environment (6). It has highly soluble in water as compared to other heavy metals (7). Its metal found in the earth's crust, associated with zinc, lead, and copper ores and pure (8, 9).

Cadmium reaches humans through their diet, drinking water or air, or through biomagnification and slowly accumulates in the human body (10). According to (11) the toxicity of cadmium is due to the long biological half-life of this metal, which is (10-30) years in human tissues, which makes it a threat and danger to many organs and systems inside the human body, particularly the kidneys. Lead is the 37th most abundant element of the earth crust. Naturally, it accounts for high crustal abundance of 14 ppm (12). Lead is one of the earliest metals discovered by the human and its distinctive nature, such as pliability, ductility, higher malleability, low melting point and corrosion resistant, make its widespread usages in numerous industrial process (13). Lead enters the human body when eating foods, sweets, or water contaminated with lead, or inhaling lead dust that arises from lead-containing paints, lead-contaminated soil, and from color additives in paints and cosmetics. In some special cases, children may use toys that contain lead (14). Lead affects various parts of the human body, due to its toxic effect on them, causing physical and mental damage. Its effect on children and women appears when they are exposed to long-term doses of lead, which leads to disorders in the reproductive system in women and damages the endocrine glands in children (15). Arsenic has affected humans more than any other toxic element or compound for thousands of years (16).

Millions of people are being chronically exposed to elevated doses of arsenic from air, food, water, and soil. It has the ability to readily change its oxidation state and bonding configuration, thus showing diverse chemical behavior in the environment and forming large numbers of organic and inorganic compounds (17). As a result of these malpractices, arsenic concentrations in groundwater exceeded the safe limits for arsenic (10 μg/L), as recommended by the World Health Organization (18). Arsenic is colorless, odorless and tasteless, so its presence in drinking water is not obvious, but greater concern is ongoing (chronic) exposure to smaller amounts of arsenic over time (19). Arsenic reaches the human body through drinking water contaminated with it, or through eating foods produced from contaminated lands, crops irrigated with contaminated water, or marine organisms in environments contaminated with arsenic (20). The concentration of arsenic in foods contaminated with it exceeds the doses to which humans are exposed through drinking water, soil or air (21).

Bioindicators

Living organism's plants, animals or microorganisms that are exploited to detect pollutants in the ecosystem (22). There are criteria for selecting and using the appropriate living organisms as bioindicators are:

- An ability to accumulation (or selection of specific compounds).
- Occurrence in large populations.

- Their presence cannot be limited to only a single habitat.
- Ease of identification and representative sampling.
- Samples should be easy for chemical analysis (23)

The importance of monitoring and following up the behavior of these elements in the environment, measuring the negative effects of industrial activity, and searching for the possibility of using some types of living organisms as bioindicators to assess the level of pollution (24).

Milk Sheep

Sheep milk is a good indicator of pollution with heavy metals, due to the behavior of these animals in grazing and searching for water and food, as these animals occupy a larger area than cows, so they move in search of water and food for very long distances, which makes them vulnerable to various types of pollutants through eating food and water heavy metal contamination (25). The chemical composition of milk (nutrients or toxic contaminants) varies according to some internal factors (lactation status, animal type, and health condition such as mastitis), and other external factors such as: production season, animal nutrition and environment) (26). the ability of animals to adjust to a range of environmental conditions such as grazing in hot, arid conditions under direct solar radiation in poor pasture (27). It has the ability to deal with diversified grazing, which is, eating different types of food (28). Thus, heavy metal concentration in milk can be an indicator of environmental pollution (29).

Problem statement:

Milk is an essential food product for humans, the research was interested in studying the extent of milk contamination with heavy metals, to reveal milk quality in terms of heavy metal contamination.

Methods

Study Area & Sample Size

Non-probability simple random sampling technique was used to select the samples in this study. A total of 45 milk samples were collected from five areas in Hadhramaut Coast included Fowah, Al-Ghaleelah, Thelah, Shaheer and Al-Khareebah for heavy metals analysis included in this study.

Samples collection

Samples of sheep's milk were randomly selected, to study milk contamination, and affected by various human activities, samples were collected from different areas as follows:

• Geographic location: Coastal areas are near cities ، and other far from sea coast.

• Human activities: Some study areas are close to large population centers, and other rural areas and mostly sparsely populated.

Samples preparation

The samples were dried by drying and sterilization oven J.P Selecta. Each 30 mL of milk samples was placed in heat-resistant glass dishes and then placed in a dry oven at 70º C overnight, then it was put in the desiccator for an hour, and then it was crushed well (31). Samples were digested by microwave digestion system Model START D (32). The digestion method of milk samples was used (HPR-FO-24) according to the" Milestone Application Book" which attached to the device. The digested samples were placed in plastic bottles and the size was completed to 50mL with Bi-distilled water from Ultra-Pure Water System.

Sample Analysis

Cadmium and lead concentrations were measured by Flame Atomic Absorption Spectrophotometer (Appendix E) Model UP 9100 (33). While Arsenic by Atomic Absorption Spectrophotometer (Appendix E) Model Pin AAcle 900F (34). Witch Mercury Hydride System 15 (MHS15) (35).

Method of preparing solutions and running the devices has been adopted for analysis elements according to (36). The limit detection of cadmium, lead and arsenic was identified by method produce signal/noise ratio of 3 Through the equation:

https://doi.org/10.20428/yjms.v18i1.2322

The detection limits of cadmium, lead and arsenic were 0.008, 0.012 and 0.0013 ppm.

$$\text{Detection Limit} = \frac{(\text{Standard Conc.}) \times 3\ (\text{Std. Dev.})}{\text{Mean}}$$

(36)

Statistical analysis

The data were statistically analyzed by Statistical Package for Social Sciences (SPSS) version 24, using ANOVA Table one way, and the significance of differences between the means were tested by Least Significant Difference Test (L.S.D) with statistically significant with a probability level (< 0.05 P).

Result

Cadmium, lead and Arsenic concentrations in milk samples in study areas

The results of cadmium, lead and arsenic concentrations were varying in milk samples between study areas Table 1. The highest concentrations of cadmium were in Al-Ghaleelah 0.0136 ppm and Fowah 0.0113 ppm, followed by Shaheer 0.01 ppm then Thelah 0.0086 ppm. The concentration of cadmium in Al-Khareebah was below detection limit <0.008. The general average of cadmium concentrations in sheep milk samples in all study areas was 0.0087 ppm.

The highest concentration of lead was in Fowah 0.098 ppm, followed by Al-Ghaleelah 0.085 ppm then Shaheer 0.074 ppm, while the lowest concentration was in Thelah 0.019 ppm. The concentration of lead in Al-Khareebah was below detection limit <0.012. The general average of lead concentrations in milk samples in all study areas was 0.55 ppm. The highest concentration of arsenic was in Thelah 0.163 ppm, Al-Khareebah was 0.130 ppm then Shaheer that was 0.098 ppm and Al-Ghaleelah 0.097 ppm, while the lowest concentration was in Fowah 0.040 ppm. The general average of arsenic concentrations in milk samples in all study areas was 0.10 ppm.

Table 1: Cadmium, lead and Arsenic concentrations (ppm) in milk samples in study areas

No.	Area	Cadmium	Lead	Arsenic
1	Fowah	0.0113	0.098	0.040
2	Al-Ghaleelah	0.0136	0.085	0.097
3	Thelah	0.0086	0.019	0.163
4	Shaheer	0.01	0.074	0.098
5	Al-Khareebah	BDL*	BDL*	0.130
Mean		**0.0087**	**0.055**	**0.10**

* Below detection limit

Results of Statistical Analysis

The results of statistical analysis showed no significant differences in cadmium concentrations between Al-Ghaleelah and Fowah, between Fowah and Shaheer and between Shaheer and Thelah. There are significant differences between Al-Ghaleelah and

Thelah and between Al-Ghaleelah and Shaheer, while Al-Khareebah were below detection limit.

The results of statistical analysis showed significant differences in lead concentrations between Fowah and all study areas, but there are no significant differences between Shaheer and Al-Ghaleelah. Al-Khareebah was below detection limit. The results of statistical analysis showed significant differences in arsenic concentrations between all study areas except between Al-Ghaleelah and Shaheer and between Shaheer and Fowah. These results are shown in Table 2.

 Online ISSN: 2227-961X.

Table 2 : Cadmium, lead and arsenic concentrations (ppm) in milk samples, the values are (mean ± SD n=3)

Area	Cadmium	Lead	Arsenic
Fowah	0.0113 ± 0.0011 [ab]	0.098 ± 0.132 [a]	0.040 ± 0.0015 [e]
Al-Ghaleelah	0.0136 ± 0.0020 [a]	0.085 ± 0.0061 [a]	0.097 ± 0.0040 [dc]
Thelah	0.0086 ± 0.0011[c]	0.019 ± 0.0068 [c]	0.163 ± 0.0035 [a]
Shaheer	0.010 ± 0.0020 [bc]	0.074 ± 0.010 [b]	0.098 ± 0.0070 [c]
Al-Khareebah	BDL	BDL	0.130 ± 0.0034 [b]
Total	0.0087 ± 0.0049	0.055 ± 0.040	0.105 ± 0.042
P-value	<0.001	<0.001	<0.001
Detection limit	0.008	0.012	0.003

Statistical significance difference at P< 0.05. The values are (mean ± SD n=3)

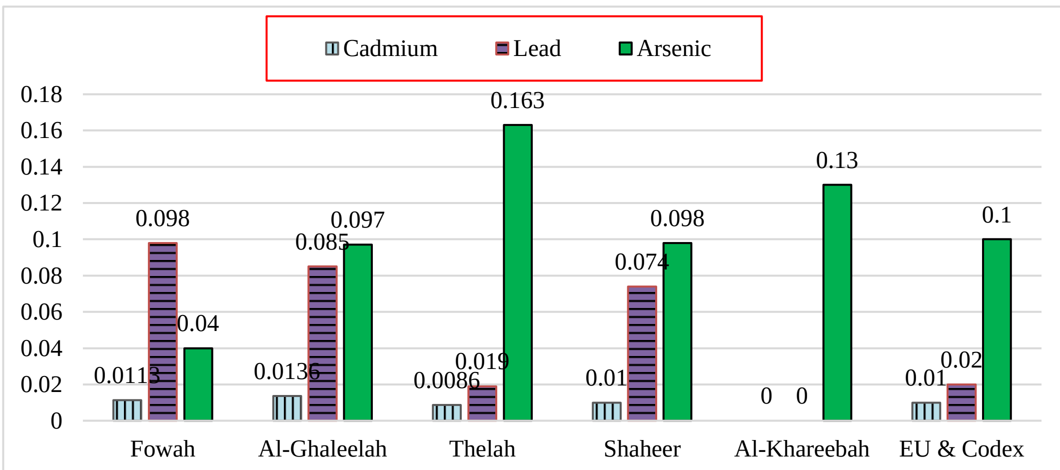

Figure 1: Comparison of cadmium, lead and arsenic concentrations in milk between (EU & Codex) and study areas

The similar letters in same column means no significant differences

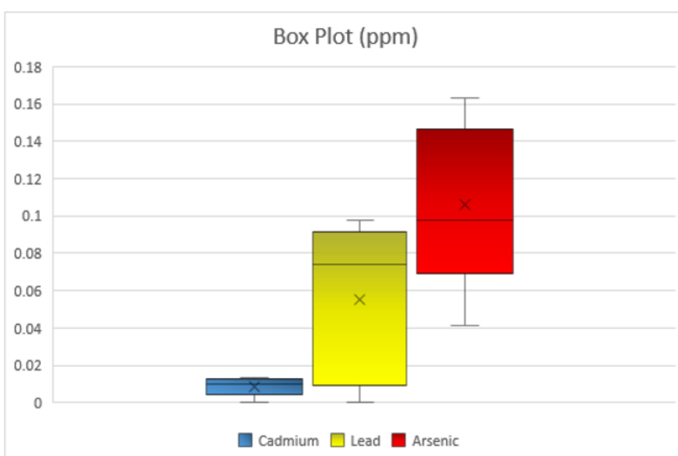

Figure 2 : Box Plot of cadmium, lead and arsenic concentrations (ppm) in sheep milk samples

4. Discussion

Cadmium in milk samples

In this study, the cadmium concentrations were <0.008 ppm, 0.0086 ppm, 0.1 ppm,0.0113 ppm and 0.0136 ppm (Table 1) in milk samples collected from Al-Khareebah, Thelah, Shaheer, Fowah and Al-Ghaleelah; respectiveiy. These results partially agree with results in north-east Hungary 0.006-0.020 ppm (37) and Egypt 0.004-0.029 ppm (38). Less than these results were reported by (39) 0.00059-0.00077 ppm, (26) 0.00079-0.00611 ppm, (2016) (40) 0.00071-0.009 ppm and (41) 0.0099-0.00044 ppm. Higher than these results were reported by (42) 0.05-0.10 ppm. The highest cadmium concentrations in this study was 0.0136 ppm in Al-Ghaleelah (Table 1) This is due to the type of water and food in addition to the style of grazing for sheeps. Stilled water is widely spread in the region and through the free grazing style. Sheep depend on this water as a source of drinking and the remnants of waste that are collected in large quantities before burning as it is within the scope of grazing for sheep. (43 and 44) Confirmed the presence of cadmium in solid waste, while (45 and 46) indicated the presence of cadmium and other elements in the soil surrounding the solid waste landfill.

Results in exceeded levels of cadmium standards of WHO to reach levels of eco-toxicological risk and the high accumulation of heavy metals in the edible plant parts of the widely consumed vegetable (47). Despite this, the concentrations of cadmium in the milk samples that analyzed in all areas in this study (Table 1) were found below the Codex Alimentarius maximum permissible limit of cadmium in milk 0.01 ppm (48). Except Fowah, Al-Ghaleelah and Shaheer, which has reached the cadmium concentration to maximum permissible limit of cadmium in milk for Codex Alimentarius Commission Standards.

Lead in milk samples

In this study, the lead concentrations in milk samples were <0.012 ppm, 0.019 ppm, 0.074 ppm, 0.085 and 0.098 (Table 1) were prepared from Al-Khareebah, Thelah, Shaheer, Al-Ghaleelah and fowah; respectiveiy. The results in this study partially agree with similar results in Calabria-Italy <0.040-0.09 ppm (49), Iran 0.0046-0.030 ppm (26), and north-east Hungary 0.007-0.040 ppm (37). Lower than lead concentrations in this study were reported by (41) 0.0025-0.033 ppm and higher than lead concentrations in this study also were reported by (38) 0.147-0.737 ppm, (42) 0.11-0.28 ppm and (50) 2.64-5.66 ppm.

Average lead concentrations in Fowah, Al-Ghaleelah and Shaheer are 0.098, 0.085, and 0.074 ppm; respectively (Table 1) were higher than Codex Alimentarius maximum permissible limit of lead in milk 0.02 ppm (51). This is due to the increase in industrial activity in Fowah, a region with high population activity in Mukalla city. It is also a transmission of lead from pollution sources (car exhausts and residues of factories, laboratory, batteries and paint pigments) to milk sheep through the food chain and excessive use of fertilizers for growth plant in invalid places of agriculture which is in the end is used as a feed of sheep. This applies to the Shaheer as well. While the spread of brick and cement coefficient and solid waste burring in Al-Ghaleelah led to high average lead concentration.

According to (52) Free-grazing mammals, have higher levels of lead exposure in urban areas also indicated that the concentration of lead in urban sheep in Egypt that graze on street waste is higher compared to the sheep that were housed indoors in the University Veterinary Teaching Hospital.

Arsenic in milk samples

The results of this study indicated that levels of arsenic in milk samples ranged from 0.040 ppm to 0.163 ppm average (0.10 ppm) (Table 1). The average results in this study partially agree with similar results in Turkey 0.14 ppm (53). Average of arsenic concentrations values above 0.10 ppm were reported by (54) 2.07 ppm and (55) 32.3 ppm. Average of arsenic concentrations values under

https://doi.org/10.20428/yjms.v18i1.2322

0.10 ppm were reported by (41) 0.0051 ppm, (56) <0.030 ppm and (57) <0.03. Average results demonstrate that milk samples from rural areas (Thelah and Al-Khareebah) shows higher values, whereas milk samples from urban areas (Fowah, Al-Ghaleelah and Shaheer) shows lower value (Table 1) The reason for this rise is the contamination of agricultural soil with fertilizers and pesticides may seep into the water which is used for drinking sheep and irrigating fodder. According to (58) concentrations of heavy metals during lactation depend mostly on feed or water intake, and possible consumption of soil. (55) concluded that arsenic concentration in milk samples were directly proportion to its levels in the drinking water. Average arsenic concentration in milk samples from Thelah area was higher maximum permissible limit for the Europe Union the presence of arsenic in milk 0.1 ppm (59) Al-Khareebah was in maximum permissible limit and this is could be because of Industrial activities near this area and waste from these factories, while urban areas (Fowah, Al-Ghaleelah and Shaheer) were found below maximum permissible limit.

Table 3 : A comparison of cadmium, lead and arsenic content (ppm) in milk samples from different countries and present study

Country	Cd	Pb	As	Reference
Present Study	0.0087	0.055	0.10	
Egypt	N.R**	3.96	N.R**	(50)
	<0.022	<0.022	N.R**	(60)
Iran	0.002	0.010	N.R**	(61)
	0.0016	0.014	N.R**	(62)
	0.0033	0.0121	N.R**	(26)
Pakistan	0.102	N.D*	N.R**	(63)
Turkey	0.13	3.17	2.07	(54)
Nigeria	0.30	N.R**	N.R**	(64)
Slovakia	<0.0040	<0.10	<0.03	(57)
Codex Maximum limit	0.01	0.02	N.R**	(48, 51)
EU Maximum limit	-	-	0.1	(59)

* Not detectable, ** Not reported

It is recommended to eliminate of pesticide waste and agricultural waste by coordinating with official authorities such as Ministry of Agriculture and Fish Wealth in order to minimize the risk of heavy metals contaminations.

Conclusion

This study confirmed that sheep milk is good bioindicator for detecting environmental pollution with heavy metals. The main reason for the high concentrations of cadmium and lead in urban areas are human industrial activities, all process of combustion and industrial and agricultural wastes. The irregular use of fertilizers and pesticides led to the concentrations of arsenic more in rural agricultural areas than in urban areas.

Conflict of interest

The authors declare that no conflict of interest.

References:

1) Welford, M. R., & Yarbrough, R. A. (2021). Human-environment interactions: an introduction. Palgrave Macmillan. pp: 146-149.

2) Nasa, P. (2019). Heavy Metal Poisoning. Principles and Practice of Critical Care Toxicology,4(3),328-339.

3) Parida, S., Dey, P., & Dey, J. K. (2020). Heavy Metals Impediments the Crop Yield. Biotica Research Today, 2 (1), 4-6.

4) Pratush, A., Kumar, A., & Hu, Z. (2018). Adverse effect of heavy metals (As, Pb, Hg, and Cr) on health and their bioremediation strategies: a review. International Microbiology, 21(3), 97-106.

5) Engwa, G. A., Ferdinand, P. U., Nwalo, F. N., & Unachukwu, M. N. (2019). Mechanism and health effects of heavy metal toxicity in humans. Poisoning in the modern world-new tricks for an old dog, p: 10.

6) Jacobo-Estrada, T., Santoyo-Sánchez, M., Thévenod, F., & Barbier, O. (2017). Cadmium handling, toxicity and molecular targets involved during pregnancy: Lessons from experimental models. International journal of molecular sciences, 18 (7), 1590.

7) Jadoon, S., & Malik, A. (2017). DNA damage by heavy metals in animals and human beings: an overview. Biochem. Pharmacol, 6 (3), 1-8.

8) Al-Ameen, M., & Majeed, N. (2020). Removal of cadmium from industrial wastewater using electrocoagulation process. Journal of Engineering, 26 (1), 24-34.

9) Symmons, A. (2021). Infrared optical material feedstocks. In Advanced Optics for Imaging Applications: UV through LWIR VI (Vol. 11737, p. 1173705). International Society for Optics and Photonics.

10) Al-Lami, A. M. A., Khudhaier, S. R. & Aswad, O. A. (2020). Effects of heavy metals pollution on human health. Annals of Tropical Medicine and Public Health, 23, 23-1125.

11) Al-Rikabi, Z. G. K., Al-Saffar, M. A., & Abbas, A. H. (2021). The Accumulative Effect of Heavy Metals on Liver and Kidney Functions. Medico Legal Update, 21 (1), 1114-1119.

12) Sarkar, D., Datta, R., & Hannigan, R. (Eds.). (2011). Concepts and applications in environmental geochemistry. Elsevier. New York. USA, p: 534 – 595.

13) Flora, G., Gupta, D., & Tiwari, A. (2012). Toxicity of lead: a review with recent updates. Interdisciplinary toxicology, 5 (2), 47-58.

14) Sabol, J. (2020). Major Analytical Methods for Determining Lead in Environmental and Biological Samples. Lead in Plants and the Environment (pp. 1-13). Springer, Cham.

15) Massányi, P., Massányi, M., Madeddu, R., Stawarz, R., & Lukáč, N. (2020). Effects of cadmium, lead, and mercury on the structure and function of reproductive organs. Toxics, 8 (4), 94.www.mdpi.com/journal/toxics.

16) Bhowmick, S., Pramanik, S., Singh, P., Mondal, P., Chatterjee, D., & Nriagu, J. (2018). Arsenic in groundwater of West Bengal, India: a review of human health risks and assessment of possible intervention options. Science of the Total Environment, 612, 148-169.

17) Olson, J. D. L. (2021). Environmental Arsenic Exposure in Humans: Toxicity and Adaptation in the Bolivian Andes (Doctoral dissertation, Karolinska Institutet , Sweden), p:18-46.

18) Rahman, M. S., Kumar, A., Kumar, R., Ali, M., Ghosh, A. K., & Singh, S. K. (2019). Comparative quantification study of arsenic in the groun-ter and biological samples of Simri village of Buxar District, Bihar, India. Indian Journal of Occupational and Environmental Medicine, 23(3), 126. https://doi.org/10.4103/ijoem.IJOEM_240_18.

19) Cullen, W. R., & Reimer, K. J. (2016). Arsenic is everywhere: cause for concern? Royal Society of Chemistry, p:17. doi: 10.1039/9781782626633-00008.

20) Barral-Fraga, L., Barral, M. T., MacNeill, K. L., Martiñá-

Prieto, D., Morin, S., Rodríguez-Castro, M. C., Guasch, H. (2020). Biotic and Abiotic Factors Influencing Arsenic Biogeochemistry and Toxicity in Fluvial Ecosystems: A Review. International journal of environmental research and public health, 17(7), 2331. https://doi.org/10.3390/ijerph17072331.

21) Mondal, D., Rahman, M. M., Suman, S., Sharma, P., Siddique, A. B., Rahman, M. A., & Polya, D. A. (2021). Arsenic exposure from food exceeds that from drinking water in endemic area of Bihar, India. Science of the Total Environment, 754, 142082.

22) Zaghloul, A., Saber, M., Gadow, S., & Awad, F. (2020). Biological indicators for pollution detection in terrestrial and aquatic ecosystems. Bulletin of the National Research Centre, 44 (1), 1-11.

23) Skorbiłowicz, E., Skorbiłowicz, M., & Cieśluk, I. (2018). Bees as bioindicators of environmental pollution with metals in an urban area. Journal of Ecological Engineering, 19(3).

24) Azzazy, M. F. (2020). Plant bioindicators of pollution in Sadat City, Western Nile Delta, Egypt. PloS one, 15(3), e0226315.

25) Herwig, N., Stephan, K., Panne, U., Pritzkow, W., & Vogl, J. (2011). Multi-element screening in milk and feed by SF-ICP-MS. Food Chemistry, 124 (3), 1223-1230.

26) Rahimi, E. (2013). Lead and cadmium concentrations in goat, cow, sheep, and buffalo milks from different regions of Iran. Food chemistry, 136(2), 389-391.

27) El-beltagy, A. R. (2017). Sheep Genetic diversity and breed differences for climate-change adaptation. In Sheep production adapting to climate change (pp. 149-171). Springer, Singapore.

28) Coulthard, S. (2021). Follow the Flock: How Sheep Shaped Human Civilization. Simon and Schuster. P:23-29.

29) Yabrir, B., Chenouf, A., Chenouf, N. S., Bouzidi, A., Gaucheron, F., & Mati, A. (2016). Heavy metals in small ruminant's milk from Algerian area steppe. International Food Research Journal, 23 (3), 1012-1016.

30) Levkova, V., Stafilov, T., Pacinovski, N., Katerina, B., Mateva, N., GJorgovska, N. & Tosho, K. (2017). Content of major and trace elements in raw ewes' milk used for production of traditional white brined cheese. Slovak Journal of Animal Science. 7-14 , (1) 50 .

31) Taher, K. N., & Ali, A. H. (2014). Determination the levels of cadmium and lead in raw milk of cows, sheep and goats in Al-Qadisiya province. Al-Qadisiyah Journal of Veterinary Medicine Sciences, 13 (2),16-22.

32) Dağcilar, K., & Gezer, C. (2021). Heavy metal residues in milk and dairy products produced in Northern Cyprus. Progress in Nutrition, Vol:23,N.1: e2021019.

33) Wojtkowska, M., Karwowska, E., Chmielewska, I., Bekenova, K., & Wanot, E. (2015). Copper and cadmium in bottom sediments dredged from Wyścigi Pond, Warsaw, Poland-contamination and bioaccumulation study. Environmental monitoring and assessment, 187 (12), 1-9.

34) Magna, E. K., Dabi, M., Badu, E., & Owusu, P. (2018). Determination of heavy metals and potential health risk assessment of honey harvested from the Tamale Metropolis of Ghana using atomic absorption spectrophotometer (AAS). Elixir Pollut., 121, 51522-51525.

35) Oyaro, N., Murago, E., & Mbiri, A. (2011). Determination of essential and heavy metals in Kenyan honey by atomic absorption and emission spectroscopy. JAST (13) 107–15.

36) Elmer, P. (2013). Atomic Spectroscopy: Mercury Hydride System (MHS15), Users Guide. The Perkin Elmer Inc. Printed in Corporation, Waltham, USA, p;38-112.

37) Póti, P., Pajor, F., Bodnár, Á., & Bárdos, L. (2012). Accumulation of some heavy metals (Pd, Cd and Cr) in milk of grazing sheep in north-east Hungary. Journal of microbiology, biotechnology and food sciences, 2 (1), 389-394.

38) Khalil, O. S. F. (2018). Risk Assessment of Certain Heavy

 Online ISSN: 2227-961X.

Metals and Trace Elements in Milk and Milk Products Consumed in Aswan Province. Journal of Food and Dairy Sciences, 9 (8), 289-296.

39) Antunović, Z., Mioč, B., Klir, Ž., Širić, I., Držaić, V., Lončarić, Z., ... & Novoselec, J. (2020). Concentrations of mercury and other elements in ewes' milk: Effect of lactation stage. Chemosphere, 261, 128128.

40) Stanovič, R., Árvay, J., Hauptvogl, M., Tomáš, J., Kováčik, A., Záhorcová, Z., & Slávik, M. (2016). Determination of heavy metals concentration in raw sheep milk from mercury polluted area. Potravinarstvo, 10(1),91-110.

41) Miedico, O., Tarallo, M., Pompa, C., & Chiaravalle, A. E. (2016). Trace elements in sheep and goat milk samples from Apulia and Basilicata regions (Italy): Valuation by multivariate data analysis. Small ruminant research, 135, 60-65.

42) Anastasio, A., Caggiano, R., Macchiato, M., Paolo, C., Ragosta, M., Paino, S., & Cortesi, M. L. (2006). Heavy metal concentrations in dairy products from sheep milk collected in two regions of southern Italy. Acta Veterinaria Scandinavica, 47(1), 1-6.

43) Chen, P., Sun, X., Gao, M., Ma, J., & Guo, Q. (2019). Transformation and migration of cadmium during chemical-looping combustion/gasification of municipal solid waste. Chemical Engineering Journal, 365, 389-399.

44) Gujre, N., Rangan, L., & Mitra, S. (2021). Occurrence, geochemical fraction, ecological and health risk assessment of cadmium, copper and nickel in soils contaminated with municipal solid wastes. Chemosphere, 271, 129573.

45) Jalali, M., & Arfania, H. (2011). Distribution and fractionation of cadmium, copper, lead, nickel, and zinc in a calcareous sandy soil receiving municipal solid waste. Environmental monitoring and assessment, 173(1), 241-250.

46) Bretzel, F. C., & Calderisi, M. (2011). Contribution of a municipal solid waste incinerator to the trace metals in the surrounding soil. Environmental monitoring and assessment, 182(1), 523-533.

47) Vongdala, N., Tran, H. D., Xuan, T. D., Teschke, R., & Khanh, T. D. (2018). Heavy Metal Accumulation in Water, Soil, and Plants of Municipal Solid Waste Landfill in Vientiane, Laos. International journal of environmental research and public health, 16(1), 22. https://doi.org/10.3390/ijerph16010022.

48) Codex Alimentarius Commission Standards. (2011). Joint FAO/WHO food standards programme codex committee on contaminants in foods. fifth session, The Hague, the netherlands.15-26.

49) Licata, P., Di Bella, G., Potortì, A. G., Lo Turco, V., Salvo, A., & Dugo, G. M. (2012). Determination of trace elements in goat and ovine milk from Calabria (Italy) by ICP-AES. Food Additives and Contaminants: Part B, 5(4), 268-271.

50) El-Badry, S., & Raslan, A. (2016). Estimation of lead and copper residues in sheep, goat milks and Karish cheese. Benha Veterinary Medical Journal, 30 (2), 1-5.

51) Codex Alimentarius Commission Standards. (2019). General standard for contaminants and toxins in food and feed. CXS193-1995 amended in 2019, PP1–66. http://www.fao.org/fao-who-codexalimentarius/ codex-texts/list-standards/en/.

52) Levin, R., Vieira, C. L. Z., Rosenbaum, M. H., Bischoff, K., Mordarski, D. C., & Brown, M. J. (2021). The urban lead (Pb) burden in humans, animals and the natural environment. Environmental research, 193, 110377.

53) Fahriye, K. A. N., & Küçükkurt, İ. (2018). Afyon manda kaymağı ve kaymakaltı sütlerinde bazı ağır metallerin ICP-MS ile araştırılması. Kocatepe Veterinary Journal, 11(4), 447-453.

54) Şanal, H., Güler, Z., & Park, Y. W. (2011). Profiles of non-essential trace elements in ewe and goat milk and their yoghurt, torba yoghurt and whey. Food Additives and Contaminants: Part B, 4 (4), 275-281.

55) Kazi, T. G., Brahman, K. D., Afridi, H. I., Arain, M. B., Talpur, F. N., & Akhtar, A. (2016). The effects of arsenic contaminated drinking water of livestock on its total levels in milk samples of different cattle: Risk assessment in children. Chemosphere, 165, 427-433.

56) Tunegová, M., Toman, R., Tančin, V., & Janíček, M. (2018). Occurrence of Selected Metals in Feed and Sheep's Milk from Areas with Different Environmental Burden. Potravinarstvo, 12(1),12-32.

57) Pšenková, M., & Toman, R. (2021). Determination of Essential and Toxic Elements in Raw Sheep's Milk from Area of Slovakia with Environmental Burden. Biological Trace Element Research, 199(9), 3338-3344.

58) Ghidini, S., Zanardi, E., Conter, M., & Ianieri, A. (2012). 16 Chemical Residues in Organic Meats Compared to Conventional Meats. Organic meat production and processing, 53. pp.275-284.

59) European Union. (2006). Commission regulation (EC) No. 1881/ 2006 setting maximum levels for certain contaminants in foodstuffs. Official journal of European union, 364, 5–24

60) Saber, A. S., & El Hofy, H. R. (2018). Determination of some chemical compositions and heavy metal residues in sheep and goat milk. Animal Health Research Journal Vol. 6, No 4.pp. 12-19.

61) Najarnezhad, V., Jalilzadeh-Amin, G., Anassori, E., & Zeinali, V. (2015). Lead and cadmium in raw buffalo, cow and ewe milk from west Azerbaijan, Iran. Food Additives and Contaminants: Part B, 8 (2), 123-127.

62) Najarnezhad, V., & Akbarabadi, M. (2013). Heavy metals in raw cow and ewe milk from north-east Iran. Food Additives & Contaminants: Part B, 6(3), 158-162.

63) Ahmad, I., Zaman, A., Samad, N., Ayaz, M. M., Rukh, S., Akbar, A., & Ullah, N. (2017). Atomic absorption spectrophotometery detection of heavy metals in milk of camel, cattle, buffalo and goat from various areas of Khyber-Pakhtunkhwa (KPK). Pakistan. J. Anal Bioanal Tech, 8(3), 2-18.

64) Abba, B., Petrol, B. B., Ali, H. A., Chamba, G., Sanda, F. S. and Modu, S. (2021). Determination of some Heavy Metals and Proximate Composition of Camel, Cow, Goat and Sheep Milk. ChemSearch Journal 12(2): 50 – 54. http://www.ajol.info/index.php/csj