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Heavy Metal Content of Cow's Milk from Maiduguri Metropolis and Its Environs, Borno State Nigeria

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ABSTRACT: *Milk is a very important component of human diet. The presence of heavy metals in milk at high concentration may create significant health problems. This study therefore was aimed at determining the level of the heavy metals: Pb, Cu, Cr, Co, Cd, Zn, Ni, Fe, Mn and Ag in fresh milk samples from, Kasuwan shanu (cattle market), University of Maiduguri animal farm and Jimtilo village all in Jere local government area; and Auno in Konduga local government area, Nigeria. Samples were collected from lactating cows by milking manually in the morning hours. Collection was done in phases; the first three month of lactation; the six, and the ninth month of lactation period. Samples were digested by the optimized microwave digestion method using* HNO_3 *and* H_2O_2*. Sample analysis was done using Atomic Absorption Spectrometer. The results indicate that, of all the elements determined Fe has the highest concentration that ranged from 0.365 to 10.688 µg/g followed by Mn (0.047 to1.965µg/g), then Pb (0.168 to 1.394 µg/g) and to some extent Zn which ranged from 0.130 to 1.177 µg/g. The level of Cd ranged from 0.005 to 0.028µg/g. Increase in the level of some of the elements is proportional to the lactation periods and as well as the rate of feeding which is one of source of the elements by the lactating cow. The sampling site in this study are primary supplier of milk to Maiduguri Metropolis, it may be ascertained that, milk from these areas of study are good sources of Fe, and to some extent Mn and Zn. Milk from these site therefore contributes to the total iron and zinc intake. Consumption of milk form Maiduguri may be free of risks, but bioaccumulation of Pb, Cd and to certain level Ni through the food chain and intake from other food stuff should also be of concern. Special attention should also be given to heavy metals as once they are present in concentrations greater than the acceptable daily intake, may be dangerous to health especially children.*

KEYWORDS: Cow's diary, Environment, Heavy metals, Pollution, , Soil, Water

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I. INTRODUCTION

The history of milk begins in the Neolithic Age, a time when humans started the transition from hunting and gathering to a more settled way of life. This, in turn, allowed for new possibilities of adapting resources to acquire food. The most important, together with agricultural development, was the domestication of animals, which meant constant access to their meat, fur, and of course milk [1].

Milk is defined as a white fluid produced by the mammary glands of mammals. It is the primary source of nutrition for young mammals before they are able to digest other types of food (wean). Milk from various mammals such as cow, buffalo, goat, sheep, camel, etc. is used for different nutritional purposes, e.g., feeding to young ones and preparation of some nutritional products such as milk cream, butter, yogurt, ghee, sour milk, etc. [2]. It is therefore defined as a dynamically balanced mixture of salt, protein, fats, carbohydrate and water, co-existing as emulsion, colloidal suspension and true solution. Report has it that, there are more than 6 billion consumers of milk and milk products worldwide [3]. In almost all mammals, milk is fed to infants through breastfeeding, either directly or by expressing the milk to be stored and consumed later. The early milk from mammals is called colostrum. Colostrum contains antibodies that provide protection to the newborn baby as well as nutrients and growth factors [4, 5].

The nutritional components in milk are energy, water, carbohydrate, fat, protein, milk flavor, vitamins, minerals and minor biological proteins and enzymes. The percentage of milk components vary not only between different species but also different individuals within a species, there are differences in the composition of milk derived from different breeds of dairy cattle as well as from animals of the same breeds [1]. Despite the essential benefits of consuming milk, the contamination of milk from moderate agricultural practices, industrial pollutants in the environment, animal feeds and use of sewage sludge in agriculture is increasing and therefore requires urgent attention [6]. Worldwide contamination of milk with undesirable substance via animal feeds, heavy metals, mycotoxins, diotoxins and similar pollutants is considered to be of great concern to public health due to their toxic effects on human and animals. The amount of heavy metals in naturally uncontaminated milk is minute, but their contents may be significantly altered through manufacturing process and most importantly from different variety of animal feeds and environmental changes [7, 8].

Heavy metal is a member of loosely defined subset of elements that exhibit metallic properties. It mainly includes the transition metals, some metalloids, lanthanides and actinides. Many different definitions have been proposed some are based on densities some on atomic number or atomic weight, and some on chemical properties or toxicity. Heavy metals are described as those metals which, in their standard state, have a specific gravity (density) of $5g/cm^3$, and atomic weight of 63.55-200.59g [9]. Living organisms require varying amount of 'heavy metals'. Iron, cobalt, copper, manganese, molybdenum, and zinc (essential metals) for instance are required by humans in trace amount to maintain proper metabolic activity; others like Pb and Cd are non-essential and have no biological role to play [10, 11]. However, at high concentrations, even essential metals also cause toxicity to living organisms [12]. Excessive levels therefore can be damaging to human. In animals, metals due enter the body via feeds, green fodder, drinking water and pharmaceutical medicines etc. Other sources are accidental access to limed field, mineral supplements with high content of trace metal and licking of painted surfaced containing metallic pigments [13]

The food chain is an important source of heavy metal accumulation, especially for plants grown on polluted soils. Significant amounts of Cd and Pb can be transferred from contaminated soil to plants and grass, causing accumulation of these potentially toxic metals in grazing ruminants, particularly in cattle [14, 15]. Accumulation of heavy metal in ruminants causes toxic effects in cattle, but also in humans consuming meat and milk contaminated with toxic metals [15, 16].

Animals reared on contaminated fodder are prone to become continuous source of heavy metal residues in edible tissues and milk. Reports has it that milk is contaminated with heavy metals such as zinc, lead, cadmium, selenium, sulphur, iodine and possibly even more dangerous arsenic and cyanide [17]. Cow milk and its products are basic foods and constitute an important source of nutrients in human diet. Their content of protein, fat, carbohydrates, vitamins and minerals [1, 19] determine their biological and technological properties. Human milk is the most natural and perfectly composed food for human infants, but in cases when breast-feeding is not possible, cow milk is commonly used as a substitute [20]. Although the fundamental composition of cow milk is known, studies on its microelements content are generally scares or unknown. It has been reported that the content of the main mineral components, such as Ca, P, K, Na, Mg, Cl, and S, do not vary and undergoes only slight changes depending on the lactation phase and the quality of nutrition as well as environmental conditions, mainly due to chemical pollutants [21].

Due to the growing environmental pollution therefore it has become imperative to determine and monitor the levels of heavy metals in food items especially milk, a natural source of nutrition for all infant mammals and a food product for humans of all ages that is derived from other animals for health safety reasons. This research therefore is aimed at assessing the level of the heavy metals; Cu, Cd, Pb, Zn, Cr, Ni, Ag, Fe, Co and Mn in fresh raw cow's milk obtained from lactating cow at three different phases of lactation periods in Jere Local Government Area of Borno State, Nigeria.

II. MATERIALS AND METHODS

2.1. Sampling area

Samples were collected from four different sites; Kasuwan Shanu (Cattle market), University of Maiduguri animal farm, Jimtilo in Jere Local government; and in Auno village, in Konduga Local Government Area of Borno State, Nigeria. With the exception of University of Maiduguri animal farm, all other sampling site consists of more than four to six cattle ranges (Fig. 1).

2.1.2. Sample Collection

Fresh milk samples were collected from lactating cows by milking manually. All collections were done in the morning hours under hygienic conditions and collected in a plastic buckets which has been washed with acid and hydrogen peroxide with covers [22]. Four different set of composite samples were collected from each sampling site. Collection was done in phases; phase one (the first three month of delivery); phase two, the second three month of delivery (i.e. six month of delivery); phase three, the third three month (i.e. ninth month of delivery); and phase four, the fourth three month of delivery (i.e. one year period of lactation).

2.2. Sample preparation

Belete et al. [23] optimized microwave digestion procedure was adopted. Three millimeter (3.0mL) of each liquid milk sample was transferred into 60 ml Teflon digestion vessel and then optimized volumes of 6 ml of 70% nitric acid and 1 ml of 30% hydrogen peroxide were added and the mixture was shaken carefully and kept for 10 min before closing the vessel. The samples were subjected to microwave digestion at the optimized microwave digestion program in the sequence of 50W, 165^{o}C (10 min); 80W, 190^{o}C (20 min); and 0W, 50^{o}C (10 min). After heating, the sample was cooled to room temperature to avoid foaming. The digest was diluted to 25 ml with deionized water and used for analysis. Blanks and reference material were run with the samples. Finally, the digest was analysed for the concentrations of Cu, Cd, Pb, Zn, Cr, Ni, Mn, Ag, Fe, Co and Mn using a graphite furnace atomic absorption spectrophotometer.

2.2.1. Statistical data handling

Mean differences were separated by Duncan's Multiple Range Test. The level of significance was set at $P \leq 0.05$. All analyses were performed using statistical software package; SPSS 17.

III. RESULTS AND DISCUSSIONS

Milk is considered as nearly a complete food in that it's a good source of protein, fat, and major minerals [8]. Cow's milk, be it fresh or fermented is a common diet supplement of many communities in northern Nigeria, the north-east in particular that share borders with Cameroon through Adamawa state and Chad through Maiduguri, Borno state. The mean heavy metals (Ag, Mn, Cd, Cr, Zn, Ni, Co, Cu, Fe, Pb) concentration in the fresh cow's milk from the four different sampling sites in Maiduguri and its environs are presented in figures 1-4 below.

3.1. Kasuwan shanu (cattle market)

The distribution of the heavy metals concentration determined in cows' milk from Kasuwan Shanu (cattle market) is shown in figure 1. As indicated, the highest levels of 4.904 ±0.101, 1.252 ±0.021, 1.191±0.031, 0.333±0.017, 0.102±0.008 and 0.025µg/g±0.012 for Fe, Pb, Mn, Zn, Cu and Co respectively, were observed at the six month period of lactation. Chromium was not detected throughout the periods of lactation. Nickel was also not detected at the three and sixth month of lactation but traces of 0.033µg/g was observed at the ninth months of lactation. Cobalt was not detected at the first three months of lactation but as the lactating mother gains energy to sufficiently graze the level increases to 0.025µg/g ±0.007 at the sixth month and slightly decreases to 0.021µg/g ±0.0131at the nine month of lactation (Fig. 2)

3.2. University of Maiduguri farm

The observed level and distribution of the heavy metals in cow's milk from university of Maiduguri farm is as shown in figure 2. The highest level of most of the metals; Fe and Pb with the levels of 10.688 and 1.353µg/g±0.021 respectively were observed at the six month period of lactation. Highest value of Zn (1.177µg/g±0.011) and Co (0.211µg/g±0.016) were observed at the first three month of the lactation periods. Chromium was not detected in the milk at all the lactation periods. Cadmium, Cu and Ni were not detected at the first three month of lactation but the levels 0.031 and 0.011µg/g were observed at the six and ninth month of lactation for Ni whereas 0.043 and 0.023µg/g were equally observed at the six and ninth month of lactation for Cu. High concentration of Mn (0.270µg/g±0.022) was found at the ninth month of lactation. A possible source of contamination of Cu in milk can be attributed to animal feed and possible high Cu content of water [24] (Fig. 3)

3.3. Jimtilo Village

In Jimtilo village, the concentration the metals determined are shown in figure 3. With the exception of Fe that has the concentration of 5.290 µg/g ±0.128 at the ninth month of lactation and was observed in all the periods of sampling, Mn had the highest level of 0.538 µg/g ±0.058 at the sixth month period of lactation. These concentration decreases at the ninth month period of lactation to 0.416 µg/g ±0.128. Cadmium was found to increase with time, the highest of 0.018 µg/g ±0.011 was observed at the ninth of lactation. At this site of sampling, chromium was not detected at first three month of lactation as well as the sixth month period but was observed at the ninth month period with the level 0.054µg/g ±0.028. Copper and Cd were not observed at the first three month of lactation, Cu was found to increase with increase in period of lactation. It has the level 0.006 µg/g ±0.012 and 0.097 µg/g ±0.008 for six and the ninth month respectively. Cobalt had 0.103 µg/g ±0.028 and 0.034 µg/g ±0.018 for six and the ninth month period of lactation respectively. Lead had the highest level of 0.194 µg/g ±0.018 at the sixth month period of lactation. This value increases at the ninth month to 1.372 µg/g ±0.111. Lead (Pb) was also found to increase with increase in lactation period (Fig. 4).

3.4. Auno village

The levels of the heavy metals in Auno village vary with the period of lactation. Iron is still in the lead, the concentration ranged from 2.999µg/g ±0.128 in the first three month of lactation to 3.799µg/g ±0.155 µg/g in the ninth month of lactation. Chromium was not detected through the lactation period. The level of Zn ranged from 0.155µg/g ± 0.032 at the first three month to 0.333µg/g ±0.055 in the ninth month of the lactation period. The concentration of Zn at this sampling site increases with time of lactation. Nickel was observed throughout the lactation period with the highest level of 0.029µg/g ±0.011 observed in the first three month of lactation. In contrast to the level of Zn, nickel was found to decrease with increase in the lactation period. The least value (0.011µg/g ± 0.081) of which was observed in the ninth month period of lactation. The concentration of Co equally decreases as with increase in the lactation period. The highest level of 0.010µg/g ± 0.005 was observed in the first three month of lactation and was not detected at the ninth month of lactation period. Copper was found in all the three phases of the sample collection. The highest level of which observed at the ninth month period of lactation. The level of the element with no non biological function in the body Pb was found to increase with increase in the period of lactation. As the lactating mother gain more energy to graze sufficiently, so is the accumulation of the metal. The highest concentration of 1.387µg/g ±0.081 was observed at the ninth month of lactation. (Fig. 5)

The results of this study as presented in the figures 1-4 shows variations in the level of the elements within a sampling site and among the sampling sites. Iron (Fe) for instance, has the highest level in all the samples from the sampling sites. The high level observed in this study is regardless of the lactation periods. The level of iron observed in this study is lower than what was reported from Benha and Kafr Shokr [25] and many fold lower than what was reported by Sikirić et al. [26]. However, the level of iron reported in this study is two-fold higher than what was reported by Muhib et al. [27]. Report has it that, Fe can represent a problem in dairy technology because of its catalytic effect on oxidation of lipids with development of unpleasant smell, bounding preferably proteins and membrane lipoproteins of milk fatty globule [28].

Manganese was observed in all the samples analysed in this study and at all the periods of lactation. The concentrations observed ranged from 0.170 ± 0.018 to 1.965 ± 0.027. The highest level of 1.965µg/g comes from Auno village at the ninth month of lactation period. Many researchers have reported the presence of Mn in cow's milk. The level observed in this study for instance is higher than what was reported in cow milk of different dairy farms near Karnafuli paper mills, Chittagong, Bangladesh [29], Borena Zone, Ethiopia [23]. However, the element could not be detected in cow's milk samples from Dodoma Urban District, Tanzania [30]. The level of manganese observed in this study is many-folds lower than what reported by Gunshin et al. [31]. Manganese is a naturally occurring element found in rock, soil, water, and food. In humans and animals, manganese is an essential nutrient that plays a role in bone mineralization, protein and energy metabolism, metabolic regulation, cellular protection from damaging free radical species, and formation of glycosaminoglycans [32]. Although the element is an essential nutrient required by both plants and animals, exposure to high levels via inhalation or ingestion may cause some adverse health effects. It has been suggested that these adverse health effects, especially neurologic effects, are occurring on a "continuum of dysfunction" that is dose-related [33].

The concentration of Lead (Pb), of this study showed high level at the six and nine month period of lactation. At these periods, the lactating cow has gained energy to strive and eat sufficient food to yield more milk. Therefore the high level of Pb observed in this study could be attributed to the anthropogenic contamination of the feeds eaten by the lactating mother. It has been reported that, one of the most important sources of lead contamination in milk is water, especially in more contaminated areas [34]. The high concentration of Pb observed in this study is many-fold lower than what was observed in Tehran and Zabol, Iran [35, 36] and many-fold lower than what was reported from California by Bruhn and Franke, [37]. The data is however, higher than what was reported from Challawa industrial area Kano and Zaria, Nigeria [38]. Lead is one of the limited classes of element that can be described as purely toxic. Most other elements such as Zn, Cu, Fe, Mn etc., are only toxic at high concentrations they are actually required nutrient at lower levels. There is no exposure level below which lead appears to be safe. Lead poisoning is one of the most frequently reported causes of poisoning in farm livestock; with cattle being most commonly affected [39]. High level of lead is particularly of great concern especially due to the fact that milk and dairy products are consumed mostly by infants and children who are uniquely susceptible to the effect of lead. It is known to induce reduced cognitive development and intellectual performance in children and increased blood pressure and cardiovascular disease in adults [40].

The concentration of cadmium did not show much variation with period of lactation and as well as sampling sites. Although it was not detected at first three months of lactation in samples from University of Maiduguri, the highest level (0.028µg/L) of element was observed in samples from this site at the sixth month's period of lactation. The concentration however is lower than what was reported from Zabol, Iran by [36] Derakhshesh and Rahimi, (2012), New Valley, Egypt by El-Bassiony et al. [41], Dhaka, Bangladesh [27], very much lower than what was observed in Benha, Kaha, Shebin El-Kanater, Tokh and Kafr Shokr [25]. It is lower than was reported from Lithuania [42]. The data for Cd of this study is however higher than what was reported by [22 and is in agreement with what was reported by [43]. The presence of cadmium with high concentration in cow's milk may be due to consumption of contaminated feeding stuffs and water [44] where it comes from industrial emissions and fertilizers (phosphate rocks, which form the basis of commercial fertilizers and sludge) which can contaminate soil and crops. Also, inhalation of fumes and dusts from industrial activities could be a great source of the metal [45]. Much of the cadmium in the atmosphere results from incineration of ferrous scrap and metallurgy processes [46]. It is considered to be one of the most toxic metals. In addition, it is implicated in high blood pressure [47], prostate cancer, mutations and fetal (embryonic) death [48].

The highest concentration of Cu (0.102 µg/g) in this study was observed in samples from Kasuwan Shanu. This level is lower than was observed in Beni Suef Province, Egypt [49], area of Giza-Egypt [8, in Sokoto Metropolis, Nigeria [50] and in Niger state, Nigeria [6]. Some heavy metals at lower concentrations are essential to maintain proper metabolic activity in living organisms; copper for instance is needed for proteins involved in growth, nerve function and energy release [51]. It is vital for the formation of some important proteins. It is a critical functional component of a number of essential enzymes, known as cuproenzymes. Copper is stored in appreciable amounts in the liver. It also has anti-oxidant properties and involved in the regulation of gene expression. However, excess copper in the body leads to Wilson's disease which is characterized by deficiency of ceruloplasmin [52]. The toxic limit of copper in cow's milk is 0.4 mg/L [53]. The concentration of copper in the present study is below this toxic limit. More so Previous studies showed that cow milk from rural areas often contained copper concentration less than 0.39 mg/L [43].

Zinc in this study was observed in all the samples analysed. The highest level (1.177µg/g) of which was found in the sample from University of Maiduguri farm. This concentration was higher than was observed in Sokoto Metropolis, Nigeria [50] and two-fold lower than what was reported by Enb et al. [8], Challawa industrial area Kano and Zaria, Nigeria [38] and Niger state [6]. It is also ten-fold lower than what was reported by Rao and Murthy, [30]. Taking too much of zinc into the body through food, water, or dietary supplements can affect health. The Recommended Dietary Allowances (RDAs) for zinc is 11 mg/day for men and 8 mg/day for women. If large doses of zinc (10–15 times higher than the RDA) are taken by mouth even for a short time, stomach cramps, nausea, and vomiting may occur. Ingesting high levels of zinc for several months may cause anemia, damage the pancreas, and decrease levels of high-density lipoprotein (HDL) cholesterol. The significance differences for mean concentration of Zn indicate that, the accumulation of Zn in soil, grass at which the cows grassed in each sites may be different. The concentrations of the elements present in milk depend on atmospheric deposits-soil-cattle feed-milk chain.

In this study, Cr was observed only in the samples from Jimtilo vilage and even that it was detected only at the ninth month of lactation period. The concentration of which was 0.054µg/g. This level is however higher than what was reported from Giza-Egypt [8]. Nnadozie et al. [50] found chromium not detectable in his research from Sokoto, Nigeria. In the contrary, chromium was detected in all the samples analysed from four different farms in Borena Zone, Ethiopia [23].

The level of nickel in this study varies within and among the sampling sites. For instance in Kasuwan Shanu, it was detected only at the ninth months of lactation with the level 0.033µg/g. it was however detected throughout the phases of sampling in Auno and Jimtilo village with highest concentration of 0.04µg/g. This level is found higher than what was reported from Giza-Egypt [8]. It is however many-folds lower than what was reported by Amaro et al. [54]. It has earlier been reported that the actual nickel content in milk and dairy products are limited and the values reported are subject to considerable variation [55]. Significant changes in nickel content of milk according to different geographical areas were established [56, 57, 58, these indicates that the geographical characteristics of the area and the environmental contamination is closely related to the nickel content in pastures [59].

There is substantial evidence that nickel is essential to animals, and is probably true that it may have a function in the human body [60, 61], it is believed to serve as a co-factor for some microbial intestine enzymes. However the specific biochemical functions of the element in higher animals, including man, have not yet been ascertained. For this reason, this element has still not been accepted as essential [62] and the National Research Council, [63] has not set up any official recommendations for dietary intake for this trace element, since there are no reliable data on which to base estimates of human requirements. However, some suggestions have been made by authors such as Nielsen [64] who proposed a recommended daily nickel intake of 75ug/d. Ni content in the adult human body should however remain below 0.1 mg per day as its presence in high amount may cause damage to DNA and cell structures [65].

The highest level of cobalt (0.215µg/g) in this study was observed in sample from University of Maiduguri farm. This concentration is however high than what was observed by Rao and Murthy, [30] and lower than what was reported by Gunshin et al. [31]. Cobalt was not detected in all the samples analysed from four different farms in Borena Zone, Ethiopia [23]. It is also not detected in milk samples from Sokoto Metropolis, Nigeria [50] This could mean that there is low pollution with respect to the metal in the area of study. The mineral composition of milk depends on the genetic characteristics, stage of lactation, environmental conditions, type of pasture, soil contamination and the health conditions of the animals [66, 67].

Chromium, nickel and cobalt are also toxic metals which are released to the environment. They originated from dumping industrial wastes in the rivers, as well as the application of phosphatic fertilizers [68]. Toxicity of metal is closely related to age, sex, route of exposure, level of intake, solubility metal oxidation state, duration of exposure, frequency of intake, absorption rate and mechanisms/efficiency of extraction [68, 69]. The maximum permissible levels of metals recommended as reported by the international dairy federation standard [70] (IDF Standard 1979) are 0.037 µg/g for Fe, 0.328 µg/g for Zn, 0.02 µg/g for Pb, 0.01 lg/g for Cu and 0.0026 µg/g for Cd. According to Codex Alimentarius Commission [71] the maximum residues limit for Pb in milk is 0.02µg/g.

Forms of silver in atmospheric emissions are probably silver sulfide, silver sulfate (Ag_2SO_4), silver carbonate (Ag_2CO_3), silver halides, and metallic silver [72]. About 50% of the silver released into the atmosphere is transported more than 100 km and is eventually deposited in precipitation [73]. Most of the silver lost to the environment enters terrestrial ecosystems, where it is immobilized in the form of minerals, metal, or alloys; agricultural lands may receive as much as 80 000 kg of silver per year from photo processing wastes in sewage sludge. An estimated 150 000 kg of silver enter the aquatic environment every year from the photographic industry, mine tailings, and electroplating [72].

The atmosphere receives 300 000 kg of silver each year from a variety of sources. The global biogeochemical movements of silver are characterized by releases to the atmosphere, water, and land by natural and anthropogenic sources, long-range transport of fine particles in the atmosphere, wet and dry deposition, and sorption to soils and sediments [73]. In this study, with the exception of Jimtilo village where the element was detected only at the ninth month of lactation, silver was observed in all the other samples and the highest concentration (0.126µg/g) comes from university of Maiduguri cattle farm. The Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA) currently enforce a Permissible Exposure Limit (PEL) of 0.01 mg/m^3 for metallic and soluble silver compounds [74, 75].

Table 1 below shows the permissible limits as well as the estimated daily intake of some elements [8,76]

IV. CONCLUSION

This study gives important information on the levels of elements Pb, Mn, Cd, Cu, Co, Cr, Ni, Ag, and Zn in milk and dairy products. Iron and Mn were had the highest concentration, significantly higher levels of Pb, and to some extent Zn were equally observed. The results of the study indicate that the levels of the elements determined with exception of Fe were below WHO permissible limits and far below the estimated daily intake. The sampling site in this study are primary supplier of milk to Maiduguri Metropolis, it may be ascertained then that, milk from these areas of study are good sources of Fe, and to some extent Mn and Zn. Milk from these site therefore contributes to the total iron and zinc intake. Consumption of milk in this area is nearly free of risks, but bioaccumulation of lead and cadmium through the food chain and intake from other food stuff should also be of concern. Special attention should be given to heavy metals as once they are present in concentrations greater than the acceptable daily intake, it may be difficult to reduce them to an acceptable level during processing.

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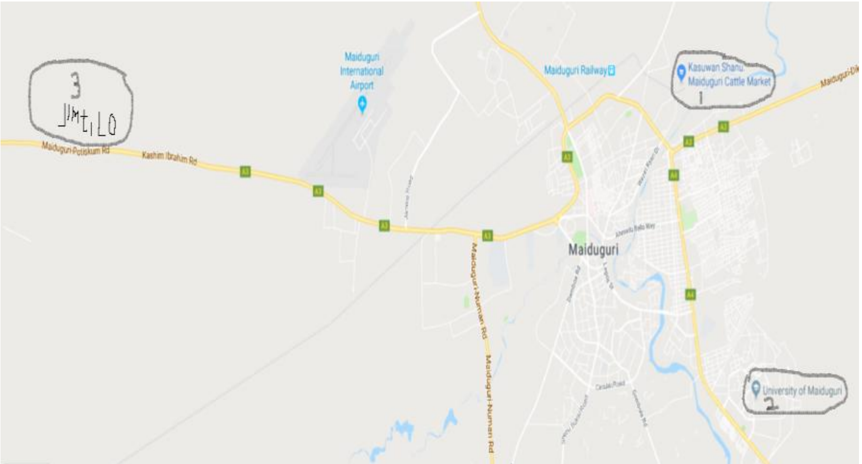

Figure 1: Showing three out of the four sampling sites; Kasuwan shanu (1), University of Maiduguri (2) and Jimtilo village (3)

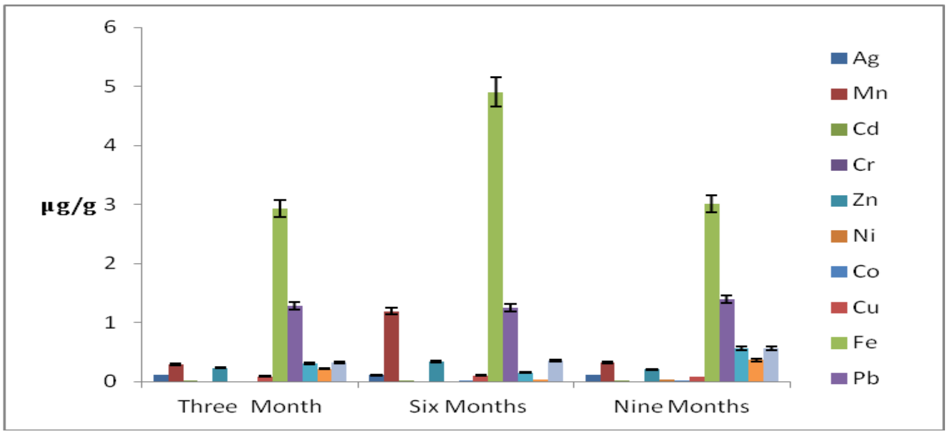

Figure 2: Concentration (µg/g) of metals in fresh cow's milk from Kasuwan shanu (Cattle market) Maiduguri, Borno state, Nigeria.

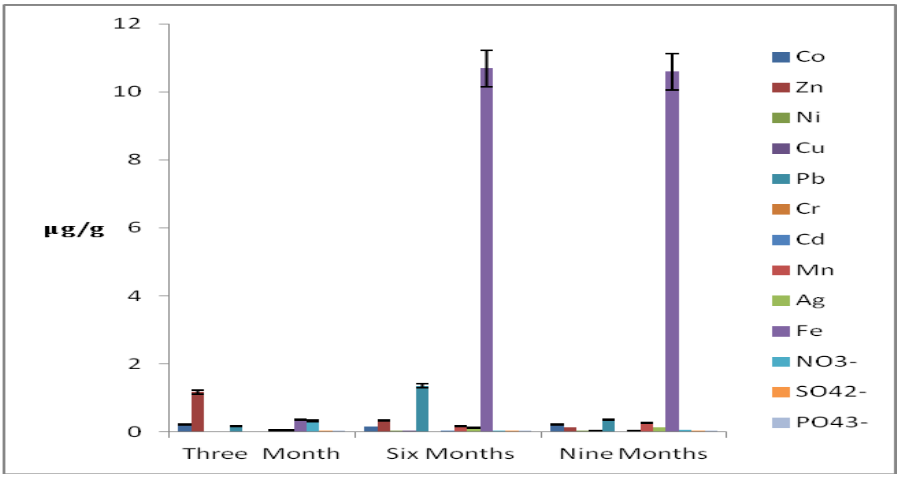

Figure 3: Concentration (µg/g) of metals in fresh cow's milk from University of Maiduguri Farm, Borno state, Nigeria.

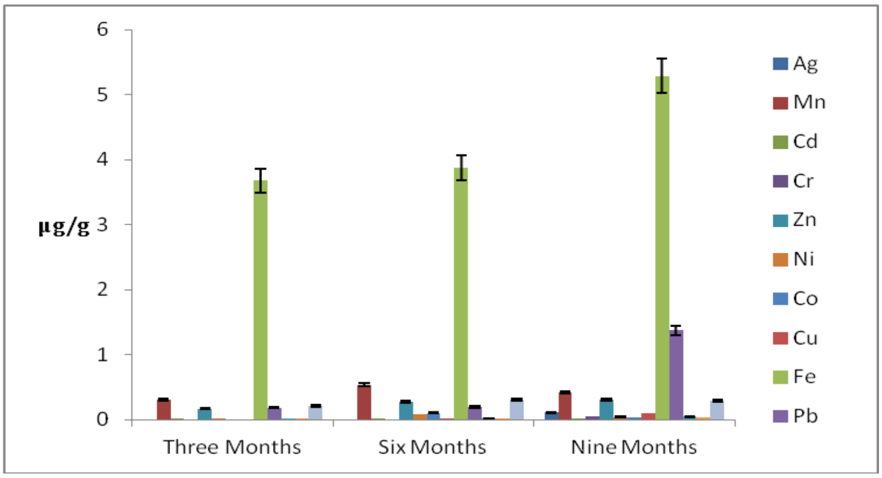

Figure 4: Concentration (µg/g) of metals in fresh cow's milk from Jimtilo Village, Borno state, Nigeria

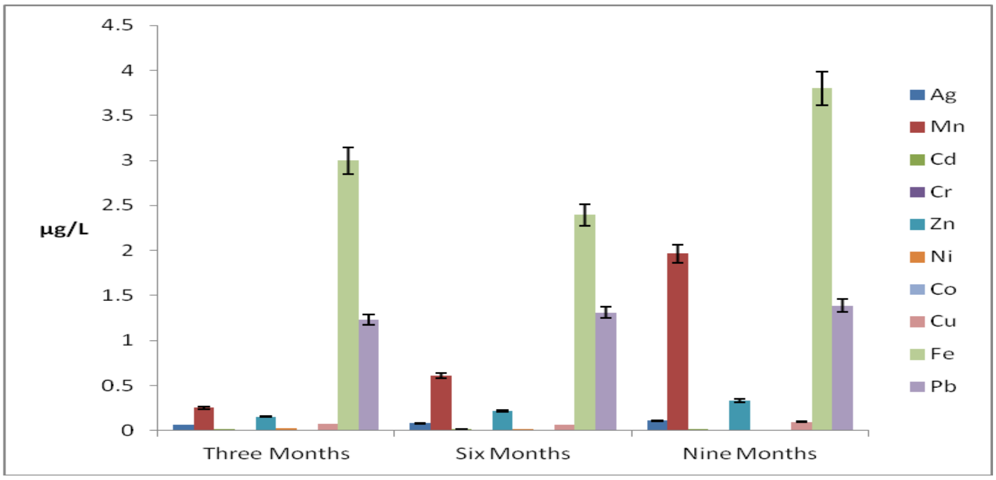

Figure 5: Concentration (µg/g) of metals in fresh cow's milk from Auno Village, Borno state, Nigeria

Table 1: The minimum and maximum level (µg/g) of some heavy metals determined in this study with their

Elements	minimum	maximum	WHO permissible limits	Estimated Daily Intake EDI
Fe	0.365	10.688	0.500	3.000 E-02
Mn	0.047	1.965	55.500	
Pb	0.168	1.394	3.460	7.100 E-04
Cd	0.005	0.028	0.580	1.700 E-04
Cu	0.006	0.102	24.200	3.200 E-04
Cr	0.021	0.054	1.610	
Zn	0.130	1.177	121.000	2.100 E-02
Ni	0.001	0.085	0.430	

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