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RESEARCH ARTICLE

Toxic metals, nitrates and nitrites in water and residues in bovine milk

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ABSTRACT

Water with toxic metals represent a risk to animal production and to public health due to their presence in milk. The information of the chemical quality in water for animal consumption in the milk basin of Xochimilco, Mexico is scarce. A water sampling was carried out to identify arsenic, lead, mercury, nitrates and nitrites, pH, temperature, colour and smell in four dairy farms in winter season, 2017. The toxic metals were identified by qualitative Reinsch test and the concentration by flame atomic absorption spectrometry technique. The results of pH and temperature showed an average of 7.8, and of 10.5 ºC, the mean nitrate content was 0.79 mg L-1and 0.070 mg L-1for nitrites. Reinsch test indicated that all water samples were positive for at least one metal, with mercury being the most frequent (66%). The detected mean concentrations were: lead (0.040±0.03 mg L-1), arsenic (0.0015±0.0011 mg L-1), cupper (0.019±0.0053 mg L-1), cadmium (0.039±0 mg L-1), all inside the livestock maximum permissible levels, while mercury (0.078±0.03 mg L-1) was found in excess. Arsenic was the only metal found inside the drinking water permissible levels and cupper was found in the limit of the drinking water. In milk samples, lead and cadmium were found. It is concluded that the contamination by toxic metals in the water of dairy cows consumption in the Xochimilco Basin, can affect milk production, and lead canbe a risk in human healthin a long term exposure.

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INTRODUCTION

Water is essential in animal production; livestock milk production requires 15,000 L of water to produce one kg of food (FAO, 2012), however little information exists of metal toxic substances in many places of animal production despite being a condition that affects their productivity principally, moreover these contaminants may transfer to food, as mentioned (Adamse et al., 2017). The toxic compounds that have been detected in rivers in Mexico are lead, arsenic and mercury, due to many human activities, as the domestic water waste (Méndez et al. (2000). Arsenic (As), is a member of cupper sulfides, cobalt, lead, zinc and organic complexes, the maximum permissible limit(MPL) is 0.20 mg L-1. This metal has a cumulative property, its toxicity depends on its chemical form, being arsenite the most powerful. In cattle a chronic intoxication is identified with lack of appetite, anemia, depression, bloody diarrhea, and reproductive problems (Bera et al, 2010).

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Cadmium (Cd), is a heavy metal, present in air, water and soil (Waisberg et al., 2003). Sources of contamination are fertilizers, recycling of electronic waste and diet; their MPL in water is 0.02 mg L-1 and 0.05mg L-1 for meat. Lead is a silver coloured solid, its MPL is 0.10 mg L-1 (WHO, 2011), since the source of contamination can be anthropogenic. In cattle this metal causes an important economic loss due to the reduction of milk production and it also causes cattle intoxication; the symptoms are anemia, nerve disorders and kidney damage (ATSDR, 2012). Mercury (Hg) is a silver coloured liquid, not biodegradable, its organic form is the most toxic for animals (methyl mercury). The maximum limit is 0.50 mg L-1 in fish meat (González, 2009). Nitrates and nitrites, from agricultural lands leached and by the decomposition of organic or waste domestic water, may provoke a lower intake of food, weakness, diarrhea and anemia. The safety limit for nitrites and nitrates, is noted by NMX-AA-079- SCFI-2001 and by NMX-AA-079-SCFI-1986 respectively. Therefore, the objective of the study was to identify the presence of lead, mercury and arsenic in the water of dairy cattle consumption in small productions, located in Xochimilco, Mexico City, the mean concentration in water and in raw milk.

MATERIALS AND METHODS

The study was carried out in Xochimilco milk basin, located near Mexico City. Sampling was performed in four small familiar productions, collecting three water samples in each sampling, during winter season from October and November 2017. Sampling began from 8:00 and 9:00 h in the morning, identifying the location and transporting them in coolers in order to be taken to the laboratory. Additionally, ten milk samples were collected from dairy cows and kept refrigerated at a temperature of 7ºC, until analysis. In water, the parameters of potential hydrogen (pH) were determined by means of NMX-AA-008-SCFI-2000, colour and od or according to the NMX-AA-007-SCFI-2000.The presence of arsenic, mercury and lead was determined in water and milk by a qualitative test and concentrations determined by Flame Atomic Absorption Spectrometry technique (FAA),NMX-AA-051-SCFI-2001. A blank and standard solutions for devices calibration were used, as well as a standard calibration curve was achieved. The results obtained were evaluated according to the criteria and norms established in Mexico (NOM-127- SSA1-1994 and CE-CCA-001/89), of the maximum permissible limits (MPL) for each metal detected in water. The maximum, minimum, mean and standard deviation of the detected concentrations were calculated. The NOM-243-SSA, 2010, from milk data.

RESULTS AND DISCUSSION

The temperature obtained in the water samples was similar to the recommended one of NMX-AA007-SCFI2013, between 10 and 11 ºC. The pH obtained was 7.8 on average, which is inside the range 5-9 according to NOM -002-ECOL-1996.

The water colour in the stables of the barn was white without smell, these characteristics are accordingly to guidelines. In water samples tested with the qualitative Reinsch test, the presence of at least one metal was detected, in water. Mercury was found in 66.6% of the evaluated samples, arsenic and lead in 33.4% (Table 1). This test showed to be a tool for an easy and quickly initial detection. In water samples tested with atomic absorption (FAA), the mean concentration of lead (0.040±0.03 mg L-1), arsenic (0.0015±0.0011 mg L-1), cupper (0.019±0.0053mg L-1) and cadmium (0.039±0 mg L-1) were found, these values are inside the livestock maximum permissible levels, while Hg (0.078±0.03 mg L-1) was out of the permissible levels. Arsenic was the only metal found inside the drinking water permissible levels (human consumption) with a mean concentration of 0.0015±0.0011 mg L-1; although cupper was found in the limit of the drinking water maximum permissible levels (Table 2). In this work, lead content found in water was similar to (Villalba et al, 2013; Villaba et al., 2011), probably due to neutral pH encountered in the water samples, since the metal requires acidic water in order to be soluble; additionally, Córdoba and col, 2012, found that the presence of lead in the Xochimilco channel is within the Mexican regulation. However, the lead concentration it is out of drinking water, moreover it is an accumulative poison can generate many health problems in public health, as osteomalacia and cardiovascular disease with a long exposure; moreover, lead with cadmium has an additive effect. The excess of mercury can cause gastroenteritis, kidney damage and infertility in dairy cows, affecting their milk production. In general, the low concentration of cadmium, cupper and arsenic detected in water in this work, can be explained with the season of the study; in this season, the rains, temperature and other environmental factors didn't contribute in the

Table 1. Quality detection of mercury, lead and arsenic in water consumed by dairy cattle

Samples	Sampling 1	Sampling 2	Sampling 3
(a)	Hg	Hg	Hg
(b)	Hg	Hg	Hg
(c)	Hg, Pb, As	Hg	Hg,Pb, As

Sampling 1, 2, 3: from different dates

Table 2. Summary of descriptive statistics for metal concentrations found in water for dairy cows

sample	Pb (mg L-1)	Cd(mg L-1)	As (mg L-1)	Nitrates (mg L-1)	Nitrites (mg L-1)	Cu(mg L-1)	Hg(mg L-1)
Minimum	0.008	0.039	0.0006	0.79	0.07	0.033	0.045
Maximum	0.072	0.039	0.003	0.79	0.07	0.026	0.135
Mean	0.040	0.039	0.0015	0.79	0.07	0.019	0.078
Standard deviation	0.03	0	0.0011	0	0	0.0053	0.03
MPL (livestock use)	0.1	0.1	0.2	5	0.5	0.5	0.01
MPL (drinking water)	0.01	0.005	0.01	NC	NC	0.02	0.001

Table 3. Concentration means of lead, cadmium, arsenic, mercury, cupper, nitrates nitrites in milk

sample	Pb	Cd	As	Nitrates	Nitrites	Cu	Hg
Mean of the detected concentration	0.09	0.02	ND	ND	ND	ND	ND
MPL	0.02-0.1	0.05	0.2	NC	NC	NC	0.5-0.05

Table 4. Lead and Cadmium detection in Holstein bovines milk

Sample	Pb(mg L-1)	Cd (mg L-1)
(a)	0.140	0.019
(b)	0.055	0.015
(c)	0.013	0.018
Composite	0.139	0.015
Mean	0.087	0.017
Standard deviation	0.0633	0.0021

concentration (Moseki, 2018), the nitrates and nitrites were found within the standard range, which is correlated with physical characteristics found which were the good colour and the odorless water. Milk samples contained lead concentrations (0.090mgL-1), that it is high compared with the reported by Elatrash and Atoweir, 2014, and with NOM- 243-SSA1, Mexican regulation, but cadmium was found into recommendations.

Conclusion

This study shows the presence in low concentrations for lead, cadmium, arsenic and cupper in water for dairy cattle consumption, being mercury, the most abundant metal, in high level. It suggests that the source of contamination is the untreated water waste, whose origin is the human economic activity. However, the residues of lead and cadmium in milk found in this work could cause a public health problem in child population, a long term chronic exposure. The lead and cadmium had been associated with anemia, osteomalacia and cardiovascular diseases. The nitrates and nitrites were found in low levels does not affect lactating dairy cows. It is strongly recommended to keep clean the water troughs, maintain water pipes in good conditions and carry out a regular sampling of the water quality for animal consumption in order to avoid the entry of toxic metals in the food chain.

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