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Water quality criteria for livestock watering – a comparison among different regulations

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ABSTRACT. This review presents water quality criteria for livestock adopted by different countries/states and discusses how those limit values are established. The method used was a literature data survey, available in the electronic pages of regulatory agencies of different countries or states. Livestock water quality criteria for chemical substances adopted by different countries/states, including Brazil (CONAMA 357 e 396), were compared. Information about the main factors can influence the derivation of livestock water quality criteria were highlighted. The analysis of the Brazilian surface water regulation, which is based on multiple uses, indicated that some standards are not appropriate for livestock use. Great variation was observed for the choice of priority substances and the water quality criteria among the different countries/states were analyzed, confirming the need for the establishment of criteria for each country, considering the use and importance of substances and specific exposure scenarios. From the compiled date it is possible to observe that water criteria for livestock have not been yet established for several chemicals, suggesting that more studies are needed in Brazil.

Keywords: livestock watering, water quality, water regulation.

Qualidade de água para dessedentação de animais - comparação entre diferentes regulamentações

RESUMO. Esta revisão apresenta valores máximos permitidos para substâncias químicas, em águas destinadas a dessedentação de animais adotados por diferentes países/estados e fornece informações sobre como esses valores devem ser estabelecidos. Os critérios de qualidade para o uso dessa água foram pesquisados nas páginas eletrônicas dos órgãos responsáveis de cada país ou estado. Os padrões brasileiros adotados pelas Resoluções 357 e 396 do Conselho Nacional do Meio Ambiente foram comparados aos valores de outros países. Os resultados mostram que os valores máximos permitidos pela legislação brasileira de múltiplos usos para determinadas substâncias não são adequados para dessedentação de animais. Existe grande variação em relação às substâncias legisladas e os valores máximos permitidos para cada substância entre os países/estados o que confirma a necessidade de que os critérios de qualidade de água para dessedentação de animais sejam específicos para cada país, contemplando a utilização e importância das substâncias e os cenários de exposição de cada um. Várias substâncias não possuem valores máximos estabelecidos para o uso da água na dessedentação de animais indicando a necessidade de aprimoramento da regulamentação vigente.

Palavras-chave: dessedentação de animais, qualidade da água, regulamentação da água.

Introduction

The importance of good quality water as a nutrient essential to animals has often been underestimated. The maintenance of water quality for this purpose is important to preserve the animal health, to ensure human health and the economy on food production. The literature indicates that the presence of toxic substances in concentrations above the allowed in the water consumed by animals can decrease the production of meat, fat, eggs, milk, reduce fertility, and pose a risk to animal and human health due to the ingestion of residues possibly present in animal products (HAPKE, 2000; PÉREZ-CARRERA; FERNÁNDEZ-CIRELLI, 2005).

In several regions of the world it has been observed a high concentration of fluoride in the drinking water of animals. Choubisa (1999) found the dental and skeletal fluorosis in cattle and buffaloes in the region of India where the fluoride concentration in water ranged from 1.5 to 4.0 mg L^{-1}. Lameness in the pelvic limb, rigidity and exostoses were observed in animals with advanced age and subjected to fluoride concentration of 2.8 mg L^{-1}. Shupe et al. (1984) observed that in the United States, deer, elk and bison had dental and skeletal fluorosis caused by high concentrations of fluoride in water to watering and vegetation consumed by the animals. Irregular bones with disorganized and inadequate mineralization, were observed in all species.

Several compounds found in the environment and water can reproduce actions inherent to reproductive hormones and thereby cause dysfunction in the neuroendocrine system or directly in the gonads (VEERAMACHANENI, 2000). Studies in rabbits have shown that exposure to octylphenol, DDT, DDE, arsenic, benzene, chromium, lead, phthalates, chloroform, trichlorethylene, disinfection products, among other substances found in the drinking water of animals may promote the occurrence of cryptorchidism, testicular carcinoma in situ, loss of libido and failure of sperm production (VEERAMACHANENI, 2000).

Pérez-Carrera and Fernández-Cirelli (2005) detected in the province of Cordoba, a major milk producing area in Argentina, high concentrations of arsenic in groundwater that was the main source of water used for livestock watering. The authors indicated that all samples taken from the water wells (2-15 m depth) had arsenic concentrations above the value that causes chronic effect in livestock (150 $\mu g\ L^{-1}$). With regard to milk analysis, one sample exceeded the maximum allowable arsenic in milk (10 $ng\ g^{-1}$), according to the International Dairy Federation.

Given the wide range of adverse effects that may occur related to poor quality of water for animal use and the limited information available regarding the water quality criteria for livestock, this study aimed to compare the quality criteria for water use in livestock watering, considering chemicals, present in the electronic pages of the agencies responsible for regulating such use in many countries/states, analyze how they are established and identify which factors influence their establishment.

Material and methods

At first we tried to find water quality criteria for livestock watering in papers published in the peer-reviewed journals. However, the necessary information was not available. Therefore we consulted electronic pages of the agencies responsible for regulating this water use in different countries/states. Importantly, the rules that define criteria for water quality for livestock watering are in the language of the country in question and different nomenclatures are used (e.g., 'niveles guia' for Argentina, 'estándares' for Peru). For this reason that type of information was not easy to be assessed. Only data in English and Spanish languages were considered in this work.

Results and discussion

Setting of limit values for water use in livestock watering

The limit values for contaminants in water intended for animal use are derived from toxicological data for species that comprise the livestock production of each scenario or region (ANZECC, 2000; ENVIRONMENT CANADA, 1999). The derivation of these values are usually estimated using at least three toxicity studies that provide information on at least three mammalian species of animal production, where at least two of them related to species farmed in the country concerned, one of them necessarily ruminant (ARGENTINA, 2005a; ENVIRONMENT CANADA, 1999). In relation to birds, regulations require at least two toxicity studies that provide information on at least two bird species of animal production, wherein at least one of them must be part of the production in the country. Preferably, the toxicological data used would be referent to chronic toxicity studies (ENVIRONMENT CANADA, 1999). When devoid of sufficient toxicological information provisional maximum values can be established. This alternative allows including the use of information on species not related to animal production and must have a minimum of data considered by the country for each animal species (ARGENTINA, 2005a). After obtaining the toxicological information, it is calculated for each animal species the tolerable daily intake rate (TDI) for the toxic parameter in question, in $mg\ kg^{-1}\ day^{-1}$ through the lowest-observed-adverse-effect-level (LOAEL), no-adverse-effect-level (NOAEL) and an uncertainty factor (UF) generally equal to 10, according to the following formula:

$$TDI = (LOAEL \times NOAEL)^{0.5} / UF$$

If the NOAEL value is unknown, it can be used the ratio NOAEL = LOAEL/5.6.This expression is derived from statistical evaluations conducted by Environment Canada on the ratio LOAEL/NOAEL for different animals exposed to a group of pesticides, and the value of 5.6 relates to the upper limit with a confidence interval of 95% (ARGENTINA, 2005a; ENVIRONMENT CANADA, 1999). In case of having only acute toxicity data, the value of NOAEL can be estimated by the 50 lethal dose (LD 50), acute/chronic toxicity rate (ACR) considered at 70 and the uncertainty factor (UF) (ARGENTINA, 2005a; ENVIRONMENT CANADA, 1999):

TDI= (LD 50/ACR) / UF

Thereafter, the reference concentration of the contaminant (RC) in mg L^{-1} for each species studied can be obtained by the formula described below, which considers the TDI, the body weight of the species (BW) in kg and daily water intake rate per individual of the species (WIR) in L day^{-1} (ARGENTINA, 2005a; ENVIRONMENT CANADA, 1999):

RC = (TDI x BW) / WIR

Once animals can be exposed to chemicals from other sources besides drinking water (inhalation, dermal absorption, feed, among others), the percentage contribution of the drinking water to animals as a source of exposure should be taken into account (ENVIRONMENT CANADA, 1999). Argentina, Australia and Canada usually adopt the value of 20%, at least if there is some evidence that this percentage is not suitable for livestock watering or for a particular substance (ANZECC, 2000; ARGENTINA, 2005a; ENVIRONMENT CANADA, 1999). In such cases, a specific evaluation should be conducted. These data are based on the contribution of drinking water for humans, since, to date, there are no data specific to animals (ENVIRONMENT CANADA, 1999). Thus, the maximum allowable value (MAV) was 20% of the reference concentration calculated as follows:

MAV = RC x 0.2

Comparison between water quality criteria from different countries / states for livestock watering

It was found the maximum allowable value specific for use in livestock watering in South Africa, Argentina, Australia/New Zealand, Canada, Chile, Ecuador, Peru and Venezuela and the U.S. states of Colorado and New Mexico. We also used the maximum concentrations suggested by the International Food and Agriculture Organization (FAO).

In Brazil, surface water and groundwater are used for livestock watering. Thus, both the CONAMA Resolution no. 357 (BRASIL, 2005) (which classifies national territory surface waters) and CONAMA Resolution no. 396 (BRASIL, 2008) (which classifies national territory groundwaters), even not prepared for this purpose, would be theoretically appropriate to compare the maximum values allowed for livestock watering with international laws (BRASIL, 2005, 2008). Resolution no. 357, which classified the surface water by use groups, i.e., the same class of water concurrently serves for various uses, including in the class 3 of freshwaters, the water used in livestock watering, among many other uses (human consumption with conventional or advanced treatment, irrigation tree crops, cereals and forages, recreational fishing and secondary contact recreation). Therefore, only the maximum values of this class were presented for comparison purposes, although not specific to the use for livestock watering (BRASIL, 2005). CONAMA Resolution no. 396, unlike the CONAMA Resolution no. 357, already has the maximum allowed values for the different uses of water in an individualized manner (BRASIL, 2005, 2008). However, watering values were based on values established by international agencies or organizations (BRASIL, 2008). Therefore, some discussions related to Brazilian regulations for multiple uses are not applied to individualized uses, since the values seem to have been obtained from the listed international standards.

The data used in Peru were related to class 3, and for Venezuela, criteria for Class 2B, which provide for the use of water both for animals watering and irrigation (PERU, 2008; VENEZUELA, 1995). The limit values used in South Africa, Argentina, Australia/New Zealand, Canada, Ecuador, FAO and the U.S. states of Colorado and New Mexico are only for the quality of water for livestock watering (ANZECC, 2000; ARGENTINA 2005b; ENVIRONMENTAL CANADA, 2006; EQUADOR, 2003; FAO, 1985; SOUTH AFRICAN, 1996; UNITED STATES, 2002).

In Chile the limit values for watering animals seem to be based on quality criteria established for human health (drinking water). Therefore these values were not used for comparison (CHILE, 1978, 2005).

Table 1 compiles the maximum values of the chemicals found in the literature, including the values of the Brazilian norm for multiple uses and individualized uses.

The maximum allowable values for chemicals varied among the different regulations studied for some substances, although almost being a consensus for others. A great variation was also observed when the Brazilian regulation of multiple uses was compared with CONAMA Resolution 396 (BRASIL, 2008), which presents the maximum values allowed for individualized use. Altogether 24 substances are considered by the two regulations, one consisting only by CONAMA 357 (BRASIL, 2005) (carbaryl) and 14 compounds only by CONAMA 396 (BRASIL, 2008).

Table 1. Maximmum allowed values for use in livestock watering.

Compound (CASnumber)	Maximum values in $\mu g\ L^{-1}$ (country or state)
Aldicarb (116-06-3)	1 (Peru); 11 (Aus/NZ, Bra_2, Can)
Aldrin (309-00-2)	0.03 (Peru)
Aluminum (7429-90-5)	200 (Bra_1); 1000 (Venezuela); 5000 (AS, Aus/NZ, Bra_2, Can, Eq, Peru, FAO, NovMex)
Arsenic (7440-38-2)	25 (Can); 33 (Bra_1); 50 (Ven); 67[(1)],195[(2)],67[(3)] (Arg); 100 (Peru); 200 (Bra_2, Col, Eq, FAO, NovMex); 500 (Aus/NZ); 1000 (AS)
Atrazine (1912-24-9)	2 (Bra_1); 5 (Can, Bra_2)
Barium (7440-39-3)	1000 (Eq, Ven)
Beryllium (7440-41-7)	100 (Bra_1, Bra_2, Can, Peru, FAO)
Boron (7440- 42 –8)	750 (Bra_1, Ven); 5000 (AS, Aus/NZ, Bra_2, Can, Eq, Peru, Col, FAO, Nov Mex)
Bromacil (314-40-9)	1100 (Can)
Bromoxynil (1689-84-5)	11 (Aus/NZ, Can)
Cadmium (7440-43-9)	5 (Venezuela); 10 (AS, Aus/NZ, Bra_1, Peru); 50 (Bra_2, Col, Eq, FAO, NovMex); 80 (Can); 140[(1)],80[(2)], 80[(3)](Arg)
Calcium (7440-70-2)	1000 (AS); 1000000 (Aus/NZ, Can)
Captan (133-06-2)	13 (Can)
Carbaryl (63-25-2)	70 (Bra_1); 1100 (Can)
Total carbamates	100 (Eq, Ven)
Carbofuran (1563-66-2)	45 (Aus/NZ, Bra_2, Can)
Lead (7439-92-1)	33 (Bra_1); 50 (Eq, Peru, Ven); 100 (AS, Aus/NZ, Bra_2, Can, Col, FAO, NovMex); 68[(1)], 110[(2)],68[(3)](Arg);
Cyanazine (21725-46-2)	10 (Aus/NZ, Can)
Cyanide (WAD)	100 (Peru)
Total cyanide	200 (Eq, Ven)
Chlordane (57-74-9)	0.3 (Peru)
Chlorides	1500000 (AS, Col)
Chloroform (67-66-3)	100 (Bra_2, Can)
Chlorothalonil (1897-45-6)	170 (Aus/NZ, Bra_2, Can)
Chlorpyrifos (2921-88-2)	24 (Bra_2, Can)
Cobalt (7440-48-4)	200 (Bra_1); 1000 (AS, Aus/NZ, Bra_2, Can, Peru, FAO, NovMex);
Total Copper	13 (Bra_1); 30[(1)],1520[(2)],30[(3)](Arg); 200 (Ven); 500 (AS, Aus/NZ, Bra_2, Eq, Peru, Col, FAO, NovMex); 500-5000 (Can)
Total Chromium	20 (Arg); 50 (Bra_1, Ven); 50[(4)],50[(5)](Can); 1000 (AS[(5)], Aus/NZ, Bra_2, Eq[(5)], Peru[(5)], Col, FAO, NovMex)
Deltamethrin (52918-63-5)	2.5 (Can)
Dibromochloromethane (124-48-1)	100 (Can)
Dicamba (1918-00-9)	122 (Aus/NZ, Can)
Diclofop-methyl (51338-27-3)	9 (Aus/NZ, Can)
Dichlorobromomethane (75-27-4)	100 (Can)
1,2- Dichloroethane (107-06-2)	5 (Bra_2, Can); 10 (Bra_1)
Dichloromethane (75-09-2)	50 (Bra_2, Can)
DDT (50-29-3)	1 (Peru)
Dieldrin (72-20-8)	0.7 (Peru)
Dimethoate (60-51-5)	3 (Aus/NZ, Can)
Ethylbenzene (100-41-4)	2.4 (Can)
Phenols	1 (Peru); 2 (Bra_2, Can); 10 (Bra_1)
Iron (7439-89-6)	1000 (Eq, Peru, Ven); 10000 (AS)
Fluoride (7681-49-4)	1400 (Bra_1); 1000-2000 (Can); 2000 (AS, Aus/NZ, Bra_2, Col, FAO, Peru)
Glyphosate (1071-83-6)	280 (Aus/NZ, Bra_1, Bra_2, Can)
Heptachlor and heptachlor epoxide	0.1 (Peru)
(2,4- dichlorophenoxyaceticacid and 2,4-D)	100 (Can)
Hexachlorobenzene (118-74-1)	0,52 (Bra_2, Can)
Lindane (58-89-9)	2 (Bra_1); 4 (Bra_2, Peru)
Linuron (330-55-2)	12 (Arg)
Lithium (7439-93-2)	2500 (Peru); 5000 (Eq, Ven)
Magnesium (7439-95-4)	150000 (Peru); 250000[(6)], 400000[(7)], 500000[(8)] (FAO); 500000 (AS)
Manganese (7439-96-5)	50 (Bra_2, FAO); 200 (Peru); 500 (Eq, Ven); 10000 (AS)
MCPA (2 methyl-4-chloro phenoxyaceticacid) (94-74-6)	25 (Can)
Mercury (7439-97-6)	1 (AS, Peru); 2 (Aus/NZ, Bra_1); 3 (Can); 10 (Bra_2, , Col, Eq, Ven, FAO, NovMex)
Metolachlor (51218-45-2)	50 (Bra_2, Can)
Metribuzin (21087-64-9)	80 (Can)
Molybdenum (7439-98-7)	5 (Eq, Ven); 10 (AS); 150 (Aus/NZ, Bra_2); 500 (Can)
Nitrate-N (14797-55-8)	10000 (Bra_1); 50 000 (Peru); 90000 (Bra_2); 90290[(9)] (Aus/NZ); 100000 (Col)
Nitrite-N (14797-65-0)	1000 (Bra_1, Eq, Peru); 9120[(9)] (Aus/NZ); 10000 (Bra_2, Can, Col, FAO)
Nitrate + Nitrite	10000 (AS, Eq); 100000 (Can, FAO)
Nickel (7440-02-0)	25 (Bra_1); 200 (Peru); 500 (Eq, Ven); 1000 (AS, Aus/NZ, Bra_2, Can); 200 (Eq, Ven)
Total organochlorine	100 (Eq, Ven)
Total organophosphate	7.5 (Peru)
Parathion (56-38-2)	
Picloram (1918-02-1)	190 (Can)
Silver (7440-22-4)	50 (Eq, Peru, Ven)
Selenium (7782-49-2)	10 (Eq, Ven); 20 (Aus/NZ); 50 (Bra_1, Bra_2, Can, Peru, FAO, NovMex); 50000 (AS)
Simazine (122-34-9)	10 (Aus/NZ, Bra_2, Can)
Sodium (7440-23-5)	2000000 (AS)

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Compound (CASnumber)	Maximum values in µg L^{-1} (country or state)
Sulfate	250000 (Bra_1); 500000 (Peru); 1000000 (AS, Aus/NZ, Bra_2, Can);
Total sulfide	50 (Peru)
Tebuthiuron (34014-18-1)	130 (Aus/NZ, Can)
Tetrachloromethane (56-23-5)	5 (Bra_2, Can)
Toluene (108-88-3)	24 (Bra_2, Can)
Triallate (2303-17-5)	230 (Aus/NZ, Can)
Tributyltin (56-35-9 oxide)	250 (Can)
Tribromomethane (75-25-2)	100 (Can)
Tricyclohexyltin (13121-70-5)	250 (Can)
1,1,2 - Trichlorethylene, TCE (79-01-6)	50 (Bra_2, Can)
Trifeniltin (76-87-9)	820 (Can)
Trifluralin (1582-09-8)	45 (Aus/NZ, Bra_2, Can)
Tritium (10028-17-8)	20000 (NovMex)
Uranium (7440-61-1)	20 (Bra_1); 200 (Aus/NZ, Bra_2, Can);
Vanadium (7440-62-2)	100 (Bra_1, Bra_2, Can, FAO, NovMex); 1000 (AS); 10000 (Eq, Ven)
Zinc (7440-66-6)	5000 (Bra_1, Ven); 20000 (AS, Aus/NZ); 24000 (Bra_2, Peru, FAO); 25000 (Eq, Col, NovMex); 50000 (Can);

[1]Unfiltered water, for mammals; [2]unfiltered water, for birds; [3]unfiltered water, applicable to mammals and birds; [4]chromium III; [5] chromium VI; [6]birds, pigs, horses, dairy cows, and sheeps with lambs; [7]beefcattle; [8]adult rams treated with dry feed; [9]values for nitrate and nitrite of Aus/NZ were converted into nitrate-N and nitrite-N according to the relationship suggested by the Aus/NZ: 1 mg L^{-1} nitrate-N = 4.43 mg L^{-1} nitrate and 1 mg L^{-1} nitrite-N = 3.29 mg L^{-1} nitrite.Arg: Argentina, AS: South Africa, Aus/NZ: Australia / New Zealand; Bra_1: Brazil-CONAMA 357; Bra_2: Brazil-CONAMA 396; Can: Canada, Col: Colorado, Eq: Ecuador, FAO: Food and Agriculture Organization; Nov Mex: New Mexico; Ven: Venezuela.

The difference in relation to controlled substances is understandable since every day new environmental contaminants are discovered and different compounds are prioritized. Furthermore, the occurrence of substances varies between surface and ground waters. For example, volatile substances can be easily found in groundwater, especially in areas under intense human activity, which no longer occurs in surface waters, by their intense contact with the atmosphere, leading to their evaporation. On the other hand, substances that can be found in surface waters may not be routinely present in groundwater due to adsorption on the ground.

With regard to the comparison between Brazilian rules, among the 24 substances, which were regulated by both, the maximum allowed value was the same only for beryllium, glyphosate, selenium and vanadium. For the remaining compounds, it was observed differences of up to 40 times. The maximum values allowed for a given substance are independent from the origin of the water, since in most cases they are based on toxicity data. An exception could only be made to regulations that set quality criteria based on occurrence, as is the case of FAO. The contradiction between the maximum values allowed for the same substances between these two regulations existing in Brazil can cause conflicts, misinterpretation and mismanagement of water resources.

Since the Brazilian regulation of multiple uses is arranged to accommodate different uses in the same quality class, the maximum allowed values are quite different from those adopted for the specific use for livestock watering in other countries/states. Many limit values in Class 3 are related to the use for human supply or other water uses, but not for livestock watering. Thus, in most cases, the maximum concentration legislated in the country is more restrictive than the regulations of other countries/states, except only for 1,2 dichloroethane and phenols (Table 1). Accordingly, using the maximum allowed values presented in this norm as a quality requirement for individual uses can be a great mistake, leading to often unnecessary restrictions. Using the lowest value, it is possible to prevent the use of a specific type of water, when it could be used for a purpose whose maximum allowable value is not as low. Certainly, the resolution by individualized uses (BRASIL, 2008) represents a major breakthrough in Brazilian regulations regarding water quality criteria for different uses and the number of substances legislated, allowing better use of water resources.

Regarding the comparison between the Brazilian and international standards, there is no compound regulated by Brazil that has not been legislated by other countries/states, because so far, Brazil seems to not have its own water quality criteria for livestock watering. This is alarming, since monitoring the concentration of some substances may not be relevant for some countries, but may be crucial to another. Additionally, countries may differ in relation to climate, type of water, soil, analytical and treatment technologies, which will certainly influence the variables considered for the determination of water quality criteria (UMBUZEIRO et al, 2011). Of the 86 controlled substances by various countries/states, only 25 are included in the Brazilian regulation for multiple uses (BRASIL, 2005), while 39 are present in the national norm for individualized uses (BRASIL, 2008). This can be explained by the grouping in the same class of maximum values for multiple uses in the current regulation in the country, not specific to the use of water for animals and/or due to the regional importance of these compounds for each country or state. Among the 25 substances in the Brazilian regulation of multiple uses, 15 have values that differ completely from other regulations evaluated, i.e., Brazil is the only country/state regulating a certain value. A comparison with the regulation of individualized uses (CONAMA Resolution 396, BRAZIL, 2008) was performed in an attempt to estimate from which water use the maximum value allowed for these 15 compounds could be obtained. For atrazine, lindane and sulfate, the values seem to have been based on human consumption (drinking water). For aluminum, 1,2-dichloroethane and nitrate-N values may have come from the human consumption and recreation. For the remaining compounds (nine substances, including lead and total copper) the maximum allowed values were not found in the regulation of individualized uses. As there are no official reports of how the values in Class 3 of CONAMA 357 were chosen, it is not possible to estimate the source of these values for the nine compounds.

The Canadian regulation has the largest number of chemicals legislated for water use in livestock watering among those evaluated in this study. Altogether there are 61 compounds, of which 14 substances are regulated only by Canada, which include organic compounds and pesticides.

Among the surveyed laws, Peru is the second country/state with the highest number of substances controlled only by this country. Considering the legislated 10 substances, six are pesticides aldrin, DDT, dieldrin, endosulfan, endrin, and parathion.

Some trends were observed in the choice of water quality criteria for watering animals. Of the 22 substances legislated by both Ecuador and Venezuela, 15 have the same maximum value allowed, and criteria for organochlorine, organophosphate and carbamate were only established by these two countries. The same was observed for Australia/New Zealand and Canada. Within the 32 compounds regulated by these countries, 22 have the same maximum values allowed; eight legislated only by these countries (all pesticides). With the exception of zinc, all substances regulated by the Colorado and New Mexico seem to have followed FAO recommendations.

The maximum allowable values, specifically for use for watering animals, of aluminum (5,000 μg L^{-1}), boron (5,000 μg L^{-1}), cobalt (1,000 μg L^{-1}) and chromium (1,000 μg L^{-1}) appear to be almost a global consensus. However, for other compounds these values can vary considerably. Substances with the greatest variance between the values regulated by different legislations were arsenic, cadmium, lead, copper, nitrate and zinc (Figure 1). This fact is interesting since there is abundant toxicological information available for these types of substances (WHO, 1981, 1992, 1995, 1997, 1998, 2001). Nevertheless, the existence of a large number of toxicological information allows for divergent choices by different countries/states. Therefore, the variability in the water quality criteria for livestock watering for these compounds may be related to differences in the toxicological data used, including different conditions of exposure, differences in sensitivity between species (data selection in different animal species), measured endpoints, life stage, duration of study, among other factors (ENVIRONMENT CANADA, 1999). Figure 1 illustrates the difference between the maximum allowed values which varied between the legislation examined.

Only four compounds are regulated by all countries/states/organizations surveyed in this study. Some are regulated only by a single country. This is probably because regulations on quality criteria are based on specific scenarios or needs of each country/state. Thus, some substances may be important for some regions and not to others. Furthermore, differences were also observed in the approach of the water quality criteria for animals supply. The values reported by FAO were collected by the National Academy of Science (1972 and 1974) on inorganic compounds, whose values were based on the amount of these substances usually found in usable surface and ground waters and do not necessarily reflect the tolerance of animals to these compounds (FAO, 1985). Therefore, for the states of Colorado and New Mexico, the maximum values should also have been based on occurrence.

Peru reports that the establishment of its quality criteria was based on documents of FAO, WHO, Canada, Paraguay and Honduras for irrigation and on norms established by Ecuador, Venezuela (cited in this paper) (PERU, 2010). Thus, the values for class 3, which includes use for livestock watering, have its own values for livestock watering, but also values for irrigation, which also occurs in Venezuela.

In a pioneer way in Latin America, Argentina establishes its own list of priority substances and their calculation algorithms for different water uses, considering the country characteristics and needs. Importantly, the country maintains a permanent group to monitor the literature and review the values adopted (UMBUZEIRO et al., 2011).

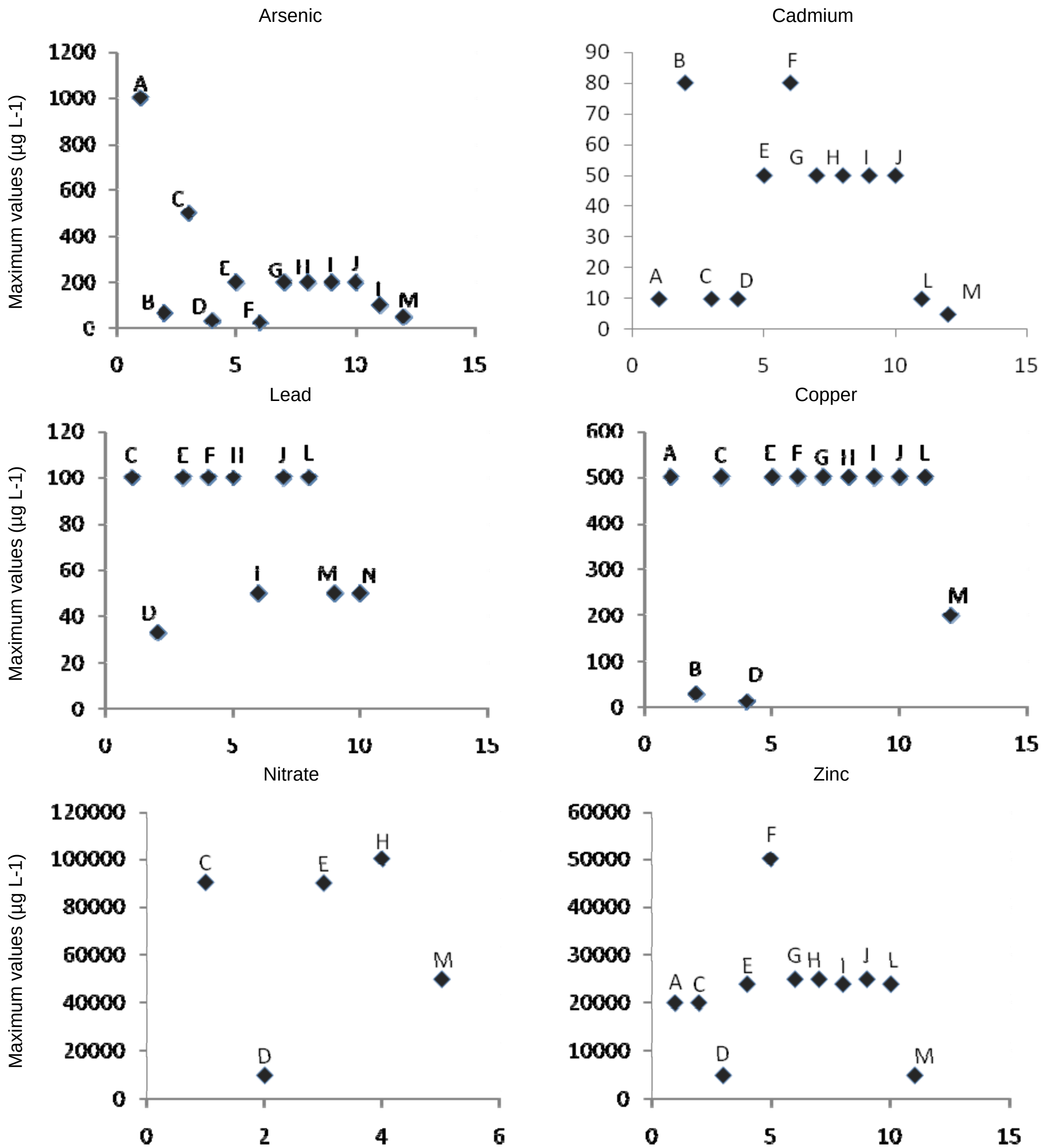

Figure 1. Comparison of the maximum allowed values of substances with greater variation in such values for watering animals in the different regulations.(**A**) South Africa, (**B**) Argentina, (**C**) Australia/New Zealand, (**D**) Brazil 1, (**E**) Brazil 2, (**F**) Canada, (**G**) Colorado, (**H**) Ecuador, (**I**) FAO, (**J**) New Mexico, (**L**) Peru and (**M**) Venezuela.

In the absence of adequate information to specifically establish quality criteria for livestock watering in relation to pesticides and other organic compounds, Australia and New Zealand recommend using the quality criteria established for human health (drinking water). Due to the large amount of substances present in the regulation for water potability and by not dealing with water quality criteria specific for livestock watering, these values were not used for comparison. In addition, Australia and New Zealand report that further information to certain pesticides may be obtained on protocols developed by Canada, which used data mainly from animal toxicology studies and provide a table containing the maximum values allowed in this country to the animals drinking water for aldicarb, bromoxynil, carbofuran, cyanazine, chlorothalonil, dicamba, diclofop-methyl, dimethoate, dinoseb, glyphosate, simazine, tebuthiuron, triallate and trifluralin (ANZECC, 2000). Therefore, for the pesticides mentioned, the values in Table 1 for Australia and New Zealand were obtained from

Canada. This explains the trend observed between these countries in establishing the same maximum values allowed for many compounds.

Canada points out that when establishing provisionally quality criteria, it can be used the quality criteria for drinking water (potable) until a detailed assessment is completed for each priority substance. Canada still makes restrictions for the use of species body weight (BW) and the daily water intake rate (WIR) per individual for the establishment of the reference concentration of the contaminant (RC). The value of BW and WIR for each animal species should be used to derive the RC when a minimum amount of data is obtained for setting definitive maximum allowable values. However, if only provisional values can be established, the most conservative BW/WIR ratio should be used, regardless of which animal species is more sensitive to the compound in question (ENVIRONMENTAL CANADA, 1999).

Finally, and importantly, the water intake rate per individual (WIR), used to calculate the reference concentration of the contaminant (RC), is influenced by several factors, such as climatic conditions of the region (temperature and humidity), temperature of water supplied to the animal, the animal species and breed, the type of diet consumed by the animals (content of sodium, fiber and protein, when elevated increases the amount of water intake), the growth stage of the animal (age), the characteristic ruminant or monogastric, and type of production to which animals are associated (ANZECC, 2000; RAISBECK et al., 2008). For example, the water intake supplied to animals for slaughter is usually lower than water intake by dairy cows (ANZECC, 2000). A lactating beef cow requires almost twice more water (64 L, approximately 16% of body weight) per day than the same non-lactating cow (32.9 L, 9% of body weight) in the same temperature of 21°C. On the other hand, a dairy cow with high milk production, of similar size, needs 90 L (20% of body weight) under the same conditions. At 32°C, however, this same animal would consume an amount of water equivalent to 40% body weight (RAISBECK et al., 2008). Thus, the variations found in the maximum allowed values of different regulations may also have originated from these variables, including the economic activities in each country/state. This confirms the need for specific water quality criteria for livestock watering according to each country/region, encompassing the scenario and the reality of each.

The information obtained from Australia/New Zealand warned about an important issue, namely, the lack of toxicity data of pesticides on animal species relevant for livestock watering. This fact is surprising, because it is precisely in agricultural regions these compounds are used, often in a widespread and diverse way.

Few countries have criteria for the quality of water intended for livestock watering regarding pesticides. However, the agricultural activity is the basis of the Brazilian economy. ANVISA registered about 375 active ingredients that can be employed in the various Brazilian crops. The drinkability guide for chemical substances published by the Public Health Technical Chamber of *Brazilian Association of Sanitary and Environmental Engineering* (ABES) selected a list of priority compounds for the State of São Paulo based on usage and occurrence (UMBUZEIRO et al., 2012). They are 48 priority pesticides and only five of these compounds have maximum values set by different countries/states for livestock watering. These data reinforce the need for further toxicity studies in relevant animal species with priority pesticides for Brazil. Although, the importance of regulations that control the levels of pesticides in the environment is clear, the Brazilian regulation is still deficient in their water quality criteria for these compounds. In establishing these criteria are not considered the peculiar characteristics of the national agriculture, as well as the variety of pesticides used in the different regions of the country, once these values are based on the criteria of regulatory agencies and international organizations. The choice of pesticides that will be legislated must be made according to the characteristics and needs of each country or region, as the use of certain compounds may be permitted in some countries and banned or not performed in other.

Conclusion

The maximum allowable values for chemicals in water used in livestock watering are generally derived from toxicological data in relation to animal species that integrate livestock production of each scenario and region, of body weight of the species, daily water intake rate per individual and an uncertainty factor. Several factors, such as climatic variations, type of feed, species, breed, growth stage of the animal, among others, may also interfere with the water consumption, and hence change the value of the reference concentration. A vast number of chemicals have no maximum values set for the use of water for livestock watering, including pesticides, which reinforces the need for further studies in this area in order to obtain maximum safe levels. Furthermore, our results suggest the need to improve the Brazilian norm, with respect to water quality criteria for livestock watering, allowing better management of water resources and considering the socio-economic aspects and national reality. Studies are needed to obtain toxicity data of the most relevant substances in our environment (priority compounds) against the animal species of importance in relation to the activities to which they are linked to, for the establishment of maximum limits that ensure protection of animal health and economic activities of the country.

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