Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2018, 8(3), 71–74

ORIGINAL ARTICLE

Minerals composition of wells water and their contribution to mineral nutrition in dairy cattle: A possible approach in reducing soil salinity by reducing mineral content in manure

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Received: 26.05.2018. Accepted: 29.05.2018

Drinking water plays an essential role in farm animals through marinating unlimited biological functions within animal body. From nutritional perspective, mineral content of drinking water is not counted when formulating dairy cattle diets. No information on the contribution of drinking water to the mineral nutrition of dairy cattle has been reported in Karak governorate. This work aimed to investigate minerals contribution of wells water in Karak governorate in the relation to nutritional requirements in dairy cattle. Furthermore, this work will give insight to possible approach in reducing soil salinity through reducing macro-mineral supplementation to dairy cattle when its manure used for fertilization in Karak ecosystem. Nine samples of wells water (three replicates) were obtained from Karak governorate and were analyzed for their cation (Sodium (Na), Potassium (K) and Calcium (Ca)) and anions (Chlorine (Cl)) concentrations. In this study, both Ca and K content were not enough to make a significant contribution to dairy cattle nutrition at different production stages. The highest contribution of different water sources to daily Ca and K requirements by dairy cattle were 4.50 and 4.52%, respectively. However, the lowest contribution of water to daily Ca and K requirements by dairy cattle were 4.10 and 0.03%, respectively. On the other hand, both Na and Cl content were relatively sufficient to make a significant contribution to dairy cattle nutrition at different production stages. The highest contribution of water to daily Na and Cl requirements were 33.56 and 43.78%, respectively. However, the lowest contribution of water to daily Na and Cl requirements were 3.67 and 7.48%, respectively. It can be concluded from this study that some water drinking sources in Karak governorate can provide a significant contribution in dairy cattle nutrition at different production stages and can minimize feed formulation cost when mineral content in drinking water is counted in feed formulation. Furthermore, counting wells water contribution of minerals in formulated dairy diets can minimize minerals excretion in manure and could be an approach to reduce soil salinity in Karak ecosystem when their manures are used as fertilizers.
Keywords: Drinking water, minerals, soil, salinity, fertilizers

Introduction

Minerals play a vital function in animal body and must be supplied in animal diets on daily basis to maintain body function and production (National Research Council, 2001). Importance of minerals supplementation in animal diets comes from the fact that animal body can not synthesis minerals. Nutritionists relay on feed ingredient and feed premixes to provide animals with needed minerals in order to maintain performance. Availability of minerals from feed ingredients after digestion is not complete due to several factors including animal age, feed processing and presence of anti nutritional factors. From financial perspective, minerals enrichment in animal diet has been reported to be associated with increase in feed cost. Drinking water has been reported to contain minerals and has a vital function in providing animals with minerals (Soder, 1972; Manera et al., 2016). The water requirement per unit of body mass of dairy cattle is greater than that of any other mammal (Beede, 2006). A mature dairy cattle has been reported to consume approximately 4.5 pounds of water for every pound of dry matter intake (Aseltine, 1992). Minerals present in water available in free form and are directly/completely absorbed by animal's body. However, contribution of water as a mineral source in animal diet has been overlooked. Ignoring minerals composition in drinking water may results in supplying dairy cattle more minerals than its own requirements. Consequently, surplus minerals execration in urine and feces (manure) are expected. Long term using of animals manure has been reported to increase soil salinity (Azeez & Averbeke, 2012) and to cause environmental problems in many countries. The objective of this study was to quantify the contribution of drinking water to dairy cattle at different production stages. This work will give insight to possible approach in reducing soil salinity through reducing feed source macro-mineral supplementation to dairy cattle when its manure used for fertilization in Karak ecosystem.

Materials and methods

Water sampling and mineral analysis

Nine water samples were gathered from wells distributed in Karak Governorate as shown in Appendix 1. The mineral composition of all water samples was determined at the Department of Chemistry-Faculty of Science at Mutah University. The concentration of Sodium (Na), Potassium (K), and Calcium (Ca) were determined by using flame photometry (Microprocessor Flam Photometer Model (FP902-5) PG Instruments limited, UK). The concentration of Chlorine (Cl) was determined by using Ion Chromatography (DX-100 Ion Chromatograph, Dionex Corp, USA). The concentration of both cations and anions in the water were measured in triplicate.

Results and discussion

Macromineral contribution of drinking water

Concentration range of Ca, K, Na and Cl in collected water samples ranged from 27-73, 1-73, 23-104, and 65-178 ppm, respectively (Data are not shown). Minimum and maximum concentration of measured minerals were taken to evaluate the lowest and highest contribution of each measured mineral in dairy nutrition. Dairy cattle have different macro-minerals requirements at different production stages/levels; dairy cattle require more minerals during lactation compared to cattle during dry period (National Research Council, 2001) (Table 1). The most important factors that affect intake level of free drinking water in ruminants are: dry matter intake, composition of the diet, milk production, temperature and humidity (Ensley, 2000). Estimated free drinking water intake for dairy cattle during lactation (Dahlborn et al., 1998) and pregnancy date (Holter and Urban 1992) are shown in table 1. In this study, Ca and K content of water content was not enough to make a significant contribution to dairy cattle nutrition at different production stages. Assuming daily water consumption at different production stages shown in Table 1, the highest contribution of different water sources to daily Ca and K requirements were 4.50 and 4.52%, respectively (Table 1). However, the lowest contribution of water to daily Ca and K requirements were 4.10 and 0.03%, respectively. On the other hand, Na and Cl content of water content were relatively sufficient to make a significant contribution to dairy cattle nutrition at different production stages. The highest contribution of water to daily Na and Cl requirements were 33.56 and 43.78%, respectively. However, the lowest contribution of water to daily Na and Cl requirements were 3.67 and 7.48%, respectively. Mineral bioavailability in each water source has been reported to be important information to validate actual potential to supply minerals for animals (Manera et al., 2016). It is very important to mention that specific minerals ratio in drinking water should not be overlooked. Elevated mineral levels tend to result in chronic conditions of poor performance or increased health problems (National Research Council, 2005). Rumen pH has been reported to be significantly influenced (decline in pH) by saline water (Attia-Ismail et al., 2008). Change in rumen pH is known to largely influence rumen microflora. For example, drinking water with a negative strong ion difference when introduced to dairy cow consuming huge quantities of fermentable carbohydrates (associated with accumulation of the anionic VFA) may change the bacterial fermentation inside rumen negatively (Elord, 2014).

A possible approach in reducing soil salinity by reducing mineral content in manure

It would be expected that applying manures obtained from dairy cattle that fed diets formulated with ignoring.

Table 1. Estimates of feed intake (kg/day), free water intake (kg/day), daily macro-mineral requirement (g/day) and daily drinking-water mineral contribution (represented as g/day and as % of daily requirement) for dairy cattle at different production stages/levels.

Estimates	Stage of production					
	Milk production Level (Kg)[a]			Day of pregnancy[b] (Day)		
	25	35	45	240	270	279
-Feed intake [a]	20.3	23.6	26.9	14.4	13.7	10.1
-Water intake [b,c]	74.16 [b]	80.56 [b]	86.96[b]	46.31[c]	44.03[c]	38.27[c]
Macro mineral Ca requirement [a]	125.87	143.96	166.78	89.28	84.94	62.62
-Minimal Ca contribution	2.00 (1.59%)	2.17 (1.48%)	2.34 (1.40%)	1.24 (1.40%)	1.18 (1.40%)	1.03 (1.65%)
-Maximum Ca contribution	5.44 (4.33%)	5.91 (4.04%)	6.38 (3.83%)	3.40 (3.81%)	3.23 (3.81%)	2.81 (4.5%)
K requirement [a]	203	245.44	285.14	73.44	71.24	62.62
-Minimal K contribution	2.00 (0.99%)	0.08 (0.03%)	0.09 (0.03%)	0.05 (0.06%)	0.04 (0.06%)	0.04 (0.06%)
-Maximum K contribution	5.43 (2.67%)	5.89 (2.4%)	6.36 (2.23%)	3.38 (4.61%)	3.22 (4.52%)	2.80 (4.47%)

Na requirement [a]	44.66	54.28	59.18	14.40	13.70	14.14
-Minimal Na contribution	1.68 (3.67%)	1.82 (3.37%)	1.97 (3.33%)	1.05 (7.3%)	0.99 (7.29%)	0.86 (6.14%)
-Maximum Na contribution	7.73 (17.32%)	8.40 (15.48%)	9.07 (15.33%)	4.83 (33.56%)	4.59 (33.53%)	3.99 (28.23%)
Cl requirement [a]	48.72	61.36	75.32	18.72	20.55	48.48
-Minimal Cl contribution	4.80 (9.85%)	5.21 (8.5%)	5.63 (7.48%)	3.00 (16.02%)	2.85 (13.87%)	2.47 (12.27%)
-Maximum Cl contribution	13.12 (26.93%)	14.25 (23.23%)	15.38 (20.43%)	8.19 (43.78%)	7.79 (37.91%)	6.77 (33.52%)

aFeed intake (Kg/day) and mineral requirements were obtained from (NRC, 2001)
bestimated free water intake (FWI) for low (25 kg/day), medium (30 kg/day) and high (35 kg/day) milk producing cow. The following equation were used to estimated FWI assuming DM%=88%. FWI=14.3+(1.28 * milk, kg/d)+(0.32 * DM% of diet) (Dahlborn et al., 1998).
cThe following equation were used to estimated Free water intake (FWI) in pregnant cows assuming DM% =88% and protein content (9.9%, 10.8, and 12.4) at different pregnancy day (240, 270 and 297 day, respectively). FWI (kg/d)=-10.34+(0.2296 * DM% of diet)+(2.212 * DMI kg/d)+0.03944 * $(CP\% \text{ of diet})^2$ (Holter & Urban 1992).

mineral contribution from drinking water may have consequence on soil sustainability for growing and soil salinity. Based on above results, it would be expected that manure obtained from dairy cattle consumed rich cation-water may increase soil salinity and nitrogen volatilization. Adding animal manures to soil has been reported to increase soil salinity (Mufwanzala & Dikinya, 2010; Azeez & Averbeke, 2012). Thus, reducing minerals content in manure would be a possible approach to reduce soil salinity if reduced mineral-manure is added to the soil. Recent study showed relatively high electrical conductivity measurement in soil at certain locations in Karak Governorate (Ghor Al-Safi) and this was partially attributed to organic fertilizers applications (Al-Dalain et al., 2018). Karak governorate is situated in the southern part of Jordan has mainly calcareous soils. Calcareous soils is characterized by having alkaline nature due to the presence of cations (mainly Ca). Calcareous soil is well known to affect negatively mineral availability to plants after adding fertilizers. Farmers in Karak usually apply fertilizers as organic and N fertilizers (mainly as ammonium compounds). Applying nitrogen in ammonium compounds to calcareous soils will cause high proportion of the N to be volatilized as NH_3, consequently, reduces its availability to plants (Martha et al., 2004; Campana et al., 2015).

Conclusion

It can be concluded from this study that some water drinking sources in Karak governorate can provide a significant contribution in dairy cattle nutrition at different production stages and can minimize feed formulation cost when mineral content in drinking water is counted in feed formulation. Furthermore, counting wells water contribution of minerals in formulated dairy diets can minimize minerals excretion in manure and could be an approach to reduce soil salinity in Karak ecosystem when their manures are used as fertilizers.

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Citation:
Al-Nawaiseh, M., Al-Rabadi, G. (2018). Minerals composition of wells water and their contribution to mineral nutrition in dairy cattle: A possible approach in reducing soil salinity by reducing mineral content in manure. Ukrainian Journal of Ecology, 8(3), 71-74.
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