WATER AS A SOURCE OF MINERALS FOR GRAZING RUMINANTS IN KWENENG WEST OF BOTSWANA

EL AGUA COMO FUENTE DE MINERALES PARA LOS RUMIANTES EN PASTOREO EN KWENENG OESTE, BOSTWANA

Aganga, A.A., C.M. Tsopito and K. More

Department of Animal Science and Production. Botswana College of Agriculture. Private Bag 0027. Gaborone. Botswana.

ADDITIONAL KEYWORDS

Total dissolved solids, NO_3^-, F.

PALABRAS CLAVE ADICIONALES

Sólidos totales disueltos. NO_3^-, F.

SUMMARY

From October 1995 to February 1996 (part of the dry season months), water samples from five randomly selected boreholes found in Kweneng West were analyzed for $S0_4^-$, CO_3H^-, Cl, $NO3^-$, F, Ca, Mg, Na, K, and Fe. Its concentrations varied from borehole to borehole as well as from month to month and were below the toxic concentration. Grazing livestock obtains appreciable amounts of evaluated minerals from their drinking water to meet part of their mineral requirements. The groundwater were of acceptable quality based on total dissolved solids and concentration of nitrates and fluoride.

RESUMEN

Desde octubre a febrero (estación seca) de 1995-6 se muestreó el agua de 5 pozos seleccionados al azar en Kweneng oeste (Botswana). La concentración, siempre por debajo de niveles tóxicos, de minerales analizados ($S0_4^-$, CO_3H^-, Cl, NO_3^-, F, Ca, Mg, Na, K, Fe) varió de un pozo a otro y de un mes a otro pero, en cualquier caso, supone un aporte sustancial de minerales a la dieta. Teniendo en cuenta los sólidos totales disueltos y las concentraciones de nitratos y fluoruros el agua puede considerarse de aceptable calidad.

INTRODUCTION

Chemical composition of water varies depending on its source: that is, either surface water (lake, ponds, streams, rivers and springs) or groundwater. Water is an important nutrient for livestock which constitute 65-85 p.cent the animal body weight at birth and 45-60 p.cent of the body weight at maturity. Water is a natural source of minerals for livestock. Aganga (1993) stated that the presence of adequate water in body tissues is an essential prerequisite for the normal maintenance of life, and water is a fundamental constituent of all living cells. The significance of water in ruminant livestock production was reviewed by Aganga *et. al.* (1986) who pointed out that the body water of ruminant animals is not fresh

Table I. *Average chemical constituents (in mg/l) of groundwater collected from five randomly selected boreholes in Kweneng West of Botswana.* (Componentes químicos (mg/l) medios del agua obtenida en cinco pozos seleccionados al azar en Kweneng oeste (Botswana).

	BH1	BH2	BH3	BH4	BH5
HCO_3^-	$130.58^{a}\pm45.94$	$443.18^{d}\pm72.33$	$246.81^{b}\pm60.30$	$351.38^{c}\pm49.04$	$297.30^{bc}\pm57.67$
SO_4^{-}	$8.91^{a}\pm1.74$	$12.87^{a}\pm4.21$	$12.01^{a}\pm1.41$	$62.31^{b}\pm1.69$	$137.53^{c}\pm7.67$
$C1^-$	$72.74^{a}\pm37.46$	$44.60^{a}\pm24.88$	$36.35^{a}\pm20.63$	$239.83^{c}\pm57.96$	$141.82^{b}\pm41.15$
NO_3^-	$0.12^{a}\pm0.05$	$0.94^{b}\pm0.51$	$0.34^{a}\pm0.47$	$0.95^{b}\pm0.73$	$0.47^{a}\pm0.14$
F	$0.34^{a}\pm0.04$	$1.07^{c}\pm0.27$	$0.55^{a}\pm0.34$	$0.79^{b}\pm0.26$	$0.45^{a}\pm0.25$
Ca^{++}	$54.45^{bc}\pm5.02$	$33.81^{ba}\pm15.87$	$21.83^{a}\pm13.15$	$49.45^{b}\pm25.03$	$73.50^{c}\pm54.22$
Mg^{++}	$13.40^{a}\pm6.68$	$36.63^{bc}\pm4.75$	$28.52^{b}\pm5.92$	$43.77^{c}\pm6.37$	$38.69^{c}\pm6.95$
Na^+	$21.12^{a}\pm0.75$	$132.35^{c}\pm1.45$	$85.72^{b}\pm16.65$	$184.10^{d}\pm9.81$	$82.01^{b}\pm8.86$
K^+	$5.03^{a}\pm1.09$	$34.93^{b}\pm3.22$	$11.66^{a}\pm6.06$	$8.43^{a}\pm2.28$	$5.41^{a}\pm2.46$
Fe^{++}	$0.45^{b}\pm0.04$	$0.07^{a}\pm0.02$	$0.36^{b}\pm0.03$	$0.05^{a}\pm0.02$	$0.07^{a}\pm0.03$
pH	$8.06^{a}\pm0.02$	$8.14^{b}\pm0.01$	$8.57^{c}\pm0.03$	$8.06^{a}\pm0.05$	$7.64^{a}\pm0.01$

BH=Borehole

[a, b, c, d]Means in the same row not having common letters differ significantly ($p<0.05$)

water since it contains salts in solution, and the salts inside and outside the cells are different in character. Minerals present in water are essential for animal growth, but there is a certain tolerable level above which the mineral elements and substances become toxic to the animal resulting in loss of weight and sometimes death if the concentration is too high. The level of toxicity of these elements and substances vary depending on the form they are in, that is in solution or in solid form.

Botswana has a semi-arid to arid climate which is characterised by annual rainfall of less than 250 mm and extreme temperatures. The arid climate is mainly experienced in the western region of the country. The implication of this is that most of the water if not all that is used in the western region of the country is mainly obtained from boreholes. There is paucity of information on groundwater quality for those boreholes used to provide drinking water to livestock. The objectives of this study therefore are to evaluate chemical composition of groundwater used by livestock and to investigate variations in the concentration of minerals found in the sampled groundwater.

MATERIALS AND METHODS

Five boreholes in Kweneng West of Botswana were randomly selected. The selected boreholes were located within 201 km from each other. The statistical design of the study was a split plot, where the five boreholes were the main plots, the five months of sampling were the sub plots and there were four replications. The study was conducted from October 1995 to February 1996. Before samples

***Table II.** Cations constituents (mg/l) of groundwater collected from five randomly selected boreholes in Kweneng West of Botswana over a five months period.* (Componentes catiónicos (mg/l) del agua recogida de cinco pozos seleccionados al azar en Kweneng oeste (Botswana) durante un periodo de cinco meses).

		Sampling period (months)				
	Boreholes	October	November	December	January	February
Ca^{++}	1	55.97±3.76[ab]	52.69±6.88[a]	49.13±0.18[a]	53.16±0.68[a]	61.29±0.52[b]
	2	13.40±0.52[a]	44.45±470[b]	47.27±0.29[b]	53.58±0.75[b]	46.17±0.30[b]
	3	16.12±0.02[b]	12.35±0.11[a]	15.60±0.13[b]	46.39±0.82[d]	18.90±1.01[c]
	4	15.99±0.18[a]	40.67±0.13[b]	75.91±0.23[c]	48.65±0.25[b]	72.75±0.64[c]
	5	42.00±0.16[c]	33.23±0.76[b]	21.25±0.91[a]	129.64±0.68[d]	141.35±0.35[a]
Mg^{++}						
	1	15.19±0.73[b]	14.63±0.95[b]	13.20±0.01[a]	12.86±0.12[a]	20.40±0.74[c]
	2	41.71±0.76[b]	51.11±0.51[c]	42.23±0.38[b]	28.26±0.30[a]	70.50±0.19[d]
	3	10.75±0.19[a]	42.52±0.87[b]	40.96±0.20[b]	38. 93±0.08[b]	79.40±0.89[c]
	4	50.00±0.24[b]	37.53±0.19[a]	36.65±0.42[a]	44.47±0.21[b]	99.00±0.98[c]
	5	36.31±0.13[a]	36.91±0.17[a]	51.56±0.61[c]	35.06±0.15[a]	44.29±0.36[b]
Na^{+}						
	1	20.55±0.64[b]	22.00±0.70[b]	21.06±0.09[b]	21.57±0.63[b]	14.50±0.52[a]
	2	115.55±0.46[c]	229.55±0.64[d]	108.70±1.00[c]	32.17±0.05[a]	41.34±0.18[b]
	3	79.65±0.25[b]	116.75±0 76[c]	74.62±0.40[b]	78.18±1.00[b]	13.40±0.26[b]
	4	222.15±0.14[b]	229.75±0.85[b]	199.10±0.25[b]	210.57±0.05[b]	95.10±0.15[a]
	5	59.80±0.65[b]	57.60±0.14[b]	84.28±0.61[c]	64.09±0.46[b]	44.82±0.36[a]
K^{+}						
	1	4.40±0.14	6.96±0.01	3.96±0.06	4.88±0.22	5.10±0.19
	2	40.65±0.50[c]	29.89±0.12[b]	40.88±0.20[c]	16.45±1.00[a]	15.27±0.18[a]
	3	23.91±0.24[a]	42.13±0.19[c]	24.09±0.10[a]	24.18±0.17[a]	30.10±0.17[b]
	4	9.84±0.17[c]	7.97±0.18[b]	4.40±0.03[a]	9.95±0.01[c]	9.13±0.28[c]
	5	59.80±0.65[b]	57.60±0.14[b]	84.28±0.61[c]	44.09±0.46[a]	44.82±0.36[a]
Fe^{++}						
	1	0.19±0.02[a]	0.07±0.03[a]	1.09±0.04[b]	0.78±0.02[b]	0.10±0.01[a]
	2	0.03±0.01[a]	0.02±0.01[a]	0.65±0.12[c]	0.82±0.19[c]	0.14±0.01[b]
	3	0.06±0.01[b]	0.03±0.001[a]	0.07±0.02[b]	0.77±0.08[d]	0.30±0.04[c]
	4	0.04±0.01[b]	0.08±0.02[c]	0.04±0.03[b]	0.11±0.02[c]	0.01±0.003[a]
	5	0.03±0.02[a]	0.04±0.01[a]	0.05±0.01[a]	0.18±0.03[b]	0.30±0.08[c]

[abcde]Means in the same row not having common letters differ significantly ($p<0.05$)

were collected water was left to pump for 10 minutes to remove water which was already in the pipes. In the laboratory, water samples were filtered through a 0.45 mm membrane to remove suspended solids. The minerals in water were analyzed according to methods developed by American Public Health Association

***Table III.** Concentration of Sodium chloride (mg/l) in the five randomly selected boreholes over a period of five months in Kweneng West of Botswana.* (Concentración de cloruro sódico (mg/l) en cinco pozos seleccionados al azar en un periodo de cinco meses en Kweneng oeste (Botswana)).

Borehole	October	November	December	January	February
1	161.29^{b}±1.14	85.10^{a}±2.93	83.81^{a}±0.97	82.90^{a}±0.77	56.20^{a}±0.38
2	205.24^{c}±4.40	268.55^{d}±0.64	146.28^{b}±0.98	142.95^{ba}±0.03	121.70^{a}±2.39
3	145.59^{b}±1.51	168.59^{c}±3.30	100.36^{a}±0.18	103.70^{a}±1.94	91.99^{a}±0.16
4	731.22^{d}±4.50	472.59^{c}±2.06	136.38^{a}±0.08	456.09^{c}±3.08	323.39^{b}±0.35
5	220.75^{c}±3.29	131.70^{b}±0.06	454.54^{d}±6.05	230.55^{c}±3.24	81.63^{a}±0.93

^{a,b,c,d}Means in the same row not having common letters differ significantly ($p<0.05$)

(1976) modified by Lewis (1987). Iron and nitrate were analyzed using the colorimetric method. Sulphate was determined by gravimetric method and fluoride was analyzed by potentiometric method. Titrimetric method was used to analyze for chloride and bicarbonate while photometric method was used to determine sodium, potassium, calcium and magnesium. pH was determined using a pH meter. All data obtained were analysed using a computer package known as Statistical Analysis System (1994) to differentiate concentrations of constituents of sampled groundwater. Analysis of variance (ANOVA) and Duncan's multiple range test were used to separate the means.

RESULTS AND DISCUSSION

Table I shows the average chemical composition of groundwater collected from five randomly selected boreholes for a period of five months. There were significant differences ($p<0.05$) in the concentrations of all constituents deter-

***Table IV.** Total dissolved solids (mg/l) in groundwater obtained from five randomly selected boreholes in Kweneng West of Botswana.* (Sólidos totales disueltos (mg/l) en el agua obtenida de 5 pozos seleccionados al azar en Kweneng oeste (Botswana)).

Borehole	October	November	December	January	February
1	96.29^{b}±0.15	96.35^{b}±0.06	88.43^{a}±0.13	93.24^{b}±0.16	86.18^{a}±0.72
2	212.34^{b}±0.01	335.02^{d}±0.02	239.72^{c}±0.60	176.66^{a}±0.03	209.14^{b}±0.08
3	110.48^{a}±0.14	213.77^{d}±0.27	135.30^{b}±0.10	168.44^{c}±0.13	167.44^{c}±0.15
4	298.01^{b}±0.19	316.00^{c}±0.69	176.08^{a}±1.02	311.94^{bc}±0.21	291.87^{b}±0.17
5	142.48^{a}±0.02	131.95^{a}±0.07	287.19^{d}±0.10	213.41^{b}±0.12	257.84^{c}±0.09

^{a,b,c,d}Means in the same row not having common letters differ significantly ($p<0.05$)

mined for all the boreholes. The water intake of ruminants are influenced by the level of salinity as well as by specific ions and combination of ions in some cases. **Table II** shows the evaluated cations in the groundwater sampled while **table III** shows the concentration of sodium chloride in the groundwater evaluated. **Table IV** shows the total dissolved solids in the groundwater sampled. Hardness of water is expressed in terms of concentrations of divalent ions, such as Ca and Mg. **Table II** shows that the evaluated groundwater contained very low concentrations of calcium and magnesium ions thus the water was not hard water. The amounts of nutrient elements in drinking water for various species can be calculated by multiplying the concentration times the volume of water intake per day. Concentrations of mineral nutrients in drinking water for ruminants are generally quite inadequate for dietary requirements. Average concentrations of NaCl in the sampled water **(table III)** in Kweneng West of Botswana would supply grazing ruminants with approximately 10 p.cent of their daily requirement. Calcium at average concentrations in the groundwater sampled was present in sufficient quantities to provide approximately 0.02 p.cent of the requirements for beef cattle and significant less for dairy cows requirement. Magnesium at average concentrations obtained in the sampled ground water could provide 0.03 p.cent of the requirements of grazing sheep and goats.

Potassium and iron at average concentrations would provide approximately 0.26 p.cent and 0.6 p.cent of mature cattle daily requirements, respectively. It is apparent that, for optimum growth and performance, ruminants need to be provided with essential mineral elements in their rations.

Water occasionally contains elements and substances in toxic concentrations. Elements and substances may vary in toxicity depending on whether they are suspended as part of solids or in solution.

Elements such as iron (**table I** and **table II**) is present in water at low level in dissolved form thus only toxic in excessive concentration. Small intakes of fluorine **(table I)** appear to be beneficial to formation of bone and teeth, but high levels will cause mottling of teeth, decreased feed intake, and weight gains. **Table I** shows low nitrate levels in groundwater evaluated. Shirley (1985) found that the amounts of nitrate in water around feedlots was found to correlate directly with the number of animals and inversely with the depth of wells.

Sodium, chlorine, calcium, sulphate, bicarbonate and magnesium **(table I)** are ions most commonly present in saline waters. The groundwater sampled from all the boreholes contained low levels of sodium chloride **(table III)** therefore could not cause any physiological or digestive disturbances to any class of livestock or poultry. Water quality depends on a number of variables such as the level of toxic substances, level of sulphate, soluble salt and total dissolved solids. Concentration of sulphate determined in all the sampled water ranged from 8.91 to 137.53 mg/l which is acceptable to the animals and could not cause laxative effect in livestock. The total dissolved solids determined **(table IV)** in the sampled groundwater ranged from 86.18 to 335 mg/l consequently, all the water evaluated could be classified as good drinking water for livestock. This study showed that groundwater sampled contained some minerals which contributed to some of the livestock requirements for the essential minerals like sodium, potassium and magnesium and also demonstrated that constituents of groundwater varied with time of sampling from the evaluated boreholes in Kweneng West of Botswana.

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