Evaluation of Livestock Water for Macro and Micro Minerals in Selected Sites of the Central Highlands of Ethiopia

Running title: Evaluation of Livestock Water for Minerals in Highlands of Ethiopia

Rehrahie Mesfin[a] , Fassil Assefa (Dr.)[b], Getnet Assefa (Dr.) [c] & Zelalem Yilma (Dr.) [d]
[a] Ethiopian Institute of Agricultural Research, Holetta Agricultural Research Center, P.O.Box 2003, [b] Addis Ababa University, Science faculty, P.O.Box 1176, [c]Ethiopian Institute of Agricultural Research P.O.Box 2003, [d] East Africa Dairy development, Heifer International

Abstract

The study was undertaken to evaluate the status of PH and mineral concentration of livestock water. Water samples were collected from three locations of the central highlands of Ethiopia: Holetta, Akaki and Ambo. Samples were analyzed for macro minerals (Na, Ca, K, Mg) and micro minerals (Fe, Zn, Cu, Mn). The analysis was investogated by Atomic Absorption Spectrophotometer (AAS). There is variation in PH and mineral concentration of in water across and within a given location. As compared to Holetta and Ambo, livestock water in Akaki has the lowest PH (6.77) and the highest mineral concentration (32.22 ppm). Extreme minimum and maximum concentrations of minerals ranging from 0-160 ppm were recorded. Zero value for some elements implies they become below the detection limit. PH values ranging 3.93 to 9.95, 7.37 to 8.45 and 7.21to 8.01were recorded in Akaki, Ambo and Holetta respectively. The concentrations of macro minerals of water were found higher than the micro minerals. Regardless of the study location, the concentration of macro minerals were found in the order of calcium 26.43 ppm > sodium 24.68 ppm > potassium 19.84 ppm > magnesium 6.59 ppm. With regard to the micro minerals, they were found in the order of iron 31.93 ppm > manganese 10.26 ppm > zinc 0.29 ppm > copper 0.13 ppm.

The highest concentration of macro minerals recorded in Akaki, Ambo and Holetta were calcium (69.02 ppm), potassium (31.82 ppm) and sodium (9.35 ppm) respectively. The highest concentration of micro minerals recorded in Akaki, Ambo and Holetta were iron (89.95 ppm), manganese (9.20 ppm) and manganese (0.83 ppm) respectively.

In general, mineral content of livestock water have their own contribution to the daily mineral requirements of cattle. The concentration of calcium, magnesium, sodium, zinc and copper were found within the acceptable range. Whereas the concentrations of potassium in Akaki and Ambo (31.82 and 26.91 ppm), iron in Akaki, Ambo and Holetta (89.95, 5.5 and 0.33 ppm) and manganese in Akaki, Ambo and Holetta (20.76, 3.87 and 0.83 ppm) respectively were found beyond the acceptable level. Therefore, for an intervention to be implemented with mineral supplementation to livestock species, the mineral concentration of livestock water in certain location should be taken in to consideration. To overcome the excessive concentration of potassium, iron and manganese in water an adjustment targeting to the problematic element is required during feed formulation.

Keywords*: Cattle, Consumption, PH, quality, macro, micro*

Introduction

Water is a basic requirement for numerous functions of animal life. It is involved in regulation of body temperature and facilitates different physiological processes. It is the main transport medium for glucose, amino acids, mineral ions, water-soluble vitamins, and wastes (Jim and Mary, 2010; NRC, 1996). Water is the most important nutrient next to oxygen to sustain life (Beede, 2006). Water is predominately required for milk production which accounts 87% of the milk in dairy cows. A cow's body weight is composed of 56-81% water depending on stage of lactation (Beede, 2006). A cow faces fatal conditions when 20% of water weight is lost (Lejune et al, 2001). Consuming water is more important than feed because of water's vital importance to the animal's physiological functions (Matt and Sonja, 2012).

Both the quantity and quality of water are important to achieve optimal livestock performances (Jim and Mary, 2010). The hygienic and physic-chemical quality of drinking water plays a key role in ensuring an efficient animal productivity (Khan et al., 2012). Excessive chemicals in water can reduce animal production, impair fertility and cause losses of animals in some extreme cases (Khan et al., 2012). Contaminants in drinking water can leave residues in animal products, i.e. meat, milk and eggs, which adversely affect product sales and transfer health risks to humans (Lili, 2009 In: Khan et al., 2012). Poor quality water brings abnormal taste and/or odor, leading to reduced water intake, feed intake and health of the animal which consequently affect growth, reproductive and productive performance (Dave, 2008). The odor or taste of water is attributed to anti-quality elements which affects the normal metabolic, physiological functions and health status of the animal (Beede, 2006; Tayler and Foster, 2012). As with the feed, water used for livestock drinking should meet the nutritional needs of the animal. Minerals found in water provide nutritional benefits when present in optimum concentrations. Very minute (micrograms or milligrams) quantities of minerals are required for effective physiological process (Dawd, 2010). Minerals are classified in to macro and micro minerals (Faye et al., 2011). Major or macro minerals are the six dietary minerals living organism needs in largest amounts. They're necessary for many processes such as fluid balance, maintenance of bones and teeth, muscle contractions and nervous system function. Major minerals include calcium (Ca),potassium (K), sodium (Na) magnesium (Mg) and phosphorous (P). Trace minerals are all essential for good health, but a living organism needs in a very small amount. They are important for immune system function, energy, metabolism and antioxidant protection. Trace minerals include chromium, copper, fluoride, iodine, iron, manganese, molbedinium, selenium, zinc (Faye et al., 2011). Minerals contribute to the bone structure (Ca, P, Mg), to the electrolyte balance (Na, K) to the protein structure (Fe and Cu), nervous and muscle activities (Ca and K) or to the enzyme activities (Zn Se). Minerals are known to be essential for normal growth (Li-Qiang et al., 2009; Tekleyohannes Berhanu and Agrawal, 2003). They are used as co-factors in many enzymes and play an important role in many physiological functions. Lack of minerals causes disturbances and pathological conditions (Enb et al., 2009). Mineral deficiency could result to deficiency disease and their excess in the diet could provoke toxicity. Mineral imbalance could affect bone metabolism, provoke growth disturbances, loss of appetite, reproductive failure, immune-depression and abnormal feeding behavior.

Since water is one of the reservoirs of minerals, there is an interest to study its minerals status (Patra et al, 2008). Water provides variable amounts of minerals depending its location (Li-Qiang et al., 2009. There is a threshold level of minerals above which may cause nutritional and (or) health problems (Breede, 2006; Federal Ministry of health, 2004). In between there is a set of intakes that represent the acceptable range of oral intakes (AROI), at which no adverse effects occur. Water should be periodically sampled for quality and potential contaminants (Matt and Sonja 2012). The parameters commonly used to evaluate water quality include pH, salinity, alkalinity, sulphate, nitrate, hardness, toxic elements, contaminations with pesticides and fertilizer products. The pH of water can affect taste of water and efficiency of chlorination (Jane, 2009). Highly acidic pH leads to acidosis and reduced feed intake and highly alkaline water causes digestive upsets, diarrhea, reduced water intake, lower feed intake and lower feed conversion efficiency (Jane, 2009). Ions of Magnesium, Calcium,' Sodium, Chloride, Carbonates, bicarbonates, sulphates, nitrates, chlorides, phosphates and fluorides, are associated with salinity of water and they may cause toxic effects when they are found beyond the acceptable level (Marx, 2003). For example deficiency of calcium and phosphorus leads to problem of poor reproductive performance such as inter-calving interval and the lower content and quality of fat in milk (Rekhis et al., 2002). Iron concentrations in drinking water greater than 0.3 ppm are considered a concern for dairy cattle health and performance. Water caused by high calcium levels can influence the incidence of milk fever in dairy herd. Higher levels of calcium, sodium and magnesium can reduce palatability of water. Higher levels of nitrates, fluorine, salts of heavy metals such as copper, zinc and manganese in water are toxic. The presence of sodium bicarbonate in drinking water can cause sheep to bloat, particularly if the animals are under stress and not accustomed to the water (Salinity management handbook, 2013).

Some research activities have been undertaken on mineral status of feed stuffs (Lemma Gizachew and Smit, 2005). However, information is lucking on mineral composition of water used for livestock drinking. Therefore, there is a need to determine the level and concentration of macro and micro minerals elements in livestock water.

Objectives

- To determine the PH status of livestock water across different locations
- To assess the concentration of macro and micro minerals in livestock water and its contribution to the daily requirements of cattle

- To compare the concentration of macro and micro minerals against the Official Standard of acceptable limits

Materials and methods

Description of the study locations
The study was carried out in three locations of the central highlands of Ethiopia: Akaki, Holetta and Ambo.

Akaki: it is located in central Ethiopia along theWestern margin of the Main Ethiopian Rift. The catchment is geographically bounded between 8°46´–9°14´N and 38°34´–39°04´E (Molla and Stefan, 2006).

Holetta: it is located at 38° 30`E, 9° 3`N and 45 km west of Addis Ababa and lies at an elevation of 2400 m.a.s.l. The annual rainfall is 1066 mm with bimodal distribution, over 70% of which occurs during the main rainy season (June to September) and 30% during the small rainy season (February to April). The average annual minimum and maximum temperatures were 6° and 22°C respectively. The area is also characterized by occasional frost that occurs in the months of October to December, where temperatures below zero for few days during these months (Fekede et al., 2004).

Ambo: it is located in central Ethiopia of the Western Shewa Zone of the Oromia Regional state. It is situated 115 km West of Addis Ababa. The area is found at a longitude of 370 32 ’to 380 3 ’ E, and latitude of 80 47’ to 90 20’ N and the altitude ranges from 1900 -2275 meters above sea level. The climatic condition of the area is 23% highland, 60% mid altitude, and 17% lowland. It has an annual rainfall and temperature ranging from 800-1000 mm and 20-29 0 C respectively. The rainfall is bi-modal with short rainy season from February to May and long rainy season from June to September (AARDB, 2006 In: Indrias et al, 2010). Agriculture is the main occupation of the population. Agricultural activities are mainly mixed type with cattle rearing and crop production under taken side by side. Ambo is known for its mineral water, which is bottled outside of town which is reportedly the most popular brand in Ethiopia.

Sampling methods and laboratory analysis
Collection of water samples was carried out at field conditions where different livestock species practically drink water within the study location of Akaki, Ambo and Holetta. Ten water samples were collected from each study locations including. Plastic sample bottles with a capacity of 0.5 lt was used for water container. To make the containers clean, they were rinsed with distilled water, labeled according to the pre-designed study locations. Water samples were taken from small water bodies manly surface water usually used for livestock drinking. The sample bottles were filled to the top and capped tightly. The bottles were wiped to make them dry. Before

taking to the laboratory , the samples were investigated for physical appearances like color, turbidity and odor. Then they were measured for PH and delivered to Debrezeit soil and plant laboratory for analysis. Investigation of water was carried out for macro minerals including Na, K, Ca, Mg, and micro minerals including Cu, Zn, Fe, and Mn based on the standard procedures of Atomic Absorption Spectrophotometer (AAS). The PH of water was measured by PH/ion-meter, WTW, Inolab (Germany).

Experimental design

The experimental design was randomized completely block design (RCBD). The study locations including Akaki, Holetta and Ambo were considered as block.

The statistical model was:

$Y_{ijk} = \mu + Mi + Lj + (M*L)k + eijk$ Where,

Y_{ijk} = the response variable

μ = the overall mean

Mi = effect of i^{th} mineral element

Lj = effect of j^{th} study location

(M*L)k = interaction effects of i^{th} mineral element and j^{th} study location

eijk = the random error

Statistical analysis

There is a wide range of variation among the concentration of mineral elements which varies from 0 ppm – 262 ppm. Due to this, the standard deviation (root MSE) of some elements was found greater than the respective mean. When the data was tested for assumptions of normality, it does not fulfill curve of normal distribution. To fulfill the normal curve, we are forced to transform the data using the square root transformation and we have got the transformed data. Then both the transformed and untransformed data was subjected to Analysis of variance and the General Linear Model Procedures (GLM) was used to perform the analysis. Ls-means of both the transformed and untransformed data are considered and the standard error is taken from the transformed data. Least square means of the transformed data is put in parenthesis.

Mineral intake from water and its contribution to mineral requirement

For the estimation of major and minor minerals, maintenance requirement of minerals was considered as focal point of calculation. To perform this different research results was used as references. To estimate the maintenance requirement of calcium for non-lactating mature cattle, the absorbed calcium required is 0.0154 g/kg body weight (Hansard et al., 1957 In: NRC 2001). This requirement should be added to the total inevitable losses in the form of urine and faces that is 0.015 grams/kg body weight per day (Gueguen et al. 1989, In: NRC 2001). To estimate the maintenance requirement of sodium, the absorbed sodium for lactating cows was set at 0.038 g/kg of body weight per day. This requirement needs to be added to the total inevitable losses in the form of urine and faces that is 0.015 grams/kg body weight per day (NRC 2001). In addition, at environmental temperatures between 25 and 30° C, an additional 0.10 g of sodium per 100 kg body weight is lost in the form of sweat which is considered to be part of maintenance (Agricultural Research Council, 1980). The maintenance requirement for absorbed potassium of lactating cows was set as 0.038 g/kg body weight (endogenous urinary loss) plus 6.1 g/kg of dietary dry matter (endogenous fecal loss) (Sanchez et al., 1994a,b In: NRC 2001). At environmental temperatures between 25°C and 30° C, an additional 0.04 g of potassium/100 kg body weight was considered part of maintenance requirement. The maintenance requirement for absorbed magnesium requirement is 0.33 g/day (Lyford and Huber, 1988). On top of rhis, the fecal loss of endogenous Mg is 3 mg/kg body weight for adult cattle and heifers in 100 kg BW (NRC, 1996, In NRC 2001). Obligate urinary loss of magnesium is negligible. The daily copper requirement for 300kg body weight is 72mg/day (NRC, 2000, In: NRC 2001). The iron requirement of mature lactating cow is 24 mg /kg DM (Henry and Miller, 1995, In NRC, 2001). The daily Mg requirement of cattle is 40 mg/kg DM feed. (NRC1989b, In: NRC 2001). The maintenance requirement of zinc is the sum total of the absorbed zinc requirement of 0.045 plus the daily endogenous fecal loss which is approximately 0.033 mg zinc/kg body weight and the the obligate urinary loss of zinc is estimated as 0.012 mg zinc/kg body weight (Hansard et al., 1968, In NRC, 2001).

Results and Discussions

PH values of livestock water across sampling sub location are presented in Table 1. Both low and higher PH values within a range of 3.93-9.95 were recorded in Akaki. Whereas PH of 7.37-8.45 and 7.21-8.01 within the acceptable range of 6.5–8.5 (Peterson, 1999) were recorded in Ambo and Holetta respectively. Majority of the sampling sites have PH within in the acceptable range. However, some sub-locations in Akaki including Legedukem 1 (PH=9.95) and Legedukem 2 (PH=9.87) have PH value of greater than the acceptable range. In the same location, lower PH values were also recorded in sub study sites called Tach Dengora 1, Tach Dengora 2, Lay Dengora 1, Lay Dengora 2 which is 3.93, 4.1, 5.28 and 4.04 respectively (table 1). As compared to Holetta and Ambo, the PH of water across Akaki sampling sites has a wide range of variation. Water pH is used to describe the acidity or alkalinity and the concentration of hydrogen ion in water determines the PH level. Most water falls within an acceptable range of 6.5 to 8.5. Water PH lower than 5.5 poses to problem of acidosis and reduced feed intake in cattle (Jane, 2009). It was also suggested that PH value greater than 9.0 may result in problems related to chronic or mild alkalosis (Adams and Sharpe, 1995). Moreover water PH is an important factor in determining the effectiveness of various water treatments. For example, chlorination efficiency is reduced at a higher water PH. A low PH may cause precipitation of some antibacterial agents delivered through the water system (MOA, 1999). Water PH as a measure of water quality could cause low water intake. Anti-quality factors (constituents in excess or unwanted compounds) present in water may affect PH value and consequently water intake, or normal metabolic or physiological functions of animals (Beed, 2006).

Table 1. PH range of livestock water across sampling sites

Akaki	Sampling sites in Akaki										
	Lege Dukem 1	Tulu Dumtu 1	Tach Dengora1	Lay Dengora1	Fanta Wenz 1	Tulu Dumtu 2	Tach Dengora 2	Lay Dengora 2	Fanta Wenz 2	Lege Dukem 2	PH range
PH	9.95	7.34	3.93	5.28	8.08	7.38	4.1	4.04	7.43	9.87	3.93-9.95
Holetta	Sampling sites in Holetta										
	Kui 1	Kui 2	Weservey 1	Weservey 2	Holetta Wenz 1	Ureni 1	Ureni 2	Koreje la 1	Korejela 2	Holetta Wenz 2	
PH	7.41	7.21	7.46	8.01	7.39	7.31	7.40	7.48	7.54	7.37	7.21-8.01
Ambo	Sampling sites in Ambo										
	Boji Wenz 1	Boji Wenz 2	Huluka 1	Huluka 2	Umuga 1	Umuga 2	Cholu 1	Cholu 2	Chancho 1	Chancho 2	
PH	7.68	7.67	8.45	7.82	7.40	7.96	7.91	7.72	7.48	7.37	7.37-8.45

The PH value and mineral concentration of livestock water is presented in Table 2. The PH of livestock water in Akaki (6.77 ± 0.15) differs significantly ($P < 0.01$) and is lower when it is compared with PH of water in Ambo (7.74 ± 0.15) and Holetta (7.45 ± 0.15). However, there is no significance ($P > 0.01$) difference between PH of water in Ambo and Holetta. There is highly significance ($p<0.01$) difference in concentration of minerals across study locations. Regardless of the mineral type, the concentration of minerals in water in Akaki (32.22 ± 3.45) is significantly ($p<0.05$) higher than that of in Ambo (9.82 ± 3.45) and in Welmera (3.02 ± 3.45). The interaction effect between mineral elements and study locations is also highly significant ($p<0.01$). The results also indicated that PH values of livestock water were almost negatively correlated with the corresponding concentration of minerals ($r = ^{-}0.40472$, $P <0 .0001$).

The PH level is determined by the hydrogen ion concentration. A pH value of 7 indicates "neutral" water. Values less than 7 are increasingly acidic and values greater than 7 are increasingly alkaline. Most water falls within an acceptable range of 6.5 to 8.5. If the pH is lower than 5.5, acidosis and reduced feed intake may occur in cattle. A low water pH is unlikely to have any direct effect on swine because of the already acidic conditions of the stomach. Water pH is an important factor in determining the effectiveness of various water treatments. Chlorination efficiency is reduced at a high pH. A low pH may cause precipitation of some antibacterial agents delivered through the water system. For example, sulphonamides are a particular concern as precipitated medication may leak back into the water after treatment has ended, contributing to potential sulpha residues in carcasses (Karen ,1999).

Few studies have linked water pH with any livestock health or performance issues. Adams and Sharpe (1995) suggested that water pH should fall between 5.1 and 9.0 based on experiences with dairy herds in Pennsylvania. They suggested that acidic water with a pH less than 5.1 may increase problems related to chronic or mild acidosis while water with a pH over 9.0 may result in problems related to chronic or mild alkalosis. Other authors have recommended a more strict pH range between 6.0 and 8.5 largely based on field observations rather than controlled studies. It was suggested that water supplies with a pH below 6.0 or above 8.5 should be further evaluated where unexplained herd health or performance issues occur. The PH of livestock water in the present study was found in the recommended range which is between 6.8 and 7.5.

Table 2. PH and mineral concentration of livestock water across study locations (LS-means ± SE)

Location	PH (unit)	Concentration of minerals (ppm)
Akaki	6.77 ± 0.15^{a}	32.22 ± 0.24^{a} $(4.01)^{a}$
Ambo	7.74 ± 0.15^{b}	9.82 ± 0.24^{b} $(2.10)^{b}$
Holetta	7.45 ± 0.15^{b}	3.02 ± 0.24^{bc} $(1.28)^{c}$

LS-means labeled with different superscripts between rows differ significantly.
Figures indicated in parenthesis are the transformed Ls-means.

Based on the assumption that camel drink about 31.3 L of water per day in hot dry season (Pallas 1986), (Zinash) the results of the chemical analysis of the waters were used to estimate the daily mineral intake of the animals from the different sources. Estimation assumed an average body weight of 410 kg per animal (1.6 TLU) and a daily feed intake of 9 kg DM (ILRI 2002). These figures were used in the calculation of the daily requirement of camel for the different minerals analyzed. In this respect, the following recommendation of the expected mineral composition per kg dry weight of forage was taken into consideration: 0.3% (Ca), 0.2% (Mg), 0.06-0.18% (Na), 0.6-0.8% (K), 0.25% (P), 40 mg kg-1 (Mn), 50 mg kg-1 (Fe), 30 mg kg-1(Zn) and 10 mg kg-1 (Cu) (McDowell and Arthington 2005).

Minerals required in gram quantities are referred to as macro minerals and they include calcium, phosphorus, sodium, chlorine, potassium, magnesium, and sulfur. macro minerals are important structural components of bone and other tissues and serve as important constituents of body fluids. They play vital roles in the maintenance of acid-base balance, osmotic pressure, membrane electric potential and nervous transmission. Minerals required in milligram or microgram amounts are referred to as the trace minerals. They include cobalt, copper, iodine, iron, manganese, molybdenum, selenium, zinc, and perhaps chromium and fluorine. The trace minerals are present in body tissues in very low concentrations and often serve as components of metalloenzymes and enzyme cofactors, or as components of hormones of the endocrine system (NRC, 2011).

The average concentration of macro and micro mineral elements regardless of the study locations is indicated in table 3. In all the study locations, the concentrations of macro minerals of livestock water were found higher than the micro minerals. The concentration of macro minerals in livestock water were found in the order of calcium (26.43 ppm) > sodium (24.68 ppm) > potassium (19.84 ppm) > magnesium (6.59 ppm). The results also indicated that there is no significance difference ($p>0.05$) among the concentration of calcium, sodium and potassium in livestock water. However, there is significance difference ($p<0.001$) between the concentration of magnesium as compared to the above elements. The concentration micro minerals in livestock water was found in the order of iron (31.93 ppm) > manganese (10.26 ppm) > zinc (0.29 ppm) > copper (0.13 ppm). There is no significance difference ($p>0.05$) between the concentration of copper (0.13 ± 0.40) and zinc (0.29 ± 0.40). Similarly there is no significance difference ($p>0.05$) between the concentration of iron (31.93 ± 0.40) and manganese (10.26 ± 0.40). However, there is significance difference ($p<0.001$) between the concentration of copper (0.13 ± 0.40) in comparison to iron (31.93 ± 0.40) and manganese (10.26 ± 0.40). Similarly, there is significance difference ($p<0.001$) between the concentration of zinc (0.29 ± 0.40) in comparison to iron (31.93 ± 0.40) and manganese (10.26 ± 0.40).

Table 3. Concentration of macro and micro mineral elements in livestock water (LS-means ± SE)

Mineral element	Concentration (ppm)	
Macro mineral		
Na	24.68 ± 0.40[a]	(4.70)[a]
Ca	26.43 ± 0.40[a]	(3.67)[a]
K	19.84 ± 0.40[a]	(3.58)[af]
Mg	6.59 ± 0.40[cba]	(2.37)[c]
Micro minerals		
Cu	0.13 ± 0.40[b]	(0.36)[b]
Zn	0.29 ± 0.40[eb]	(0.50)[e]
Fe	31.93 ± 0.40[a]	(2.75)[fcd]
Mn	10.26 ± 0.40[da]	(1.77)[dc]

LS-means labeled with different superscripts among rows are significantly different.
Figures indicated in parenthesis are the transformed Ls-means.

The concentration of macro and micro minerals in livestock water across different study locations is indicated in table 4. Among the macro minerals, highest concentration of calcium (69.02 ± 0.70 ppm), potassium (31.82 ± 0.70 ppm) and sodium (9.35 ± 0.70 ppm) were found in Akaki, Ambo and Holetta respectively. The lowest concentration of magnesium (9.77 ± 0.70 and, 3.87 ± 0.70) was measured in Akaki and Ambo respectively. Potassium has the lowest concentration in Holetta (0.79 ± 0.70 ppm). For the micro minerals, highest concentration of iron in Akaki (89.95 ± 0.70 ppm), manganese in Ambo (9.20 ± 0.70 ppm) and manganese in Holetta (0.83± 0.70 ppm). Copper was the element found in lowest concentration in Akaki (0.10 ± 0.70), Ambo (0.13 ± 0.70) and Holetta (0.16 ± 0.70).

Sodium in water is rarely problematic for dairy cattle but sodium concentrations should be included in the ration formulation if levels are below 20 mg/L (ppm). The sodium levels in the present study were 40.78 ppm, 23.93 ppm and 9.35 ppm in Akaki, Ambo and Holetta respectively. Since the sodium level in livestock water in Akaki and Ambo are found beyond the recommended level, there is no need to include sodium in the feed formulation. Whereas, the concentration of sodium in livestock water in Holetta was found below the recommended level, there is a need to include sodium in the ration formulation.

Iron and manganese are very common pollutants that can occur naturally in groundwater or from nearby mining activities. Both cause severe staining and a metallic taste to water resulting in reduced water intake and reduced milk production. Iron levels above 0.3 mg/L and manganese concentrations exceeding 0.05 mg/L are sufficient to cause unpleasant tastes in water that may cause reduced water intake and milk production. In the present study, the concentration of iron in Akaki, Ambo and Holetta were 89.95 ppm, 5.5 ppm and 0.33 ppm respectively. Here the concentration of iron especially in Akaki and Ambo are beyond the recommended level. Here attention is required no to supplement feeds rich in iron to minimize the cumulative effect of excessive iron coming from water and feed. The concentration of manganese in Akaki, Ambo and Holetta were 20.76 ppm, 9.20 ppm and 0.83 ppm respectively. In all the study locations, manganese was found in higher concentration. Here care is required not to supplement feeds rich in manganese so as to minimize the cumulative effect of excessive iron coming from water and feed.

Copper usually occurs in water from corrosion of metal plumbing components. It may also be elevated in mining areas or from treatment of ponds with copper sulfate algaecides. Copper levels above 1.0 mg/L may cause a metallic taste resulting in reduced water intake and milk production. High copper concentrations may also cause liver damage. The concentration of copper in livestock water in the present study was 0.1 ppm, 0.13 ppm and 0.16 ppm in Akaki, Ambo and Holetta respectively. Here the indicated copper concentration is found below the recommended level. It is therefore required to include copper in the feed formulation to optimize the cupper requirement of different livestock species.

Table 4. Concentration (ppm) of macro and micro minerals in livestock water across locations (Ls-means ± SE)

Mineral element	Akaki	Ambo	Holetta
Macro mineral			
Sodium	40.78 ± 0.70a (6.37)a	23.93 ± 0.70ac (4.69)a	9.35 ± 0.70c (3.04)c
Calcium	69.02 ± 0.70a (6.92)a	3.94 ± 0.70bc (1.63)bc	6.35 ± 0.70c (2.47)c
Potassium	26.91 ± 0.70ac (5.01)a	31.82 ± 0.70c (4.99)a	0.79 ± 0.70ab (0.73)c
Magnesium	9.77 ± 0.70a (2.94)a	3.87 ± 0.70a (1.70)a	6.12 ± 0.70a (2.47)a
Micro mineral			
Copper	0.10 ± 0.70a (0.31)a	0.13 ± 0.70a (0.36)a	0.16 ± 0.70a (0.39)a
Zinc	0.46 ± 0.70a (0.59)a	0.20 ± 0.70a (0.44)a	0.22 ± 0.70a (0.47)a
Iron	89.95 ± 0.70a (6.23)a	5.5 ± 0.70bc (1.62)bc	0.33 ± 0.70c (0.40)c
Manganese	20.76 ± 0.70a (3.67)a	9.20 ± 0.70a (1.36)bc	0.83 ± 0.70a (0.29)c

LS-means labeled with different superscripts among rows are significantly different. Values indicated in parenthesis are the transformed Ls-means.

The mean PH value and mineral concentration of livestock water across study locations is presented in fig 1. The PH of livestock water in Akaki (6.77) is lower than that of Ambo and

Holetta. The mineral concentration of livestock water in Akaki (32.22) is higher than that of Ambo (9.82) and Welmera (3.02).

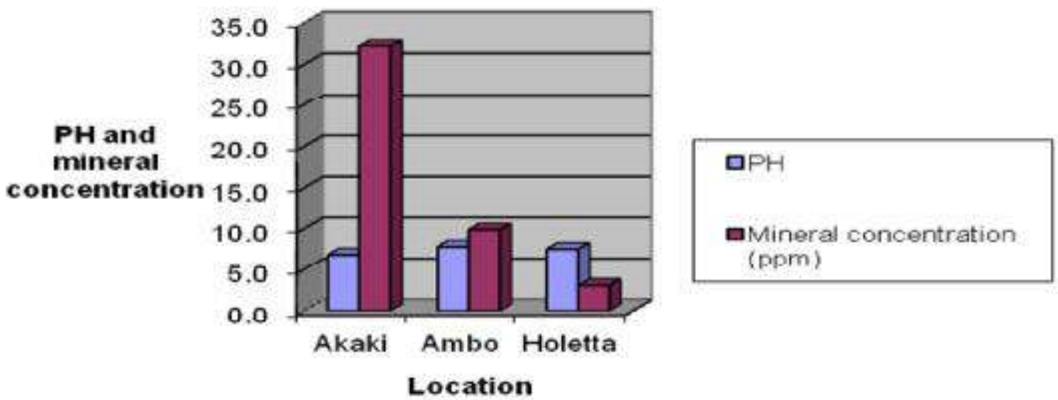

Fig. 1 PH value and mineral concentration (ppm) of livestock water across location

The concentration of mineral elements in livestock water in the study location is presented in fig 2. All mineral elements in exception of potassium constitute the highest concentration in Akaki as compared to the other study locations (Ambo and Holetta). This is in agreement with the study of Frezer (2012). He was justifying that the reason for high concentration of mineral elements in Akaki is a result of rapid urbanization, industrialization and problem of waste disposal facilities. Direct discharge of foreign materials from different sources to rivers and open lands and the leakage of industrial wastes from poorly designed septic tanks to the ground water, discharge of effluents without detoxifying the waste solid/liquid from domestic and municipal, organic matter of plant and animal origin, land and surface washing and sewage effluents are among few sources of pollution that changes the water quality. Among the mineral elements, iron concentration in Akaki has the highest value followed by calcium. Copper and zinc are the minerals recorded a lowest concentration in all the study locations.

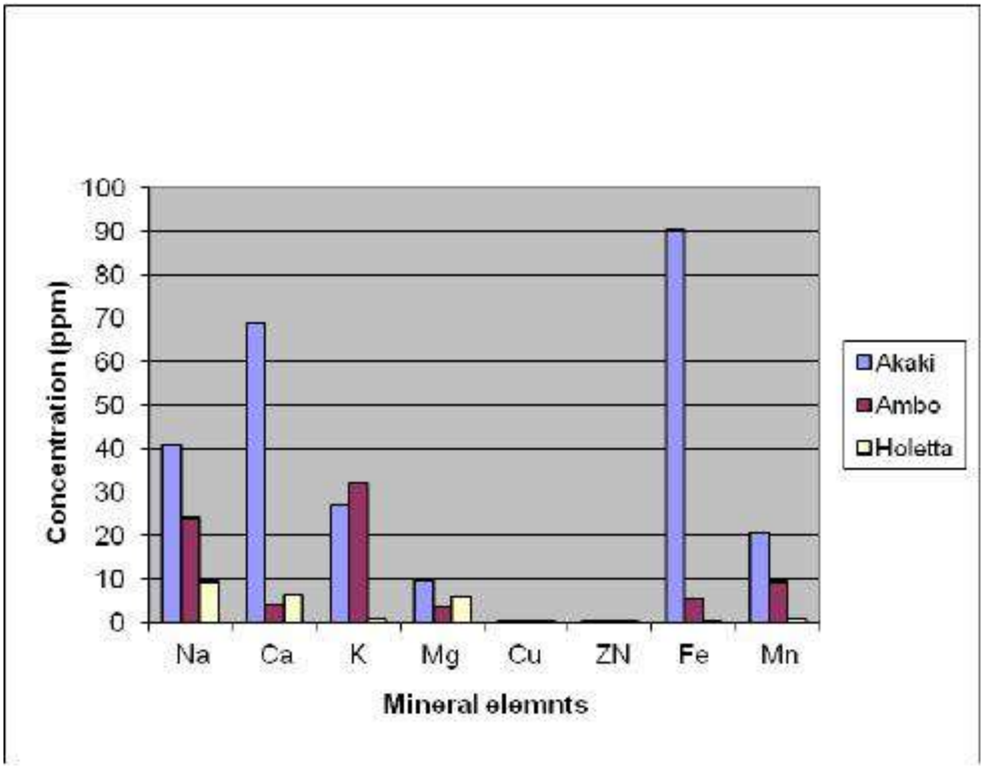

Fig 2. Concentration (ppm) of mineral elements in livestock water by location

The concentration of mineral elements in livestock water as compared to the acceptable levels is presented in table 5. Among the minerals studied, Calcium, Magesium, sodium, zinc and copper were found in satisfactory concentrations (Zinpro Water Analysis Program, 2002). Whereas the concentrations of potassium in Akaki and Ambo (31.82 and 26.91 ppm), iron in Akaki, Ambo and Holetta (89.95, 5.5 and 0.33 ppm) and manganese in Akaki, Ambo and Holetta (20.76, 3.87 and 0.83 ppm) respectively were found beyond the desired level (Zinpro Water Analysis Program, 2002). It is known that iron and manganese are very common pollutants that can occur naturally in groundwater or from nearby mining activities. Both cause severe staining and a metallic taste to water resulting in reduced water intake and reduced milk production. Iron levels greater than 0.3 mg/L and manganese concentrations exceeding 0.05 mg/L are sufficient to cause unpleasant tastes in water that may cause reduced water intake and milk production (Salinity management handbook, 2013). Low levels of iron can be troublesome in water. Levels over 0.1 mg/L have been reported to cause red meat in veal calves. Iron levels in excess of 0.3 mg/L can stain clothes. It can also support the growth of iron bacteria, which result in foul odors and plugging of water systems. As little as 0.1 mg/L iron may cause oxidized flavor in milk (Karen, 1999). Since iron and manganese are essential heavy metals, they will be toxic when they exist in excessive concentrations (Florin et al, 2008). Manganese, at a concentration beyond the acceptable level presents problems when the water is to be disinfected. It was also reported that manganese together with iron discolors fixtures. They can bring problems in restricted flow devices in drinking water lines where manganese precipitation may plug the line (Peterson, 1999). Manganese toxicity in ruminants is unlikely to occur, and there are few documented incidences with adverse effects limited to reduced feed intake and growth (Jenkins and Hidiroglou, 1991). These negative effects began to appear when dietary manganese exceeded 1000 mg/kg. The maximum tolerable amount of manganese, as given by the National Research Council (1980), is 1,000 mg/kg.

In the present study potassium is the other mineral found in excessive concentration. Since potassium is a soluble macro mineral, livestock species provided with waters of high levels may suffer with physiological upset or lead to death (Florin et al, 2008).

Table 5. Concentration (ppm) of minerals in livestock water in comparison to recommended desired and maximum upper levels

Mineral	Desired levels*	Maximum upper levels**	Concentration of minerals		
			Akaki	Ambo	Holetta
Calcium	<100	200	69.02	3.94	6.35
Iron	<0.2	0.4	89.95	5.5	0.33
Magnesium	<50	100	9.77	9.20	6.12
Manganese	<0.05	0.5	20.76	3.87	0.83
Potassium	<20	20	26.91	31.82	0.79
Sodium	<50	300	40.78	23.93	9.35
Zinc	<5	25	0.46	0.20	0.22
Copper	<0.2	0.5	0.10	0.13	0.16

Source: *Zinpro Water Analysis Program, Version 2.0, 2002.*

** Animals consuming water exceeding these limits may reduce performance*

*** The consumption of this water poses a potential animal health risk*

Table 6. Intake of mineral from water and its contribution to the daily mineral requirement of cattle

Element		Akaki			Ambo			Holetta		
	Mineral requirement ofcattle,mg/d	Concentration of mineralinwatermg/lt	Mineralintakefrom watermg/d	contribution to the dailyrequirement,%	Concentration of mineralinwatermg/lt	Mineralintakefrom water/day	contribution to the dailyrequirement,%	Concentration of mineralinwatermg/lt	Mineralintakefrom water/day	contribution to the dailyrequirement,%
Ca	5500	69.02	1173	21	3.94	67	1.2	6.35	108	2
Na	9680	40.78	693	7	23.93	407	4.2	9.35	159	1.6
Mg	59540	9.77	166	0.3	9.20	156	0.3	6.12	104	0.2
K	39872	26.91	458	1	31.82	541	1.4	0.79	13	0.03
Fe	144	89.95	1529	1061	5.5	94	65.3	0.33	5.6	4
Cu	72	0.10	1.7	2.4	0.13	2.2	3.1	0.16	3	4.2
Mn	240	20.76	353	147	3.87	66	28	0.83	14	5.8
Zn	16	0.46	7.8	50	0.20	3.4	21.3	0.22	4	25

NB. Mineral intake of cattle based on voluntary water intake of17 lt/day/animal for 0.7 TLU (180kg BW) of tropical indigenous cattle

With regard to macro minerals, the Ca content of water in Akaki can satisfy 21% of the daily requirement of cattle, while water from Ambo and Holetta can fulfill 1.2% and 2% of the daily requirement respectively (table 6). In similar study in Jijiga (Biya'ada), livestock water could satisfy about 15% of the daily mineral requirement of camel (Temesgen and Mohammed, 2012). Sodium content of livestock water from Akaki, Ambo and Holetta can satisfy 7%, 4.2% and 1.6% of the daily mineral requirement of cattle respectively. Water from Akaki was observed to be a better source of Na. In similar study in Jijiga, livestock water could contribute about 38.3% of the daily mineral requirement of camel (Temesgen and Mohammed, 2012). Magnesium content of livestock water from Akaki, Ambo and Holetta can satisfy 0.3%, 0.3% and 0.2% of the daily requirement of cattle respectively. Magnesium content in all the study sites was found to be very low. In similar study in Jijiga (Biya'ada and Golajo'o) the contribution of mineral water could contribute 1.8% and 1.3% to the daily mineral requirement of camel respectively (Temesgen and Mohammed, 2012). Potassium content of livestock water from Akaki, Ambo and Holetta can fullfill 1%, 1.4% and 0.03% of the daily requirement of cattle respectively. Potassium content in all the study sites was found to be low, particularly in Holetta was too low. In similar study in Jijiga (Biya'ada and Golajo'o) mineral water could contribute 1.2-1.6% and less than 0.001% to the daily mineral requirement of camel respectively (Temesgen and Mohammed, 2012).

Regarding the micro minerals, the contribution of Fe from water to the daily mineral requirement of cattle was found to be extremely high (1061%) in Akaki. In Ambo the contribution of Fe from water to the daily mineral requirement was also high, this was 65% (Table 6). The Cu content of water in Akaki, Ambo and Hoetta can contribute 2.4%, 3.1% and 4.2% to the daily mineral requirement of cattle respectively. In similar study in Jijiga, the Cu content of water could contribute about 8% to the daily mineral requirement of camel (Temesgen and Mohammed, 2012). The contribution of Mn from water to the daily mineral requirement of cattle was found to be very high (147%) in Akaki. As compared to Ambo (28%) and Holetta (5.8%) (Table 6). In similar study, the consumption of mineral water from Jiiga (Biya àda) can contribute up to 18.5% of the daily requirements of Mn for the camels. The contribution of Zn from water to the daily mineral requirement of cattle in was too high (50%) in Akaki. The contribution in Ambo (21%) and Holetta (25%) was also found to be high (table 6). In similar study in jijiga (Golajo'o) Zn content of water can contribute about 2.09% of Zn requirements of camels (Temesgen and Mohammed, 2012).

Conclusions

- There is variation in PH and mineral concentration of livestock water across the study locations. Thus, livestock water in Akaki has the highest mineral concentration and the lowest PH which was followed by Ambo and Holetta respectively.
- In some of the sub-locations sampled, extreme values of mineral concentration were recorded. This indicates that there is a wide range of variation in mineral concentration among the sub locations studied. Zero value for some mineral elements implies those elements were found to be below the detection limit of PPm.
- Mineral content of livestock water have their own contribution to the daily mineral requirements of cattle.
- Among the mineral elements studied, the concentration of potassium in Akaki and Ambo, and iron and manganese in Akaki, Ambo and Holetta were found in excessive level.

Recommendations

- For an intervention to be implemented with mineral supplementation to livestock species, the mineral status of the specific location should be taken in to consideration.
- To overcome the excessive concentration of potassium, iron and manganese in livestock water an adjustment targeting to the problematic element is required through feed/ration formulation.

- The sodium level in livestock water in Akaki and Ambo are found beyond the recommended level. Therefore, there is no need to include sodium in the feed formulation.
- Attention is required in Akaki and Ambo not to supplement feeds rich in iron and manganese to minimize the cumulative effect of these minerals coming from water and feed.
- Mineral analysis of the composition of forage feeds grown in these locations is required.

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