# PHYSICAL AND CHEMICAL PROPERTIES OF LIVESTOCK WATER IN SELECTED AREAS OF NORTHERN KENYA

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## ABSTRACT

In northern Kenya the cases of livestock water poisoning due to unsuitable levels of mineral elements in water has been widely reported. The situation had led to massive deaths of livestock. Previous efforts to understand the causes of livestock water poisoning were not comprehensive and did not ascertain chemical concentration levels in water. We investigated the various physical and chemical properties of livestock water in order to draw up possible recommendations. Random sampling of livestock water sources were done in all selected study sites. Independent sample T-test used in the analysis of parameters and significant differences accepted at $P<0.05$. The levels of Total Soluble Salts (TSS) measured as electrical conductivities and nitrates were significantly high in most water sources sampled. Heavy metals and other toxic mineral elements were nevertheless within required level concentration except Lead and Chromium. The study recommended protection water sources and livestock watering at reasonable distance from source as strategy to reduce nitrates. Further study to ascertain high levels Chromium and Lead and possible use of remedial measures was also recommended.

## INTRODUCTION

Physical and chemical properties of water determine its quality for livestock use. Water of good qualities is expected to have suitable levels of pH, temperature, metal elements, and total soluble salts (TSS). Mineral elements present in water provide nutritional benefits to livestock within the required concentration range. Above or below the required concentrations are normally considered toxic to livestock and other organisms. For example metal elements such as Zinc and Copper are essential and required for metabolic activity in the organisms at trace levels (Fatoki et al., 2002). A slight increase in their concentration levels is toxic to animals. Other minerals such as Cadmium, Lead, Mercury, Chromium, Nickel and Aluminium are non-essential and exhibit toxicity to livestock even at trace levels and therefore considered as contaminants (Bolan et al., 2003). For acceptable concentration levels of common mineral in water refer Ayers and Westcot (1994).

The cases of water for livestock having increased levels of mineral elements are not rare. Kvansnicka et al. (2005) reported high levels of nitrates in livestock water which caused 57% of herd deaths in Mexico. In New Zealand and Australia high concentration of Cadmium in livestock water affected meat quality and thus compromised country export (Bolan et al., 2003). In northern Kenya, cases of unsuitable levels of mineral elements in livestock water have also been reported. Some water sources have been found to have toxic levels of Nitrates, Arsenic and Lead making it unsuitable for livestock use *(*Mbaria et al., 2005). The situation had led to massive deaths of livestock in Kargi areas of Marsabit District (Shivoga and Coppock 2003). In this study we investigated the various physical and chemical properties of water for livestock in Kargi, Korr and Maikona areas of Marsabit District in order to establish quality status and draw up possible recommendations.

## METHODOLOGY

### Study areas

Study was conducted in Kargi, Korr, and Maikona areas of the larger Marsabit District, northern Kenya. Kargi and Korr are located in south western part of Marsabit while Maikona located in northern part. The areas are semi-desert receiving annual rainfall of less than 200mm with frequent drought

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occurrences and mean monthly temperatures of 27$^o$c -29$^o$c (Kuria *et al.,* 2005). Rainfall follows a bimodal pattern where long rains are received in March-April and short rains in October-December. Vegetation in the areas are mainly dwarf shrubs interspersed with trees or annual grasses and used for communal grazing. Soils are either volcanic or metamorphic in nature. For example, soils in Kargi area are volcanic while those in Korr area are metamorphic (Kuria *et al.,* 2004). Kargi and Korr are predominately inhabited by Rendille community whilst Maikona by Gabra community. The two communities are largely pastoralists and keep livestock species comprising of camels, goats, sheep and cattle. The mean livestock holding at household level was 38 Tropical livestock Unit (TLU) in the the year 2005 and 2006 for areas such as Kargi and Korr (Roba and Oba, 2009). Livestock keeping is however faced with a myriad of challenges, among them availability of clean and safe water in addition to frequent droughts, insecurity, poor marketing infrastructures, overgrazing and shrinking of grazing range. Safe and clean water for livestock is always perceived to be priority problem for Rendille pastoralists of Kargi and Korr areas (Shivoga and Coppock, 2003) and possibly so for the Gabra community of Maikona area. The implication of unsafe water for livestock production is usually enormous. Shivoga and Coppock (2003) gave an example of livestock loss due to poor water quality. They observed over 1,000 animal deaths soon after consuming water from a borehole in Kargi area in the year 2000.

### Data collection

### Water sampling

Main livestock water sources in the areas were listed with help of local people (water committee) and sample sources randomly selected. Source of the sampled water was marked with GPS for future reference. Visual inspection of site was done so as to note the potential contaminants around the water source. Underground water was pumped along the supply line and sufficient time given to flush out water in the pipes before sampling while direct sampling done for surface water. Deliberate mixing was done for stagnate water. Samples were collected in 1-litre plastic containers. The containers were rinsed twice with water to be sampled prior to sampling. Sample containers were filled to the brim leaving little or no air space and seal tightly with the cap. Sample containers were then labelled with name of water source, location, time of collection and date. Labelled sample containers taken to laboratory for analysis.

### Data analysis

Parameters that are perceived to be high based earlier studies conducted in the study areas and also likely cause health problem due to their high concentrations were selected for laboratory analysis. Independent sample T- test (Minitab statistical package version 14) was used to understand variation of mineral concentration in sampled water from maximum acceptable concentration limit based on FAO livestock water quality guidelines by Ayers and Westcot (1994). Tests of significance accepted at $P<0.05$.

## RESULTS

The results of this study generally presents mean concentration levels of all measured parameters for each type of livestock water in each study site compares them with maximum acceptable limit. P-values indicated shows with difference between mean concentration results and maximum acceptable limit is statistically different or not.

### Comparison of measured parameter with maximum acceptable mineral concentration limit

## DISCUSSION

### PH

The suitable pH range for livestock is 5 to 9 (Higgins *et al.,* 2008). The water sources in study areas had pH level within the required range. Tests of significance for above limit concentration were not also significant. This is contrary to the findings of Coppock and Shivoga (2003) where they found high pH levels in most water sources of Kargi areas.

### Conductivity

Conductivity measures Total Dissolved Solids (TDS) or Total Soluble Salts (TSS) in water. Maximum acceptable level of conductivity for livestock water is 2,500ppm. Most water sources had conductivity level above 2,500 ppm. Higher conductivity indicates possibility of high content of mineral such as carbonate, bicarbonate, sulphate, nitrates, chlorides, phosphate, Sodium, Chloride, Calcium and Magnesium among others (Bagley, 1997). Such water may lead to diarrhoea, reduced feed intake & reduced growth rate in cattle (Higgins *et al.,* 2008). However, these signs were not observed in the animals during sampling period

TABLE I- COMPARISON OF MEASURED PARAMETER WITH MAXIMUM ACCEPTABLE MINERAL CONCENTRATION FOR LIVESTOCK WATER SOURCES IN KORR

| Parameter Measured | Maximum Acceptable Limit (Mg/L) | Well (n=12) | | Borehole (n=4) | |
|---|---|---|---|---|---|
| | | Mean Result (Mg/L) | P-Value | Mean Result (Mg/L) | P-Value |
| PH | 9.000 pH units | 7.549 pH units | 0.000 | 7.552 | 0.000 |
| Conductivity | 2,500 Us/cm | 3117.08 Us/cm | 0.088 | 2337.5 Us/cm | 0.396 |
| Nitrate | 100 | 104.688 | 0.595 | 62.14 | 0.015 |
| Nitrite | 33 | 0.547 | 0.000 | 0.021 | 0.000 |
| Fluoride | 2 | 1.184 | 1.000 | 1.03 | 1.000 |
| Suphate | 1000 | 551.408 | 0.075 | 597.919 | 0.116 |
| Lead | 0.05 | 0.072 | 0.839 | 0.103 | 0.986 |
| Aluminum | 5 | 0.075 | 0.000 | 0.082 | 0.000 |
| Iron | 2 | 0.335 | 0.000 | 0.357 | 0.004 |
| Zinc | 25 | 0.13 | 0.000 | 0.1303 | 0.000 |
| Boron | 5 | 0.485 | .000 | 0.42 | 0.000 |
| Chromium | 0.05 | 0.0341 | 0.059 | 0.024 | 0.174 |
| Copper | 1 | 0.0683 | 0.000 | 0.085 | 0.002 |

TABLE II- COMPARISON OF MEASURED PARAMETER WITH MAXIMUM ACCEPTABLE MINERAL CONCENTRATION FOR LIVESTOCK WATER SOURCES IN KARGI

| Parameter Measured | Acceptable Limit (Mg/L) | Well (n=12) | | Borehole (n=4) | | Spring (n=2) | |
|---|---|---|---|---|---|---|---|
| | | Mean Result (Mg/L) | P-Value | Mean Result (Mg/L) | P-Value | Mean Result (Mg/L) | P-Value |
| PH | 9.000 pH units | 7.807 pH units | 0.000 | 7.095 pH units | 0.000 | 9.824 pHunits | 0.919 |
| Conductivity | 2,500 Us/cm | 1,923 Us/cm | 0.010 | 7,834 Us/cm | 0.993 | 5170 Us/cm | 0.696 |
| Nitrate | 100 | 305.33 | 0.995 | 15.672 | 0.002 | 13.01 | 0.004 |
| Nitrite | 33 | 1.203 | 0.000 | 0.0725 | 0.000 | 0.23 | |
| Fluoride | 2 | 0.713 | 0.962 | 0.735 | 0.005 | 3.525 | 0.957 |
| Suphate | 1000 | 84.017 | 0.000 | 599.745 | 0.077 | 77.35 | 0.120 |
| Lead | 0.05 | 0.062 | 0.712 | 0.1305 | 0.797 | 0.131 | 0.678 |
| Aluminum | 5 | 0.049 | 0.000 | 0.0127 | 0.00 | 0.0615 | 0.003 |
| Iron | 2 | 0.172 | 0.000 | 0.25 | 0.003 | 3.645 | 0.640 |
| Zinc | 25 | 0.0766 | 0.000 | 0.407 | 0.00 | 0.255 | 0.002 |
| Arsenic | 0.2 | 0.002 | 0.000 | 0 | 0 | 0.003 | |
| Boron | 5 | 0.365 | 0.000 | 0.790 | 0.000 | 1.36 | |
| Chromium | 0.05 | 0.0215 | 0.002 | 0.034 | 0.031 | 0.121 | |
| Copper | 1 | 0.09 | 0.000 | 0 | 0.000 | 0.06 | |

TABLE III- COMPARISON OF MEASURED PARAMETER WITH MAXIMUM ACCEPTABLE MINERAL CONCENTRATION LIVESTOCK WATER SOURCES IN MAIKONA

| Parameter Measured | Acceptable Limit (Mg/L) | Well (n=14) | | Spring (n=2) | |
|---|---|---|---|---|---|
| | | Mean Result (Mg/L) | P-Value | Mean Result (Mg/L) | P-Value |
| PH | 9.000 pH units | 8.084 pH units | 0.000 | 8.005pH units | 0.043 |
| Conductivity | 2,500 Us/cm | 4366.69 Us/cm | 0.993 | 2291 Us/cm | 0.384 |
| Nitrate | 100 | 42.375 | 0.000 | 18.77 | 0.011 |
| Nitrite | 33 | 0.384 | 0.000 | 0.006 | |
| Fluoride | 2 | 0.499 | 0.000 | 0.291 | 0.034 |
| Suphate | 1000 | 265.835 | 0.000 | 145.8 | 0.009 |
| Lead | 0.05 | 0.0702 | 0.855 | 0.0555 | 0.532 |
| Aluminum | 5 | 0.060 | 0.00 | 0.011 | 0.000 |
| Iron | 2 | 0.223 | 0.000 | 0.005 | 0.001 |
| Zinc | 25 | 0.104 | 0.000 | 0.115 | 0.000 |
| Arsenic | 0.2 | 0.0001 | 0.000 | 0.00 | |
| Boron | 5 | 0.377 | 0.000 | 0.11 | |
| Chromium | 0.05 | 0.043 | 0.172 | 0.039 | |
| Copper | 1 | 0.082 | 0.000 | 0.05 | 0.000 |

### Concentrations of nitrate and nitrite

High concentration of nitrate in water is usually associated with livestock poisoning. Nitrates are normally converted into nitrite which are absorbed into blood stream and react with haemoglobin to form methamoglobin, a product that cannot be transported by blood and causes suffocation. While nitrite concentrations in all water sources for all study sites were within the acceptable level, concentrations of nitrate in Korr and Kargi water sources were above required limit except the boreholes. Nitrate accumulation in water normally occurs when run-off collects faecal wastes into water source (Vough *et al*., 2009). Lack of protection of wells in Kargi and Korr areas coupled with livestock watering at close proximity might have led to high nitrate concentration in water. Borehole waters are protected from faecal accumulation whilst spring waters are not and therefore accumulate faecal materials (running water).

### Heavy metals concentration (Arsenic, Copper, Mercury, Cadmium, Chromium, lead, Aluminium, Zinc)

Normal concentrations of heavy metals such as Copper and Zinc are essential for usual metabolic activities of organisms but heavy metals such as Cadmium and Mercury exhibit extreme toxicity even at trace levels (Fatoki *et al.,* 2002). Generally most heavy metals considered in the analysis were within acceptable levels of concentration, except for Lead and Chromium. High mean concentrations of Chromium were observed in the water from Maikona , Kargi and Korr (both wells and borehole) whilst Lead was high in all water sources in the study areas. Concentrations of Chromium are usually caused by weathering of igneous ultramafic rocks while high Lead concentrations are caused by smelters, industries effluent, dumped lead batteries or lead-based paint (Siddiqui *et al.,* 2008). Further study on rock type and its associated mineral in the areas is necessary to ascertain the cause of high Chromium concentration. High Lead concentration could also be a subject of further research.

### Concentration of other toxic mineral elements (Boron, Suphate and Fluoride)

Mineral elements such as Boron, Sulphate and Fluoride are also toxic at high concentration levels. Excessive levels of Boron causes slow growth, inflammation and oedema of legs while excess Flouride causes loss of enamel leading starvation. High concentration of sulphate causes diarrhoea and in some instances deficiency of essential mineral such as copper in livestock body (Higgins *et al.,* 2008). The observed concentration levels for Boron, Fluoride and Sulphate in the sampled waters were however within the acceptable limits in the all study areas.

## CONCLUSION AND RECOMMENDATION

This study was conducted to understand physical and chemical properties of livestock water in arid areas of northern Kenya where cases of water poisoning were reported. Several toxic mineral elements in the water for livestock in the areas studied were investigated and comparison of their concentration levels with maximum acceptable levels made. High concentration of Total Soluble Salts (TSS) and mineral elements such as nitrates, lead and chromium were observed in most of the water sources. Fencing of water sources and livestock watering at reasonable distance from source is recommended to reduce nitrate levels in water. Further study to ascertain high levels Chromium and Lead in water and possible remedial measures such as use of water-hyacinth plant to remove chromium is recommended.

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