

Assessment of Drinking Water Quality from Different Sources in Smallholder Ruminant Production in Abeokuta, Nigeria

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Abstract
The importance of good quality water for ruminant survival and productivity in smallholder farming system is an indispensable feature for disease prevention and improving performance. This study examined the physiochemical and organoleptic properties of different water sources consumed by ruminants in smallholder farming systems. Samples of tap, well, rain, stream and borehole water were collected and analyzed. Results showed that the physiochemical properties monitored varied ($P<0.05$) across water treatments with exception of temperature that ranged ($P>0.05$) from 27.83 to 29.90^{o}C. Mineral content also varied ($P<0.05$) across water treatments with iron and magnesium having higher ($P<0.05$) content (0.39 – 1.04 mg/L and 30.24 and 32.59 mg/L), respectively, than the maximum acceptable level for most locations. The organoleptic properties across treatments comply with the standard of drinking water with exception of stream water where odour and suspended particles was observed. It was therefore recommended that routine observation and testing should be conducted to detect levels and changes in some aspects of water quality, which will allow for remedial action before too much damage or loss of production occurs.
Keywords: Drinking water, Ruminant, Physicochemical, Mineral composition, Organoleptic

1. Introduction

Drinking water for ruminants has been a relatively inexpensive and abundant resource among smallholders that combine ruminant husbandry with other agricultural and non-agricultural activities in Nigeria. Most of these ruminant producers utilize surface water as drinking water for their animals and the provision and quality of water may not be optimal to maximize animal performance and health.

Water is a nutrient of extreme importance for animals and intimately involved in a wide array of bodily functions. It serves as the universal solvent in the extracellular and intracellular compartments, as 99% of all molecules in the body (NRC, 2007). Water is necessary to sustain life, optimize growth, lactation and reproduction in animals. It is required for digestion, metabolism of energy and nutrients, transport in circulation of nutrients and metabolites to and from tissues, excretion of waste products, maintenance of proper ion, fluid and cushioning environment for developing foetus (Murphy, 1992). However, drinking water for livestock may be contaminated by a number of factors including minerals, manure, microorganisms, and algae (Megan *et al.,* 2008). These contaminants can impact the appearance, odour, and taste of drinking water as well as its physical and chemical properties which may directly impact animal health by causing disease and infection; others have a more indirect effect and may cause animals to decrease their overall water intake.

With the availability of good quality water been an indispensable feature for improving animal performance, ruminant producers need to be concerned about the provision of high quality drinking water sources for their animals so as to ensure optimal nutrition and good performance. This study therefore assesses the physical and chemical composition as well as the organoleptic properties of different water sources supplied to ruminant animals among smallholder farmers in Abeokuta, Ogun state, south west, Nigeria.

2. Materials and methods

2.1. Water samples Collection

Samples of tap, well, stream, rain and borehole water collected from different locations within Abeokuta metropolis were used for this study. The tap and well water samples were obtained from a residential building where people fetch water for domestic uses and human consumption, rainwater was harvested when it rained and stored in plastic container before it was used. Water samples were collected with sterile plastic containers and taken to the Biotechnology laboratory, Federal University of Agriculture, Abeokuta, Ogun state for chemical analysis.

2.2. Sample analysis

The physio-chemical tests of water samples determined include temperature, alkanility, total dissolved solid, pH, conductivity and chloride content. pH was measured with a pH meter (Thermo Russell instrument, Model RL150). Temperature was measured at the point of water collection using a digitron thermometer (Model 275-K). Chemical analysis of the water samples was determined using AOAC (2005). Total dissolved solids were measured using activated carbon filters; total alkalinity measured using electronic pH meters and electrical

conductivity measured using a conductivity meter.
The mineral contents of the water samples such as sodium, calcium, magnesium and iron was measured using Perkin Elmer Model 306 atomic absorption spectrophotometer. The organoleptic properties of freshly collected water samples were detected by sensory evaluation.
2.3. Statistical Analysis
All data collected were subjected to analysis variance (SAS, 1999); means were compared using the Duncan's Multiple Range Test (Duncan, 1955).

3. Results and discussion
The physical and chemical composition of water samples for ruminant production is shown in Table 1. The temperature values for the different sources of water ranged between 27^0C - 30^0C which is within the acceptable range recommended (WHO, 2003). National guidelines and standards for water quality in Nigeria also recommended (20^0C -33^0C) for aquatic life, industrial and agricultural uses (FME, 1992). Earlier reports has shown that cool water helps ruminants to maintain a proper body temperature and can increase water intake as well as animal's weight gain (Braul and Kirychuk, 2001). There are studies indicating that a drinking water temperature between 20^0C and 28^0C is the most accepted by cattle (Lanham *et al.,* 1986). Although, there is seasonal fluctuation in water temperature values as a result of the function of the climatic conditions at a particular geographical location and period. However, it should be taken into consideration that fresh water dissipates body heat better and will promote greater animal comfort in hot weather (Pereyra *et al.* 2010).
The pH level ranged from 6.78 to 7.99 across water treatments with the highest value recorded for borehole water which could be due to the fact that borehole water does not flow and its receives most of its minerals from the bottom sediments and run offs and thus giving rise to a relatively constant composition (Ipinmoroti, 2005). The varied pH levels in the water samples may be partly attributed to the differently organic matter content in the soil. However, the pH values obtained for water from different sources in this study are within the permissible limits of 6 – 9 (NRC, 1974). Adams and Sharpe (1995) suggested that water pH should fall between 5.1 and 9.0. 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 stricter pH range between 6.0 and 8.5 largely based on field observations rather than controlled studies (Braul and Kirychuk, 2001). Drinking water within this pH is said to be acceptable to ruminants and does not have any effect on ruminal pH due to the overpowering highly reductive environment of the rumen.
The total alkalinity of the water samples in this study ranged from 121.7 – 179.0 mg/l and it falls within the permissible range of 30 -500mg/l for portable water (WHO, 1993). Alkalinity is an important property governing the toxicity of metals (Ademoroti, 1996), as highly alkaline waters (pH approx. 10) will contain carbonates. Most waters have alkalinities below 800mg/l, which is measured as calcium carbonate, and is not harmful to ruminants. Water with low alkanility may tend to accelerate natural corrosion leading to water problems while excessive alkalinity in water may produce scaly incrustation on service pipes, and also can cause physiological and digestive upset in livestock.

Table 1: Physiochemical composition of water samples for ruminant production.

Parameters	Tap	Borehole	Rain	Well	Stream
Temperature (^{0}C)	29.27±0.30	29.67±0.12	27.83±0.19	29.90±0.27	28.63±0.22
pH	7.13^b±0.06	7.99^a±0.09	7.60^a±0.09	6.78^c±0.09	7.64^b±0.10
Alkalinity(mg/l)	121.7^d±0.02	140.3^c±0.02	122.7^d±0.03	179.0^a±0.03	167.0^b±0.09
Chloride(mg/l)	184.67^b±1.73	210.60^a±4.16	130.67^c±3.06	129.67^c±1.53	116.00^d±1.00
Electrical Conductivity (µmhos/cm)	289.33^d±2.08	601.67^b±11.2	374.00^d±5.19	413.67^c±4.16	802.33^a±10.6
Total dissolved solids(mg/l)	197.00^d±6.56	401.33^a±5.03	244.00^c±7.00	311.33^b±5.86	240.67^c±4.62

^{abc} Means with different superscript on the same row are significantly different ($P < 0.05$)

The chloride level of the water samples ranged between 116 – 210 mg/L. These values are within the permissible limits of the expected required standards of 250mg/l for potable water (WHO, 1993). Chlorides above 250 mg/l can impart a salty taste to water which could result in reduced water intake and milk production in ruminants. Excessive chloride levels have been found to increase osmotic pressure in the rumen (Curran and Robson, 2007). This causes a decrease in microbial population and metabolic activity, so there is a reduction in the animal's food intake.
The electrical conductivity (EC) of 289.33 – 802.33µhmos/cm obtained in this study for water sources correspond to 310 - 600.7µmhos/cm observed by Abulude, (2006) and Ipinmoroti (1997) for drinking water and fresh pond water, respectively. The stream water with the highest ($P<0.05$) EC in this study might be due to the

high amount of ionic solute in these water sources while the least EC values observed in tap water could be due to dissolved mineral matters in this water source (Ademoroti, 1996). This corroborates the findings of Folorunso *et al.,* (2011) among various water sample sources for poultry. However, the values obtained for EC in this study were higher than values reported in the streams, wells and bore-hole water in Nasarawa State, Nigeria (Aremu *et al.,* 2011) which may be due to differences in geochemical conditions and soluble ions in the locations analysed.

Total dissolved solids (TDS) values obtained for the water samples in this study ranged ($P<0.05$) from 197.00 – 401.33 mg/l. These values are within the 1000mg/l maximum permissible limits (NRC, 2005) recommended for safe drinking and pose no health problem on the animal. Overall, water with a TDS above 1,000 mg/l has the potential to cause livestock problems (Adams and Sharpe, 1995) and has been implicated to cause animals to have initial reluctance to drink resulting in scouring, with loss of production and a decline in animal condition and health would be expected. Stock may tolerate these levels for short periods if introduced gradually (ANZECC, 2000).

The mineral content of different water sources for ruminants is highlighted in Table 2. The concentration of mineral content in the different water samples varied ($P<0.05$) thus indicating lack of uniform distribution within each source of water.

Sodium ranged from 0.94 – 3.06 mg/l, with the minimum ($P<0.05$) value obtained in rain water, which could be attributed to the lower microbial activity, while the higher ($P<0.05$) values observed in well, bore hole and stream water might be due to high rate of mineralization in the sediments. The sodium concentration values obtained for the water samples are lower than the normal range for sodium level of portable water (WHO, 2003). Sodium in water is rarely problematic for ruminants, however, high sodium level in water has been found to affect reproduction in female animals (WHO, 2003).

Table 2: Mineral content (Mg/l) of drinking water samples in ruminant production.

Parameters	Tap	Borehole	Rain	Well	Stream
Sodium	$0.94^{c} \pm 0.07$	$2.83^{b} \pm 0.01$	$0.28^{d} \pm 0.03$	$3.06^{a} \pm 0.10$	$2.80^{b} \pm 0.43$
Calcium	$86.15^{a} \pm 4.61$	$72.04^{b} \pm 0.00$	$70.55^{b} \pm 0.03$	$70.89^{b} \pm 0.03$	$72.31^{b} \pm 0.02$
Iron	$0.77^{b} \pm 0.08$	$0.58^{bc} \pm 0.07$	$0.48^{c} \pm 0.02$	$1.04^{a} \pm 0.05$	$0.39^{c} \pm 0.02$
Magnesium	$32.59^{a} \pm 0.05$	$32.11^{c} \pm 0.94$	$30.24^{e} \pm 0.03$	$31.65^{d} \pm 0.03$	$32.48^{b} \pm 0.08$

^{abc} *Means with different superscript on the same row are significantly different (P < 0.05)*

Iron was found in all water samples with the range of 0.39 – 1.04 mg/l which is higher than the permissible limit of 0.3mg/l stipulated for drinking water. The first concern is that high iron in drinking water may reduce palatability and therefore reduce the amount of rate of intake. The values observed for the water samples with high concentration are expected because it has been reported that iron occurs at high concentration in Nigeria soils (Nwajei and Gagophien, 2000, Asaolu and Olaofe, 2004). However, the values obtained in this study corroborates the reports of Ibitoye (1996) and Folorunsho *et al.* (2011) for high content of iron in water from different sources in other parts of Nigeria. The high iron concentration observed in well water might be due to the run-off water from iron containing materials, while the problems of burst pipes might have been responsible for the high iron values found in tap water (Lande, 1977). High levels of soluble iron are usually associated with deep bores and dams where oxygen supply is limited. Iron is soluble in water where there is little or no oxygen. Aeration oxidizes the iron, forming solid particles that can then settle out of solution. This justifies the lower content of iron observed in rain and stream water in this study.

Calcium content for water samples in the present study was within the acceptable recommended level (WHO 1993). The higher calcium level observed in tap water could be due to the presence of chlorine and alum used in treating this water source (Abulude, 2004) suggesting it's desirability for drinking without any adverse effect on consumers.

Magnesium level of water samples were a little above the recommended level of 30mg/l for drinking water. Higher concentrations of magnesium have been reported to be found sometimes in drinking water (Beede, 1992). Hardness is mostly a measure of the calcium and magnesium in water. Hard water causes many aesthetic problems with the use of the water, such as restricted water flow from mineral deposits, but it generally does not adversely affect ruminants. However, no studies in literature have reported the negative response of animal to high concentration of either calcium or magnesium.

The organoleptic properties of sampled water are shown in Table 3. All water sampled comply with the standard of drinking water with exception of stream water where the presence of suspended particles and odour were observed. Within the context of water quality, sediment is perhaps most significant as a carrier of pollutants (pathogens, nutrients, chemicals), but in excess can be a pollutant itself. Natural events, soil properties, topography, climate, and vegetation have been reported to influence sediment production.

Table 3: Organoleptic properties of water sources for ruminant production

Water samples	Colour	Odour	Taste	Presence of particles
Tap	Colourless	Odourless	Tasteless	None
Well	Colourless	Odourless	Tasteless	None
Rain	Colourless	Odourless	Tasteless	None
Bore hole	Colourless	Odourless	Tasteless	None
Stream	Creamy	Not offensive	Soar	Suspended

The colour, taste and odour found in stream water source may be as a result of suspended matter, algae, organic wastes and chemical pollutants. Odour and presence of toxic compound may affect acceptability and palatability of drinking water as well as animals digestive and physiological functions once consumed (Beedee, 1992). Some researchers speculate that cattle are sensitive to certain taste and odours as they have been found to respond differently to various water types.

4. Conclusion

Conclusively, this study presents the mineral content, physiochemical and organoleptic properties of water sources for drinking in smallholder ruminant production system in Abeokuta, Nigeria. The results shows that quality of drinking water for ruminant animals differed across water sources with most of the parameters determined not exceeding the permissible limit of the World Health Organization. Iron and magnesium had higher content than the maximum acceptable level for most locations with odour and suspended particles observed in stream water. It is therefore recommended that a water management plan be developed to document seasonal and annual trends of water quality across a few years where routine observation and testing can be conducted to detect levels and changes in some aspects of water quality, which will allow for remedial action before too much damage or loss of production occurs.

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