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Impact of total dissolved solids in drinking water on nutrient utilisation and growth performance of Murrah buffalo calves

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ABSTRACT

This study was carried out to evaluate the effect of total dissolved solids (TDS) in drinking water on nutrient intake, utilisation and performance of growing Murrah buffaloes under tropical climatic conditions (maximum ambient temperature (T_{max})=10–42.6 °C; relative humidity (RH)=10-100%). Twenty male Murrah buffalo calves were divided according to body weight (BW=220 ± 36 kg) into 5 groups viz. 557, 2571, 4467, 6113 and 8789 which were offered water containing TDS 557, 2571, 4467, 6113 and 8789 mg/L, respectively for a period of 165 days. Animals in all groups were offered a total mixed ration (crude protein=10.3% and metabolisable energy=8.6 MJ/kg dry matter) prepared from green oats, concentrate mixture and wheat straw in 20:35:45 proportion daily. Results revealed an increase in the concentrations of calcium (Ca), magnesium (Mg), sodium (Na) and chloride (Cl) ions with increasing levels of TDS in drinking water. Daily drinking water (L/100 kg BW) and dry matter intake (kg/100 kg BW) decreased ($P < 0.05$) by 36.1% and 17.2% in group 8789 as compared to group 557. Similarly, average daily gain (g/d) and nitrogen intake (g/d) was lower ($P < 0.05$) in groups 6113 and 8789 in comparison to all other groups. However, nutrient digestibility and concentration of major minerals (Na, Ca, K and Mg) in plasma showed non significant differences among the groups. Overall it can be concluded that TDS level > 4500 mg/L in drinking water adversely affected water and feed intake which ultimately resulted in reduced growth performance of Murrah buffalo calves.

1. Introduction

An adequate supply of good quality water is often considered a limiting factor for all animals to maintain their optimal health and productivity (Meyer and Casey, 2012; Kumar et al., 2016; Ansorge et al., 2016). However, availability of clean and potable water resources is on decreasing trend globally due to salinity intrusion resulting from changing precipitation patterns and increased ground water abstraction (Jeppesen et al., 2015). Moreover, in the near future, there would be an additional pressure on availability of land, water and energy resources to meet increased demands of dairy, meat and eggs in response to increasing world population (Makkar, 2016). Usually, under tropical climate (high temperature and humidity), availability of clean and good quality water for animals is restricted (Casamassima et al., 2008; Nejad et al., 2014). Furthermore, as maximum ambient temperature (T_{max}) tends to be higher in such climate, water requirement of animals is further elevated (Sharma et al., 2016a).

Water salinity/total dissolved solids (TDS) is one of the principal factors affecting water quality (NRC, 2001; Sharma et al., 2016b). Water having higher TDS has been found to cause detrimental effects on animal health due to its adverse effect on feed intake, absorption and its utilisation (Meyer and Casey, 2012). On the other hand, currently in many parts of the world, ruminants are being reared on drinking water containing higher concentrations of TDS (FAO, 2007). Hence, it is necessary to identify detrimental effects of this poor quality available water on animal's performance, find ways to make it acceptable for ruminants particularly reared under extreme environmental conditions and determine the upper safe level of TDS that can be tolerated by animals for sustainable production (Beede, 2012; Capper and Bauman, 2013). Thus, the hypothesis was planned to elucidate the impact of saline water on water consumption, nutrient intake and utilisation as well as to determine the levels of TDS in drinking water that may affect performance of Murrah buffalo calves under tropical climate.

2. Materials and methods

2.1. Location and meteorological data

The present study was conducted after clearing the approval of Institute Animal Ethics Committee (IAEC) of ICAR-National Dairy

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Table 1
Environmental variables observed during the growth trial.

Variable	Mean ± SE	Range
Maximum temperature (T_{max}) (°C)	24.6 ± 0.6	10.0–42.6
Minimum temperature (T_{min}) (°C)	11.4 ± 0.4	2.0–24.5
Dry bulb temperature (morning) (°C)	13.8 ± 0.5	3.6–29.0
Wet bulb temperature (morning) (°C)	13.2 ± 0.8	3.6–136.4
Dry bulb temperature (evening) (°C)	23.5 ± 0.6	0.8–41.2
Wet bulb temperature (evening) (°C)	16.8 ± 0.3	9.0–25.0
Relative humidity (morning) (%)	87.6 ± 1.0	40.0–100.0
Relative humidity (evening) (%)	50.8 ± 1.6	10.0–100.0
Rainfall (mm/d)	1.4 ± 0.6	0–98.8
Sunshine (h)	6.1 ± 0.3	0–11.1
Wind speed (km/h)	3.7 ± 0.2	0.2–14.3

Research Institute, Karnal, India, situated at an altitude of 250 m above mean sea level and latitude and longitude position being 29° 42′′ N and 79° 54′′ E, respectively. All the climatic variables like maximum ambient temperature (T_{max}), minimum ambient temperature (T_{min}), relative humidity (RH), dry and wet bulb temperature, wind speed and sunshine hours were recorded at 0722 and 1422 h (Table 1) at meteorological laboratory situated at ICAR-Central Soil Salinity Research Institute, Karnal, India.

2.2. Animals, treatments and feeding management

Twenty male Murrah buffalo calves, based on body weight (BW) were assigned to five treatment groups (average BW=220 ± 36 kg) for a period of 180 days (winter=14th November 2014 to 31st March 2015; summer=1st April 2015 to 14th May 2015). Animals in different treatment groups 557, 2571, 4467, 6113 and 8789 were offered varying levels of TDS (mg/L) i.e., 557, 2571, 4467, 6113 and 8789, respectively, in drinking water. All animals were tethered individually using nylon rope in a well-ventilated shed having facilities for individual feeding with an adequate floor space of minimum 2 m^2 for each animal. All calves were raised in the same environment and none of them had prior exposure to saline water. Calves were acclimatised to feeding, experimental and environmental conditions for a period of 15 days before feeding trial and medicated orally with anthelmintics to combat any parasitic infestation. Thereafter, they were subjected to respective water treatments for a period of 165 days. All groups were fed total mixed ration (TMR; crude protein (CP)=10.3%; metabolisable energy (ME)=8.6 MJ/kg dry matter (DM)) prepared by hand mixing of green forage (oats, chopped to 2–4 cm), concentrate mixture and wheat straw (threshed to 1–2 cm) in 20:35:45 proportion daily in the morning at 1000 h to fulfill requirements (ICAR, 2013). Concentrate mixture (CP=19.9%; ME=12.3 MJ/kg DM) comprising of maize 33%, pearl millet 5%, groundnut cake 18%, cottonseed cake 5%, mustard cake 10%, wheat bran 20%, deoiled rice bran 6%, mineral mixture 2% and salt 1%.

2.3. Preparation of different TDS levels

Naturally available underground high saline water (TDS=8789 mg/L) was collected through borewell from ICAR-Central Soil Salinity Research Institute, Nain farm, Haryana, India. The underground water (TDS=557 mg/L) available at farm was used as control (557 group). Different levels of TDS were prepared by diluting borewell water with farm underground water in 25:75, 50:50 and 75:25 ratio daily and the level of TDS was checked with the help of portable instrument (TDStester 11+, Eutech company) at the time of preparation. Water samples of each treatment were collected every fortnight (here onwards referred to as two-week period) in order to analyse ionic composition and microbial contamination.

2.4. Chemical analyses of water and mineral estimation

Water samples were taken in 500 mL sterile plastic bottles at two-week period and analysed for pH (Eco tester pH meter), TDS (conductivity method; ES & D model 76 conductivity meter and TDSTestr11+ Eutech company) and hardness as calcium carbonate equivalent [calculated as (Ca×2.5)+(Mg×4.1); #773.52]. Na and K were estimated by flame photometer, while other minerals like Ca, Mg, Cl and HCO_3 were analyse using colorimetric and volumetric methods (AOAC, 2005). Microbial contamination for *Escherichia coli* was evaluated by most probable number (MPN; #966.24) method (AOAC, 2005).

2.5. Water intake, dry matter intake and body weight

All groups were offered ad libitum drinking water of particular TDS level twice daily using calibrated buckets (25 L capacity) of polyvinyl chloride (Cello®, India) at 0930 and 1630 h. Individual drinking water intake (DWI) was recorded daily by comparing amount of water offered and left in the bucket. Feed and residue samples were dried at 60 °C for 48 h in a hot air oven till a constant weight and daily dry matter intake (DMI) was estimated individually by subtracting the residue left from feed offered at 24 h interval. All animals were weighed at the beginning of the study and then two-week period to know changes in the BW on an electronic weighing balance before feeding and watering. Two-week period average daily gain (ADG) of each animal was calculated individually by subtracting final BW from initial weight and dividing it by fifteen.

2.6. Metabolism trial

A metabolism trial of 10 days duration was conducted to estimate nutrient digestibility and balance/retention of nitrogen (N), water, Ca, Na, K and Mg in mid of growth trial (from 1st March to 10th March 2015; T_{max} °C=22.8 ± 0.8; RH %=76.1 ± 1.8). All calves were shifted to metabolism cages having arrangements for separate collection of faeces and urine. Collection of feed, residues, urine and faeces were done daily for 7 days, after initial 3 days of adaptation period. Faeces voided during 24 h were collected with the help of shovel in a plastic container (to avoid metal contamination) separately for all animals and weighed daily in the next morning at 0700 h. After thorough mixing, approximately 0.5% of total faeces on weight basis were kept for DM estimation and known quantities of faecal samples were stored in plastic containers having 30 mL of 25% (v/v) sulphuric acid (H_2SO_4) solution for N estimation. Total urine output for 24 h was collected in plastic container and measured daily at 0730 h. Thereafter, an aliquot (1/500th of total output) was taken for the N estimation in plastic containers having 25 mL of 50% H_2SO_4. Aliquots (1/500th of total output) of urine were also collected, pooled and frozen for later mineral analysis. DM content of urine was also determined by drying a 3 mL urine sample at 60 °C for 12 h in silica crucible. The samples of feed, residue and faeces were further processed to analyse ether extract (EE; # 920.39), neutral detergent fibre (NDF; # 2002.04), acid detergent fibre (ADF; # 973.18), acid detergent lignin (ADL; # 973.18), total ash (# 942.050), CP (# 984.13) (AOAC, 2005). Neutral detergent-insoluble protein (NDICP) and acid detergent-insoluble protein (ADICP) were estimated as per the methods of Licitra et al. (1996). Total digestible nutrient (TDN) and ME content of TMR were calculated (NRC, 2001).

2.7. Apparent mineral and water balance

Total water intake (TWI) was estimated as sum of DWI, feed water intake (FWI = DMI × moisture content of TMR) and metabolic water (calculated according to Taylor (1970) using the factors 0.62, 0.42 and 1.10 for digestible carbohydrates, protein and fat, respectively). Thereafter, apparent water balance was estimated by subtracting total water loss through urine and faeces from TWI. Blood, urine, dried feed