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High-salinity water as a cause of salt poisoning in livestock: two case studies in Northwestern Argentina

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Abstract
This study aims to describe two outbreaks of salt poisoning in cattle and buffalo associated with the consumption of high-salinity water in northwestern Argentina. In both cases, elevated salinity in drinking water was associated with high mortality rates. In Santiago del Estero, calves that drank from an old well with high salinity experienced a mortality rate of 38%. Similarly, in San Pedro de Jujuy, buffalo and bulls exposed to saline water sources showed mortality rates of 10.8% and 13% mortality rates, respectively. Clinical signs included dehydration, diarrhea, and marked neurological symptoms such as ataxia and seizures. Postmortem examination revealed severe dehydration and mild brain lesions characterized by spongiosis and pseudolaminar necrosis, along with generalized vascular congestion and reactive changes in the capillary walls. Biochemical analyses confirmed elevated sodium concentrations in both serum and cerebrospinal fluid (CSF), supporting the diagnosis of salt intoxication. Water samples collected from the affected sites revealed total dissolved solids and salt concentrations significantly exceeding safe thresholds, underscoring the critical importance of water quality monitoring to prevent such toxic events in livestock.

Key words: quality water, nervous disease, water deprivation, sodium-chloride poisoning, ruminants.

Agua con alta salinidad como causa de intoxicación por sal en ganado: dos estudios de caso del Noroeste de Argentina

Resumen. Este estudio tiene como objetivo describir dos brotes de intoxicación por sal en bovinos y búfalos asociados al consumo de agua de mala calidad en el Noroeste argentino. En ambos casos, se vinculó la elevada salinidad del agua de bebida con altas tasas de mortalidad. En Santiago del Estero, se registró una incidencia del 38% de terneros que consumían agua de un pozo con alto contenido salino. De manera similar, en San Pedro de Jujuy, búfalos y toros expuestos a fuentes de agua salinizada registraron tasas de mortalidad del 10,8% y 13%, respectivamente. Los signos clínicos incluyeron deshidratación, diarrea y síntomas neurológicos marcados, como ataxia y convulsiones. Los hallazgos *post mortem* revelaron deshidratación severa y lesiones cerebrales leves, consistentes con espongiosis y necrosis pseudolaminar, acompañadas de congestión vascular generalizada y reacción de los capilares. Los análisis bioquímicos confirmaron niveles elevados de sodio en suero y líquido cefalorraquídeo, lo que respaldó el diagnóstico de intoxicación por sal. Las muestras de agua tomadas de los sitios afectados mostraron concentraciones de sólidos disueltos totales y sales muy por encima de los límites seguros, lo que resalta la importancia crítica de la calidad del agua para prevenir este tipo de eventos tóxicos en la producción animal.

Palabras clave: calidad de agua, enfermedades nerviosas, privación de agua, rumiantes.

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INTRODUCTION

Water is an essential nutrient and critical for maintaining acceptable animal production levels (Martinez Beltran and Manzur 2005, Lopez et al. 2016). The quantity and quality of water required vary between animal species and are influenced by environmental factors, such as seasonal changes in pasture, food and water availability, and temperature (Wagner and Engle 2021, Burkhardt et al. 2024). One key factor determining water quality is salinity, which is measured by total dissolved solids (TDS) (Lopez et al. 2016). Elevated levels of certain inorganic ions such as calcium, magnesium, sodium, chloride, sulfate, and bicarbonate in animal drinking water can have adverse effects, leading to reduced performance, poor health, or even death (El-Mahdy et al. 2016, Giri et al. 2020). TDS includes all salt ions dissolved in water, such as sodium, calcium, magnesium, chloride, sulfate, and carbonate, measured in milligrams per liter (mg L^{-1}) (Martinez Beltran and Manzur 2005).

Water intoxication, also known as sodium chloride poisoning, can result from an excessive intake of sodium chloride (direct salt poisoning) or an inadequate intake of fresh water (indirect salt poisoning). Often, it is a combination of the two. (Assad and El-Sherif 2002, Gupta 2012). The level of NaCl in drinking water that meets physiological needs without causing toxicity is typically less than 0.5%. It's worth noting that dissolved NaCl is more toxic than the solid form because it is more easily absorbed (George and Van Metre 2009, Senturk and Huseyin 2004). Water deprivation plays a critical role in the development of salt poisoning, since animals with limited access to fresh water may ingest large volumes of high-salinity water once it becomes available. Though animals can often adapt to moderately saline water if they acclimate gradually, sudden consumption after a period of thirst markedly increases the risk of intoxication. (Pearson and Kallfelz 1982). This paper describes two outbreaks of water intoxication in cattle and buffalo, associated with the consumption of high-salinity water.

MATERIAL AND METHODS

On December 7, 2022, the Specialized Veterinary Diagnostic Service (SDVE) of INTA-SALTA conducted a diagnostic visit at a livestock farm in Bandera Bajada, Santiago del Estero, Argentina (Case 1). The consultation was prompted by the death of a significant number of calves weighing approximately 190 kg/LW that arrived from a field about 200 km away. The calves were separated by gender at loading and kept apart at the destination field. The females had access to water from a recently dug well, while the males (n = 82) drank from an Australian tank filled with water from an old well about 25 days prior to the animals' arrival. Both groups arrived in the field between 1:00 p.m. and 2:00 p.m. on Friday, December 2. One day after their arrival, several animals in the male group began showing clinical signs. All of the deaths occurred in this group, with 32 out of 83 animals dying resulting in a mortality rate of 38% (32/83). In contrast, no animals in the female group were affected. During the outbreak, ambient temperatures ranged from 32 °C to 42 °C, with an estimated relative humidity between 40% and 60%. Under these conditions, the temperature-humidity index (THI) ranged from approximately 82 to 91, indicating moderate to severe heat stress for Braford cattle. This may have contributed to increased water intake. The second case (Case 2) occurred on January 25, 2023, at a mixed cattle and buffalo ranch in San Pedro de Jujuy, Argentina. A group of 250 buffalo and 22 adult bulls shared a paddock with two water sources: a stream running through the field and a cistern drinker that was replenished daily with water from another field. The animals had access to both sources of water. Within 24 hours, three bulls were found dead. Over the next 48 hours, several additional animals showed clinical signs. The outbreak resulted in a total of 27 deaths among the buffalo. The cumulative incidence was 13.6% in bulls (three out of 22) and 10.8% in buffalo (27 out of 250). Ambient temperatures during the outbreak ranged from 28 °C to 36 °C, with relative humidity levels typical of the region (60% to 80%). Based on these values, the calculated temperature-humidity index (THI) ranged from 77 to 92, indicating moderate to severe heat stress conditions.

Both necropsies were performed using the methodology established by our laboratory (Micheloud 2025). During the procedures, tissue samples were collected in 10% neutral-buffered formalin, and cerebrospinal fluid was obtained via atlanto-occipital puncture prior to decapitation. The histological samples were processed using standard techniques: paraffin embedding, microtomy, and hematoxylin and eosin staining. Water samples were collected directly from the animals' drinking sites using clean containers designated for this purpose. These samples were sent to accredited laboratories for chemical and physicochemical analyses according to the procedures outlined in the manual Procedimientos analíticos: aguas de riego y consumo animal (Melgratti 2005).

RESULTS AND DISCUSSION

The main features of acute salt intoxication in cattle are central nervous system and gastrointestinal disturbances (Assad and El-Sherif 2002, Gupta 2012), consistent with observed during both outbreaks herein analyzed. In outbreak 1, many animals exhibited various clinical signs ranging from spontaneous convulsions and severe depression to marked dehydration and diarrhea. Some animals were found dead near the drinking site (Figure 1A), while others, particularly buffalo, showed prominent neurological and gastrointestinal signs, including ataxia, circling, blindness, convulsions, partial paralysis (Figure 1B) and diarrhea. These symptoms are consistent with those previously reported (George and Van Metre 2009, Al-Saad et al. 2021, Thompson 2025). In outbreak 2, involving bulls and buffalo, no clinical signs were observed in the cattle because the bulls were found dead at the time of examination. The expulsion of water through the nostrils and mouth in recumbent animals, forming puddles (Figure 1C), suggests regurgitation and possible terminal brainstem dysfunction. Death occurred within 12 hours following seizures, although some animals remained symptomatic for several days. Clinical signs included marked depression and diarrhea, which is consistent with the variable course described in the literature (Senturk and Huseyin 2004).

Figure 1. Clinical and pathological findings of salt poisoning in cattle and buffaloes. **A)** Several dead animals near the water stream. **B)** Buffaloes exhibited neurological signs, such as head pressing, indicative of forebrain dysfunction. **C)** Dorsal view of the buffalo brain showing separation of the cerebral hemispheres and sulci due to turgidity caused by edema. **D)** Brain tissue revealed mild pseudolaminar necrosis and diffuse cerebral spongiosis. The insert shows a vascular reaction. H&E. 20x.

External examination of both cattle and buffalo revealed dehydration and evidence of paddling. In outbreak 1, three cattle were clinically examined, while in outbreak 2, two buffalo underwent clinical assessment. During the field visit, three animals—two from outbreak 1 (both cattle) and one from outbreak 2 (a buffalo)—were euthanized and subjected to necropsy. The cattle's gastrointestinal contents were greenish and watery, but rumen changes were absent. Both animals exhibited diffuse congestion and edema of the brain. Notably, the lesions were confined to the gray matter of the brain. Histopathological lesions included mild laminar cortical necrosis and diffuse spongiosis, characterized by vacuolation of the neuropil and the presence of a few eosinophilic neurons. These findings suggest early neuronal injury (Figure 1D). These findings are consistent with acute or peracute polio encephalomalacia associated with sodium intoxication (Trueman and Clague 1978, Njoroge et al. 1997, Thompson 2025), though severe parenchymal destruction and marked cerebral edema were not evident. Vascular changes, such as mild arteriolar necrosis and perivascular inflammatory infiltrate, were also present, supporting the presence of cerebrovascular damage associated with hypernatremia.

A biochemical analysis of serum and cerebrospinal fluid (CSF) was performed on three animals. The study revealed hypernatremia, with serum sodium levels ranging from 166 to 170 mEq L^{-1} and CSF sodium levels ranging from 178 to 194 mEq L^{-1} (see Table 1). Although the CSF/serum sodium ratio was slightly above 1 in all tested animals – a parameter often considered suggestive of salt intoxication (Njoroge et al. 1997, Gupta 2012, Thompson 2025), the difference was modest and not conclusively diagnostic. Depending on the timing of sampling and progression of intoxication, this ratio may equilibrate. Therefore, diagnosis is best supported by a combination of clinical signs (e.g., head pressing and paddling), epidemiological context (e.g., limited access to water and high salinity levels), and pathological findings. Although direct measurement of sodium in brain tissue was not possible, biochemical data provide additional support when considered in the context of the broader clinical picture.

Water quality analysis revealed marked differences between sources connected to animals showing disease and those not exhibiting any signs. Water samples, associated with animals showing diseases, showed elevated levels of total soluble solids, electrical conductivity, chlorides, and sulfates at sites or paddocks where the animals died (Table 2). These values exceeded the recommended thresholds for cattle (López et al. 2016). These results underscore the importance of identifying and monitoring the water sources used by livestock since different sources (e.g., wells, tanks, and natural streams) can have significantly different chemical compositions. Interestingly, the high-salinity water that caused the buffalo outbreak originated from a natural watercourse. This is an unexpected finding, as such sources are generally considered safer than stagnant or

confined supplies. This highlights the need for conducting site-specific water quality assessments, especially during droughts or when access to alternative drinking sources is limited. These findings are consistent with salt intoxication caused by excessive saline water ingestion, particularly after water deprivation or exclusive access to contaminated sources (Buck and Ewan 1973, El- Mahdy et al. 2016). While sodium intoxication has been reported in species such as pigs, sheep, goats, and cattle, few reports exist for buffalo (Fukui et al. 2015, Duarte et al. 2019, Al-Saad et al. 2021). The pronounced neurological signs and mortality observed in buffalo during this event suggest that this species may be more susceptible to salt intoxication than recognized.

Table 1. Serum and cerebrospinal fluid (CSF) sodium concentrations in affected animals from Case 1 and Case 2.

Case	Register number/animal	Serum Na (mEq L^{-1})	CSF Na (mEq L^{-1})	CSF Na / Serum Na	Reference Values (mEq L^{-1})*
1	HP 1723/Cattle	170	194	1.14	136-144
	HP 1724/Cattle	166	183	1.10	136-144
2	HP 1735/Buffalo	169	178	1.05	136-144

*Latimer (2011). Patología Clínica Veterinaria. pp. 418. CSF = cerebrospinal fluid. All measured values exceeded the reference range (136-144 mEq L^{-1}), with CSF sodium consistently higher than serum sodium, supporting the diagnosis of salt poisoning.

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Table 2. Physicochemical characteristics of water samples from affected farms in Case 1 (Santiago del Estero) and Case 2 (San Pedro de Jujuy).

Water sources	Case 1		Case 2	
	Well Water (new)	Well Water (old)	Stream	Water tank
Total Soluble Solids (mg L^{-1})	5645	15950	12168	1196
Electrical conductivity (µS cm^{-1})	8800	25416	18900	2010
pH	7.71	8.35	8.2	7.2
Chlorides (Cl) (mg L^{-1})	46.93	1666	1450	35.9
Sulfates (SO_4) (mg L^{-1})	37.00	1776	1469	331.30

Elevated levels of total soluble solids, electrical conductivity, chlorides, and sulfates were observed in several sources, particularly the old well water and stream, indicating poor water quality and supporting the diagnosis of salt poisoning.

The environmental conditions during both outbreaks included ambient temperatures ranging from 28 to 42 °C and relative humidity ranging from 40% to 80%. This resulted in a THI of approximately 77-92, consistent with moderate to severe heat stress in cattle and buffalo (Sharma et al. 2023). Heat-stressed animals markedly increase their water intake, especially when they are deprived of water or competing for scarce resources. This increases the risk of salt intoxication if only saline sources are available. Although buffalo possess adaptive traits such as wallowing and darker skin, they still exhibit an altered fluid and electrolyte balance under thermal stress. This includes significant sweating and elevated respiratory water loss, stimulating thirst (Marai and Haeeb 2010). In this case, providing only a natural water source with unexpectedly high salinity likely caused excessive ingestion and subsequent salt intoxication, highlighting the need to assess not only the presence of water sources but also their origin and chemical composition, particularly during heat events that predispose cattle and buffalo to water-electrolyte imbalance.

In summary, the gathered evidence confirms that sodium toxicity in livestock is closely associated with excessive salt intake and inadequate water availability. Outbreaks of salt intoxication can occur under various circumstances, such as when animals consume saline water or management practices allow salt to accumulate in water sources. Clinical signs in cattle and buffalo predominantly

affect the gastrointestinal and neurological systems, and postmortem findings support a diagnosis of salt toxicosis. While brain sodium levels could not be determined in this study, the observed hypernatremia in serum and cerebrospinal fluid (CSF), along with a CSF/serum sodium ratio greater than one, provided strong diagnostic support, consistent with previously published data. These results underscore the importance of controlling water quality and properly managing animals to prevent this preventable yet potentially fatal condition.

In conclusion, the combination of clinical signs, gross and microscopic lesions, serum and CSF hypernatremia, and the identification of high-salinity water sources provides a consistent picture of salt intoxication as the cause of morbidity and mortality in these outbreaks. These findings underscore the importance of monitoring water quality and ensuring adequate water availability, especially under conditions conducive to salt accumulation in water sources.

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