Sodium Ion Poisoning in Livestock From Oil Field Wastes

C. P. McCoy, *D. V. M.*
W. C. Edwards, *D. V. M.*
Oklahoma Animal Disease Diagnostic Laboratory
Oklahoma State University
Stillwater, Oklahoma 74078

Sodium ion toxicity can be encountered when livestock consume large amounts of salt in feed or water followed by a period of water deprivation and/or water engorgement. One source of salt to livestock is from fluids accumulated around petroleum production sites. These fluids are often accessible and cattle will drink them if other fresh water sources are limited or are not available.

Crude oil is often pumped out of the ground as a mixture of oil and salt water (5). The production fluid of some wells may be more than 95% salt water. The concentration of sodium chloride ranges from 5,000 ppm to more than 200,000 ppm with the average about 40,000 ppm (4). For comparison, sea water contains about 20,000 ppm sodium chloride. Nine samples of fluids collected around oil wells in pastures in which cattle had access to the fluids were analyzed at the Oklahoma Animal Disease Diagnostic Laboratory. The average salt concentration was 43,000 ppm (see Table 1).

Table 1
Salt Concentration of Oil Field Wastes

	Type of Material	Total Soluble Salts (ppm)
1.	Slush pit material	100,000
2.	Slush pit material	10,000
3.	Drilling mud	28,000
4.	Polluted pond water	10,200
5.	Gastrointestinal contents of a suspected salt toxicity case	50,000
6.	Polluted pond water	8,000
7.	Disposal well	11,500
8.	Polluted pond water	90,000
9.	Fluid around well accessible to cattle	80,000
10.	Slush pit water	96,000
11.	Fluid from broken injection pipe	75,000

Disposal of salt water presents a potentially serious environmental pollution problem. Solar evaporating ponds provide a temporary solution but the residue salts remain as a potential polluter. Flooding of slush pits and evaporation ponds is another potential source of brine contamination of fresh water supplies.

Subsurface injection of brine into porous and permeable strata has been a good method of disposal but this method also has several potentially serious drawbacks. It is possible that high pressure subsurface injections of fluids could cause earthquakes (4). Also, naturally occurring earthquakes could produce new faults or fractures in subsurface strata, allowing contamination of the fresh water aquifer by the deposited waste pool.

Thus, spillage of brine fluids from surface disposal ponds (slush pits), evaporation ponds, from salt water injection systems, or access of livestock to unprotected disposal ponds can result in livestock consumption of petroleum-associated brine solution.

Salt water concentration above 7,000 ppm are not recommended for most livestock (6). Water containing greater than 10,000 ppm salt can cause sodium ion toxicity if circumstances resulting in water deprivation and/or subsequent water engorgement should occur. Clinical signs of acute sodium ion toxicity in cattle include both that of gastrointestinal irritation and central nervous system impairment. Vomiting, diarrhea, mucoid feces, abdominal pain, anorexia, thirst, salivation and polyuria are often seen. Nervous system signs may include knuckling, blindness, muscular spasms, paresis and convulsions (7,2).

Chronic ingestion of water containing greater than 7,000 ppm sodium chloride can affect herd health and performance. Pregnant or lactating animals are especially susceptible to stress such as that of ingestion of water containing borderline safety concentration or greater of salt (see Table 2). The possible effects of high salt concentrations on rumen microorganisms and rumen functions have not been thoroughly investigated.

The following summarizes one theory of sodium ion toxicity (1). Sodium diffuses passively from the plasma to the cerebrospinal fluid. However, passage from the cerebrospinal fluid to plasma involves active transport requiring energy. Increased sodium levels in the blood diffuse passively into the cerebrospinal fluid. At these elevated concentrations, sodium inhibits anaerobic

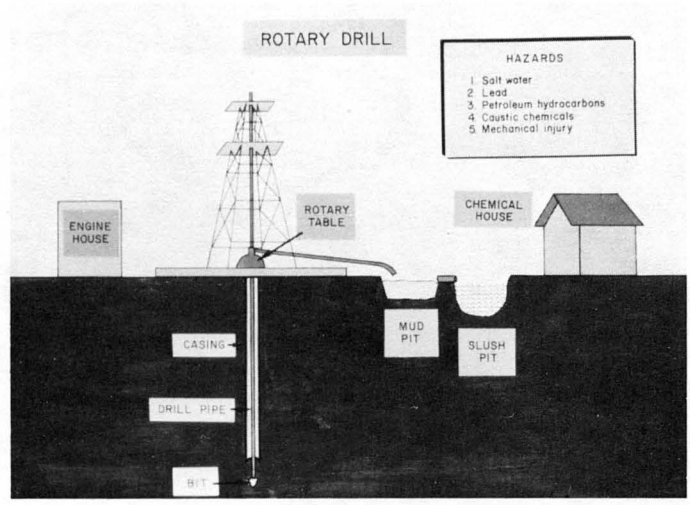
glycolysis resulting in reduced energy production. This reduction in available energy inhibits the active transport of sodium back into the bloodstream. When hydration of the animal occurs, sodium in the plasma is diluted and returns to normal osmotic levels. Because of the lack of active transport the sodium levels in the cerebrospinal fluid remain elevated. This produces an osmotic gradient between the two compartments which favors passive diffusion of water into the central nervous system, resulting in cerebral edema. This theory explains the presence of cerebral edema and central nervous system signs but does not explain the presence of eosinophils in the cerebrum of swine affected with sodium ion toxicity.

Table 2

A Guide to the Use of Saline Waters for Livestock

Total Soluble Salts Content of Waters (mg/liter)	Comment
Less than 1,000	These waters have a relatively low level of salinity and should present no serious burden to any class of livestock.
1,000 - 2,999	These waters should be satisfactory for all classes of livestock. They may cause temporary and mild diarrhea in livestock not accustomed to them, but should not affect their health.
3,000 - 4,999	These waters should be satisfactory for livestock, although they might very possibly cause temporary diarrhea or be refused at first by animals not accustomed to them.
5,000 - 6,999	These waters can be used with reasonable safety for dairy and beef cattle, sheep, swine, and horses. It may be well to avoid the use of those approaching the higher levels for pregnant or lactating animals.
7,000 - 10,000	These waters are probably unfit for swine. Considerable risk may exist in using them for pregnant or lactating cows, horses, sheep, the young of these species, or for any animals subjected to heavy heat stress or water loss. In general, their use should avoided, although older ruminants, horses, and even poultry and swine may subsist on them for long periods of time under conditions of low stress.
More than 10,000	The risks with these highly saline waters are so great that they cannot be recommended for use under are so great that they cannot be recommended for use under any conditions.

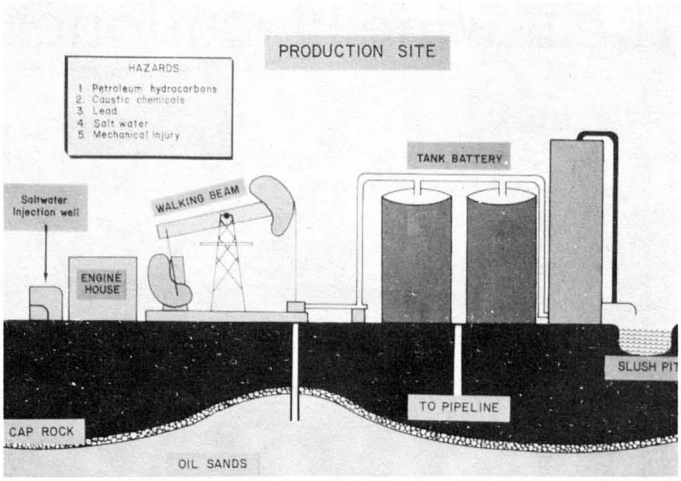
In addition to salt water pollution, other chemicals in drilling fluids and muds are dangerous sources of poison if they are accessible to livestock. Drilling fluids are circulated



to remove cuttings from the bottom of the hole and to keep the drill bit and the bottom of the hole clean[4] To prevent flow of gas, oil, and brine from the various strata (formations) into the drill hole, a fluid-mud column is used that produces a hydrostatic pressure that counter-balances or exceeds the formation pressure[4]. The fluids and muds also function to control bacteria, calcium build-up, corrosion, density, dispersion, emulsion, foam, filtrate reduction, heaving shale, lost circulation, lubrication, pH, surface activity, and viscosity[3]. Some of the potentially toxic chemicals in drilling muds and fluids include: paraformaldehyde, hydroxides of sodium and calcium sodium pentachlorophenate, sodium arsenite, lead sulfide, sodium sulfonates, long chain alsohols, silicones, sulfonated oils, lignosulfonates, sulfonated asphalt, barium, carbonate, aluminum sulfate, calcium sulfate, ferric sulfate, metallic oxides, hydrochloric, formic and acetic acids, and quaternary ammonium derivatives.

The volume of drillings fluid in use at any given time during a drilling operation ranges from about 500 to more than 1,500 barrels. Some of these fluids and muds may be spilled during drillings. It also is difficult to inhibit the acid-containing solutions to prevent corrosion which, when it occurs, allows escape of the fluid at the point of pipe failure and may pollute adjacent livestock water supplies. Toxic arsenicals are often used as corrosion and scale inhibitors[4].

Consumption of petroleum hydrocarbons is probably the most common cause of petroleum industry-related livestock losses. Symptoms of petroleum hydrocarbon toxicity include bloat, dyspnea, increased heart rate, dilated pupils and muscular incoordination in the terminal stages. Death is often due to foreign body pneumonia. Caustic chemicals, petroleum hydrocarbons and salt water must all be considered when evaluating suspect poisoning cases associated with oil drilling or production sites[1,2].



The following cases exemplify the potential for salt poisoning in pastures containing oil well pollution.

Case History I

Two six-month-old Hereford cattle became ill April 22, 1977. These animals had been seen around an open slush pit in the pasture[3]. Clinical signs included dehydration, incoordination and abdominal pain. One heifer died 4-23-77. A postmortem examination by the attending veterinarian revealed hemorrhagic enteritis and hydroperitoneum. Gastro-intestinal contents submitted to the laboratory were found to contain 50,000 ppm sodium. The slush pit material contained greater than 100,000 ppm total soluble salts.

Case History II

Ten of 138 mixed breed heifers died April 5, 1978. Twenty-nine others showed signs of diarrhea and/or weakness. One animal submitted live to the Oklahoma Animal Disease Diagnostic Laboratory was prostrate and blind. These cattle were on wheat pasture and were fed a feed mix containing 5% salt. Cattle on four other pastures and on the same feed were not affected. The involved pasture contained an oil well and cattle had been seen drinking water near the well.

Necropsies of several affected animals revealed pulmonary edema and a moderate amount of froth in the trachea and bronchi. Rumenitis was found on histopathological examination. No significant bacteria or viruses could be isolated from the tissues. Blood lead concentrations were insignificant. Water collected near the oil well contained over 12% total salts. A tentative diagnosis of sodium ion toxicity was made on the basis of history, signs, postmortem findings and analysis of feed and water for salt.

It is important to remember that access to a toxic material alone is not sufficient for a diagnosis of petroleum production-related poisoning. A list of items helpful in establishing such a diagnosis should include:

1. A history of accessibility to toxic chemical pollutants and/or salt water.
2. Limited access to fresh water.
3. Compatible symptomatology, physical findings, and postmortem lesions.
4. Demonstration of significant amounts of the suspected toxin in the tissues and intestinal contents.

Samples to be submitted to the laboratory that are of value in confirming a diagnosis of poisoning from petroleum hydrocarbons, brine or oil field wastes include rumen contents, serum, cerebrospinal fluid, lung tissue and the suspected pollutant for analysis.

Being aware of the hazards associated with oil production is the first step in preventing and properly diagnosing such cases.

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