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REVIEW ARTICLE

Impacts of saline water stress on livestock production: A review

Abdelsattar M.M. [1*], Ahmed M. A. Hussein [2], M.N. Abd El-Ati [2], and A.M. Saleem [1]

[1]*Department of Animal and Poultry Production, Faculty of Agriculture, South Valley University, Qena 83523, Egypt*

[2]*Department of Animal Production Department, Faculty of Agriculture, Assiut University, Assiut 71515, Egypt*

Abstract: Limited freshwater resources and climatic change are major challenge face animal production industry, especially in the arid and semiarid regions. Climate changes are reflected in global warming and rainfall reduction, which in turn may increase the salinity of both soil and water. Within the reclamation strategy, groundwater will be the main source of used water in cultivated desert lands in Egypt. However, the groundwater has high salinity and the cost of desalination is expensive. This review gives an overview of the impact of using saline water as an alternative source of fresh water to avoid water scarcity effect on the performance, carcass traits, and meat quality of farm animals. The ability of animals to tolerate saline water depends on the animal species, salinity level and the type of salt minerals in water. Some studies indicated that the animals' performance improved in low levels of salinity, but the performance decreased when the salinity levels was increased. In conclusion, this study implies that the saline water containing high concentrations of minerals mainly sodium chloride can largely affect the livestock productive aspects.

Key words: Water quality, Ground water, Climatic change, Total dissolved solids, Livestock

1. Introduction

Salinity or total dissolved solids (TDS) are used to determine the suitability and palatability of particular water resource for livestock (Ray, 1989; Bahman *et al.*, 1993). The water in its normal state is not pure but contains a number of impurities such as dissolved solids. Apart of fresh water, there are other sources of water that contain high rate of these impurities such as ground water and sea water. The groundwater varies highly in the type and contents of dissolved solids.

*__Corresponding author__: **Abdelsattar**
Email: *m.m.abdelsattar@agr.svu.edu.eg*
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Then using poor quality water can influence water and feed consumption, health, and the production state of ruminants (NRC, 2007). Drinking saline water increased the thirst feeling made an increase in water consumption which increase urination to help the kidney flush the harmful minerals (Marai *et al.*, 1995; Kii and Dryden, 2005; Masters *et al.*, 2007). However, several studies indicated that animals may stop drinking water at the extremely minerals concentrations to avoid toxicity. Consequently, saline water could decrease the body weight, appetite and feed consumption of animals Agricultural Research Council (1980). on the other hand, the using moderate levels of salts may enhance the feed intake, body weight, carcass lean content (Pearce et al., 2008; Visscher *et al.*, 2013; Hekal, 2015). Then, the salinity level and the type of salt minerals in water will determine if the animal is able to tolerate saline water or not. In this review, we classified the impact of saline water in each livestock performance, carcass and meat quality.

1. Effect of saline water on water consumption.

Substantial amounts of water normally are consumed by ruminants, many environmental factors have been examined as modulators of water intake. Among those considered most important is water salinity. The effect of saline water on the amount of consumed water in ruminants has been studied for an extended period. Many studies found that water consumption is increased as the salinity level increased. The effect was to help the kidney removing the exceeded salt from their body (Kii and Dryden, 2005). For example, Hemsley *et al.* (1975) noted that the water intake was increased when sheep offered salt exceed to 130 gram NaCl per day from food or water. In addition, Yousfi *et al.* (2016) found that offering water with 7 g NaCl/l in Barbarine lambs increased water intake ($P<0.001$) compared with lambs offered fresh water. Moreover, in Barbarine rams, Yousfi and Salem (2017) reported that water intake was increased ($P<0.05$) with the increasing of salt in drinking water from 11 to 15 g NaCl/l compared with tap water group. More related studies showed similar results, increasing water consumption of sheep as salinity level increased (Singh and Taneja, 1978; Mittal and Ghosh, 1983; Moura *et al.*, 2016). Moreover, local Egyptian breeds showed an increase in their water consumption as the offered water salinity increased (El-Sherif and El-Hassanein, 1996; Assad *et al.*, 1997; Badawy, 1999; Assad and El-Sherif, 2002).

Sheep are not the only species that showed an increase in the amount of water consumption when drank saline water. Also, goats showed a similar response. Mohammed (2008) studied the effects of saline water (1.5% NaCl) for six weeks in Nubian goats and observed a significant increase in water intake ($P<0.05$) compared with the fresh water group. Moreover, El Gawad (1997) reported that water intake was increased in goats offered saline water containing 8250 mg TDS/l for six weeks compared with those offered water containing 1050 mg TDS/l . In addition, comparable results have been reported in dairy cattle. Also, water consumption was increased with salinity in cows (Valtorta *et al.*, 2008), heifers (Alves *et al.*, 2017), calves (Kewalramani *et al.*, 2017) and young bulls (Visscher *et al.*, 2013). Similar results were observed in pigs (Anderson and Stothers, 1978), deer (Kii and Dryden, 2005) and rabbits (Abdel-Samee and El-Masry, 1992; Habeeb *et al.*, 1997; Ahmed and Abdel-Rahman, 2004).

In some studies, it has been noticed that water consumption was increased in low levels of salinity, but when the level is increased to 2%, the water consumption was decreased. For example, Wilson (1975) noted that water consumption was increased in Merino sheep maintained on grassland using 1.2 or 1.6 % TDS in drinking water compared with the fresh water group, but on the 2.0 % water consumption was decreased and revealed to the control level. Moreover, Eltayeb (2006) observed that water intake was increased ($P<0.05$) in Nubian goats consumed saline water (0.8 and 1.6% NaCl) compared with those consumed tap water, but when he used NaCl at 2% the water intake was decreased ($P<0.05$) compared with tap water group.

On the other hand, some studies found no effect of saline water on water consumption in ruminant species, Tsukahara *et al.* (2016) noted that the water intake was not affected in Boer and Spanish yearling wether goats consuming fresh water or brackish water containing 6,900 mg TDS/l . In addition, Bahman *et al.* (1993) found that water intake was not affected in Friesian Holstein cows consuming brackish well water (3574 mg TDS/l) or desalinated water (449 mg TDS/l). Moreover, in dairy cattle, Shapasand *et al.* (2010) found that drinking saline water containing 900 or 3400 ppm TDS did not affect the water consumption.

In contrast, many other studies had been revealed that water consumption was decreased as the salinity level increased in drinking water due to less palatability of saline and to decrease the salt stress. Mdletshe *et al.* (2017) showed that the average daily water intake was decreased ($P<0.05$) in non-lactating female Nguni goats which offered 5.5 and 11 g NaCl/l in drinking water compared with those offered reservoir water 0.033 g TDS/l . In addition, López *et al.* (2016) found that saline water (7478 mg TDS/l) decreased ($P<0.01$) the water intake by 22% in beef cattle compared with tap water group. Furthermore, water consumption was decreased by saline water consumption in steers (Patterson *et al.*, 2003, 2004; López *et al.*, 2014), calves (Kewalramani *et al.*, 2017) and buffalo calves (Sharma *et al.*, 2017).

2. Effect of saline water on feed consumption.

Many studies have shown that the feed intake is negatively affected by the increased salinity of drinking water because saline water reduce appetite and the utilization of feed (Agricultural Research Council, 1980). From this point of view, Yousfi and Salem (2017) reported that the administration of NaCl in water at rates of 11 and 15 g/l decreased feed intake ($P<0.01$) in Barbarine sheep by 4% and 14%, respectively compared with tap water group. In addition, in both Egyptian Zaraibi bucks and Rahmany rams, Abou Hussien *et al.* (1994) showed that the 9,500 mg TDS/l decreased the feed consumption in sheep only but not in goats. Moreover, the 17,000 mg TDS/l reduced the feed intake in both of them. In addition, in goats, Mdletshe *et al.* (2017) showed that the average daily feed intake was significantly ($P<0.05$) reduced with increasing salinity levels in drinking water in female goats from 0 to 5.5 and from 5.5 to 11 g TDS/l . Similarly, saline water decreased feed intake in sheep (Wilson and Dudzinski, 1973; El-Sherif and El-Hassanein, 1996), goats (Eltayeb, 2006; Mohammed, 2008; Zoidis and Hadjigeorgiou, 2017), heifers (Weeth *et al.*, 1960; Weeth and Haverland, 1961), steers (Patterson *et al.*, 2003, 2004; López *et al.*, 2014), beef cattle (López *et al.*, 2016) and calves (Sharma *et al.*, 2017). In addition, in monogastric animals, saline water decreased feed intake in weanling pigs (Anderson and Stothers, 1978) and rabbits (Abdel-Samee and El-Masry, 1992).

On the other hand, many other studies showed no effect of saline water on feed consumption. For example, in the crossbred Santa Inês sheep, Moura *et al.* (2016) noted that the dry matter intake was not influenced by water salinity level (640, 3188, 5740 and 8326 mg TDS/l). In addition, Tsukahara *et al.* (2016) noted that offering brackish water containing 6900 mg TDS/l did not affect feed intake in Boer and Spanish yearling wether goats. Furthermore, Alves *et al.* (2017) reported that the increase of TDS concentrations in drinking water from 640, 3187, 5740 to 8326 mg TDS/l did not affect the dry matter intake in heifers. In addition, saline water did not affect feed intake in sheep (Badawy, 1999; Yousfi *et al.*, 2016), both camels and sheep (Assad *et al.*, 1997), goats (Youssef, 1995), Holstein cows (Jaster *et al.*, 1978; Bahman *et al.*, 1993; Valtorta *et al.*, 2008), deer (Kii and Dryden, 2005) and rabbits (Marai *et al.*, 2005).

In contrast, many other studies indicated that the increasing water salinity could enhance the feed intake. For example, El Gawad (1997) reported that feed intake was increased in goats offered saline water containing 8250 mg TDS/l for six weeks compared with those offered water containing 1,050 mg TDS/l . In addition, Visscher *et al.* (2013) indicated that the feed intake was significantly (P<0.05) increased in young bulls consuming saline water (5 or 10 g TDS/l) compared with 0.1 g TDS/l group. Moreover, Ahmed and Abdel-Rahman (2004) reported that daily berseem intake was significantly (P<0.01) increased in growing rabbits offered saline water (2980 ppm TDS) compared with those offered tap water, but the daily concentrates intake was not affected by water salinity. The authors suggested that the at saline water stress animals try to excrete the salts by increase the consumption of water and forages with high water level.

3. Effect of saline water on body weight.

In sheep, Peirce (1963) showed that offering saline water (1.30% NaCl) decreased the body weight compared with groups offered rain-water .In addition, in rabbits, Marai *et al.* (2005) showed a significant decrease in final live weight by increasing the TDS level in drinking water (3000, 4000 and 5000 ppm) compared with those offered tap water .Moreover, Qar and Abdel-Monem (2014) found that the final live body weight of rabbits consuming saline water containing 5, 10, 15 and 20% sea water was decreased by 7.7, 11.1, 20.2 and 28.1%, respectively, compared with those offered fresh water.

In contrast, in Barbarine lamb, Yousfi *et al.* (2016) found that offering saline water containing 7 g NaCl/l did not affect the final body weight. In addition, in castrated goats, Zoidis and Hadjigeorgiou (2017) indicated that the NaCl at the levels of 0.5, 5, 10 and 20% in drinking water did not affect the body weight. In addition, El Gawad (1997) found that the body weight was not affected in goats consuming saline water containing 1,050 or 8,250 mg TDS/l for 6 weeks. Similar results were observed in sheep (Walker *et al.*, 1971), cows (Bahman *et al.*, 1993; Valtorta *et al.*, 2008) and rabbits (Ahmed and Abdel-Rahman, 2004).

On the other hand, in many studies, it has been found that the body weight was not affected at low salinity level, but when it is reached 2%, the body weight decreased. For example, Peirce (1957) and Wilson (1966) observed that 2% NaCl in drinking water reduced the body weight, but 1% NaCl in drinking water did not affect the body weight in lambs. In addition, in Merino sheep, Wilson (1975) noted that 1.2 % soluble salts in drinking water did not influence body weight. However, the increase in water salinity from 1.2 % to 1.6 % or 2 % decreased the body weight .Moreover, Weeth *et al.* (1960) noted that the body weight was not affected in heifers offered saline water containing 1% NaCl, but the body weight was decreased at the level of 2% NaCl.

4. Effect of saline water on average daily gain.

Many studies investigated the effects of saline water on the average body weight gain. Some studies stated that the body weight gain was adversely affected by water salinity. For example, Mdletshe *et al.* (2017) showed that the average daily gain was decreased ($P<0.05$) in goats with the increase of TDS in drinking water from 5.5 to 11 g TDS/l compared with the fresh water group. Also, in growing steers, Patterson *et al.* (2003) reported a reduction in the average daily gain by 27% when water TDS increased from 1,019 to 4,835 ppm. Similarly, Patterson *et al.* (2004) reported a reduction in daily gain by 65% ($P<0.05$) in steers offered saline water containing 7,268 ppm TDS compared with those offered 1,226 ppm TDS. In addition, Sharma *et al.* (2017) showed the average daily gain was decreased by 19.3% in Murrah buffalo calves offered water with 8789 mg TDS/l compared with 557 mg TDS/l group. Similar results were observed in goats (Eltayeb, 2006), heifers (Weeth and Haverland, 1961; Saul and Flinn, 1985).

Furthermore, many other studies found that saline water decreased the average daily gain in monogastric animals. For example, in pigs, Anderson and Stothers (1978) found that the weanling pigs offered saline water containing 6,000 ppm TDS had a lower body weight gain ($P<0.05$) than the fresh water group. In addition, the daily weight gain was decreased as TDS of water increased over 3000 ppm TDS compared with those offered tap water in rabbits (Ayyat *et al.*, 1991; Habeeb *et al.*, 1997; Marai *et al.*, 2005).

However, the body weight gain was not affected by saline water according to some studies. For example, in Barbarine lamb, Yousfi *et al.* (2016) found that offering water with 7 g NaCl/l did not affect the average daily gain. Similar results were shown in beef cattle (López *et al.*, 2016), heifers (Alves *et al.*, 2017) and rabbits (Ahmed and Abdel-Rahman, 2004).

On the contrary, few studies reported that the body weight gain was increased by saline water at low TDS levels. For example, in Barki ram lambs, Hekal (2015) showed that saline water (2886 ppm TDS) increased the average daily gain compared with the group of 275 ppm TDS, the average daily gain was 80 and 50 g, respectively.

5. Effect of saline water on carcass characteristics.

Carcass traits were adversely affected by saline water according to many studies. For instance, in rabbits, Ayyat *et al.* (1991) found that the dressing percentage and the weights of the carcass were decreased when offering saline water containing 6000 ppm TDS compared with those offered water containing 906 ppm TDS. In addition, Marai *et al*. (2005) showed a significant decrease (P<0.05) in slaughter weight, carcass weight, trunk weight, hind limbs weight, liver, and kidneys (with fat) weights in rabbits offered saline water (5000 ppm TDS) compared with tap water group. In spite of, saline water did not affect the forelimbs weight and dressing percentage. In addition, using high salt plants such as halophytes (saltbush) in sheep diets significantly (P<0.05) decreased the carcass fat and increased carcass lean and bone, but did not affect the hot carcass weight or dressing percentage (Pearce *et al*., 2008). Moreover, in lambs, Kraidees *et al*. (1998) showed that offering halophytes significantly (P<0.05) decreased the hot carcass weight and increased (p<0.01) the percentages of kidneys and heart weights, but did not affect the empty body weight and dressing percentage. Furthermore, in Najdi sheep, Al-Owaimer *et al*. (2008) showed that saltbush significantly (p<0.05) decreased fat percentage and slightly decreased the dressing percentage, but did not affect the fat thickness and bone ratio. Moreover, in Barki lambs, Ahmed *et al*. (2015) showed that *Atriplex* significantly (p<0.05) decreased both dressing percentage and spleen weight and increased the full gut weight (p<0.05) and pelt weight (p<0.01), but did not affect the slaughter body weight and carcass weight, empty gut, liver, heart, lung, best rib bone, best rib fat and best rib meat. In addition, in steers, Croom *et al*. (1985) showed that 5% NaCl in feed resulted in decreased carcass weight (P<0.05) compared with the control group.

On the other hand, the low level of saline water could improve the carcass characteristics of sheep according to Hekal (2015). The author showed that in Barki lambs, drinking water containing 2886 ppm TDS increased the weights of hind quarter, lungs, heart, spleen, liver, and kidneys compared with tap water group. However, saline water decreased the forequarter weight and the weights of non-edible and edible organs, but the hot carcass weight and dressing percentage were not affected by water salinity. Moreover, Honarbakhsh *et al*. (2007) showed that saline water (1,000 and 2,000 mg TDS/l) improved the breast yield (P<0.01) of broiler chicks, but slightly decreased the abdominal fat and sartorial percentages compared with fresh water group

On the contrary, many studies reported that saline water did not influence carcass traits. Such as, Walker *et al*. (1971) found that the carcass weight was not affected in Merino wethers consuming saline or tap water. Similarly, in Barbarine lamb, Yousfi *et al*. (2016) found that offering saline water (7 g NaCl /l) did not affect the slaughter weight, hot carcass weight, chilled carcass weight, full and empty digestive tract weight, tail weight and liver weight. In addition, in sheep Castro *et al*. (2017) reported that offering water with different salinity levels (640, 3188, 5740 and 8326 mg TDS/l) did not affect slaughter weight and both cold and hot carcass weights. In addition, the measurements for internal and external carcass lengths, leg length, and rump width were not influenced by water salinity. Moreover, in rabbits, Abdel-

Samee and El-Masry (1992) showed that the carcass weights were not affected by desalinated water or saline well water.

6. Effect of saline water on meat quality.

Few studies investigated the role of saline water in meat quality. For example, in lambs, Yousfi *et al*. (2016) found that offering water with 7 g NaCl /l did not affect the meat cooking loss. In addition, in lambs, Castro *et al*. (2017) reported that saline water containing 8326 mg TDS/l did not affect water holding capacity and cooking losses of meat. Moreover, in sheep, Pearce *et al*. (2008) showed that salt load from the consumption of halophytes such as saltbush did not affect the pH of meat. In Najdi sheep, Al-Owaimer *et al*. (2008) showed that *Atriplex species* did not affect the pH of meat. Similarly, in Awassi lambs, Obeidat *et al*. (2016) showed that *Atriplex halimus* did not affect the meat pH, cooking loss or water holding capacity.

However, Moreno *et al*. (2015) showed that the water holding capacity was 11% higher in the meat of lambs fed diets with saltbush but did not affect the meat pH or cooking weight loss.

Conclusion

Generally, it can be concluded that the effect of saline water in livestock changes with the level of salinity, the type of minerals and the tolerance of animal. Low levels of saline water can be recommended for livestock. Although, using of high salinity levels decreased the animal performance and its health status. further research needed to evaluate the impact of saline water with different levels and types of minerals in different livestock animal to compare the mechanism of action of each which will help in the future to investigate how to overcome these harmful effects.

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