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Review Article

Effects of Water Quality on Productivity and Performance of Livestock: A Mini Review

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Abstract
Water is principle constituent of living bodies and it is vital nutrient needed to sustain life. Water quality is an important parameter, directly or indirectly affecting feed intake and physiological health status of animals thus influencing on productivity and performance. Total dissolved solids [TDS], turbidity, temperature, mineral, pH, hardness, and microbial load are the quality determining factors of water. Livestock farmers are usually unaware of the importance of water quality for production and performance of livestock. They can make a big profit by reducing the productivity losses associated with water quality. This article tends to review water quality parameters and their effect on livestock production and performance.
Key words: Mater quality, Livestock, Milk production, Animal health

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Introduction

Water is a vital nutrient needed for sustaining life and to optimize the milk production, growth rate and reproduction in livestock [1, 2, 3], but unfortunately it is poorly studied component [4]. If somebody talks about nutrient requirements of livestock, water is often considered as afterthought. It is important for intracellular metabolism and it is superabundant components of living bodies. Water constitutes about 70-80% at birth and 65-70% of adult live weight of livestock depending upon age, fat cover, and physiological condition [5]. It is superabundant component of milk ranging from 78-90% and most customary molecule of body ranging 98% of all molecules. Water is used in body for different purposes, almost in everybody function [60], including thermoregulation, lubrication, medium for chemical reactions, digestion, absorption, lactation, carrier, support, cushion, mineral balance and help for other nutrients to complete their functions [5,6].

With this importance water quality is considered as a factor effecting intake in evaluating water nutrition of livestock [3,6]. It is essential for increasing growth rate, resistance against diseases [7]. Livestock mostly obtain their drinking water from dugouts that mostly are loaded with contaminants; drinking such water, may result in problems associated with decreased growth and performance. Research has shown that if animals are provided with clean drinking water, the resistance against diseases is increased and performance becomes better. The cost of using clean water from any sources by treatment is refunded by increased performance in a short time [8].

Ruminants use water coming from voluntary drinking, feed and metabolism. The voluntary sources of water for livestock are surface water i.e. streams, ponds, lakes, and ground water i.e. wells. The quality of water will be influenced by its source of contamination either biotic or a biotic as a result of dissolved nutrients, debris and pathogens. If we talk about the ground water it may be contaminated by dissolved salts, depending upon the geology of area, rainfall, vegetation and topography. Natural and human activities may influence on both ground as well as surface water. Poor quality water is not palatable and animal do not accept it easily, it results in low water and feed intake, low feed conversion ratio ultimately decreased growth and production, poor performance, and non-specific disease conditions [9]. Performance of animals is improved when small positive changes are made in water quality; potential for disease and illness decreases resulting in net gain of profit [8].

Salinity and TDS are usually used synonymously [6] but they might be different depending upon the adulterants in water. Odor, guise and taste as well as its physiochemical properties of drinking water are affected by these contaminants. The effect of these contaminants is either direct on health or may cause decrease in overall water intake indirectly lowering the growth and production of animals [8].

Common contaminants of drinking water

The water available to livestock for drinking may be adulterated by a number of contaminating determinants including minerals [TDS], manure, microorganism, chemicals and algae. Salinity is considered as basic quality parameter effecting palatability and health status along with performance.

Contaminants may be biotic or a biotic in nature making the water quality parameters. Biotic factors include: Bacteria, Virus, Protozoa, Algae, Fungus while biotic factors include: Salinity TDS /TSS [Total Soluble

Table 1: Guide for the use of saline waters for livestock [14].

Salinity mg/L or ppm.	Comment
<1000 [fresh water]	No serious problem
1,000-2,999 [slightly saline]	Satisfactory - for adult ruminants- temporary and mild diarrhea may be reported but should not affect performance or health.
3,000-4,999 [moderately saline]	Usually satisfactory- but may cause diarrhea on initial consumption
5,000-6,999 [saline]	Safe for adult livestock- consumption by pregnant, lactating, high producing, or young animals should be avoided.
7,000-9,999 [very saline]	Should be avoided if possible- can cause serious problem to pregnant, lactating, stressed and young animals
>10,000 [brine]	Unsafe- never be used under any condition

Salts]/ EC [electric conductivity], minerals and complexes [nitrates, sulphates, phosphates], suspended particles, hardness, livestock sources i.e. manure, urine, grazing runoff, Accidental spills of petroleum, pesticides and fertilizers, temperature, taste and odor. Biotic factors such as bacteria, virus and parasites are killed by ultraviolet rays from sunlight except algae, seem to resist it.

Effect on performance and productivity

Economy is the main factor involved in livestock production and it is directly related with productivity and performance of animal. Livestock producers can enhance health, productivity and performance of their animal by improving the quality of water being offered; just small mitigations in water quality may show surpassed performance and growth [8]. Animal grows well when it is healthy and having no stress. Low water quality causes health problems that result in retarded growth and decreased performance. Every contaminant affects water quality in its own way and subsequently on growth and performance, but mostly water quality results in reduced intake of water and feed ultimately reducing reproductive potential, milk production and weight gain [3, 10]. Suspension of material [i.e. algae, clay, slit and other organic material] results in turbidity and it makes water unpalatable above 5ppm.

Manure is a usual contaminant of livestock drinking water, abundant in pond where cattle may spend time for loitering. Animals carry manure stuck to their hooves, and shed in water drinking places. It affects the intake by altering the taste and odor. Manure also contains excessive nutrients that allows algal and phytoplankton growth and also becomes hotspot for bacterial and fungal growth in water resulting in changed water quality [7, 11].

Animals shed pathogens spores and parasite eggs in feces and urine and leeching of nitrates and salts also occurs [12]. Manure level doesn't affect consumption until it is more than 0.25% in water. Studies have shown that livestock offered manure contaminated water doesn't grow well as compare to those having free access to clean water [13, 14].

Large numbers of bacteria are found in watering facilities of livestock. Coliform illness results in outbreaks of *E.coli Campylobacter jejuni*, *Klebsiella, E. aerogenes, Salmonella* spp., *shigellae*spp. and *Vibrio cholera* are the common causes of coliform illness outbreaks; these can lead to diarrhea, urinary tract infections, mastitis and many other unappealing and usually deadly infections [8, 15]. Urine contaminated water contains *leptospira* that causes reproductive loss [infertility and late term abortion] and decreased milk production in cattle by leptospirosis [11]. Contaminated water can transmit *Fusobacterium necrophorum*, a soil-borne microbe known to be primary cause of foot rot [8, 11, 16]. *Listeria*,*Coxiella*, *Brucella*, and *Mycoplasma* infections are transmitted through water. Where, possible animals should be given water which is bacteriologically clean as well as chemically satisfactory.

Algae and algal blooms [*Cyaonobacterium* spp. such as *Anabaena*, *Microcystis* and *Nodularia*] grow in warm sunny weather and produce harmful chemical that cause hepatic or neurotoxicity in animals [17] reducing their productivity [14] and many produce aromatic compounds that affect the palatability [8, 13]. Williams et al. [2002] conducted a comparative study of less algae effected water and highly algae infected pond water and found that calves having access to cleaner water achieved 9% more weight, while yearling heifers getting less contaminated water acquired 20–23% more weight. Poisoning by blue green algae in animals, show the signs like allergy, ataxia, muscle tremors, dysentery, convulsions, photosensitization, jaundice and death in acute cases [11, 18, 19].

Other forms of unicellular organisms in water also affect its quality and have their own effects on health and performance. Eggs, larvae and adult parasites itself are present in drinking water and they can infest the animal,

subsequently affecting the health status, growth and performance.

Faciola hepatica, *F. giggntica* are transmitted through water bodies. In addition, cattle are commonly hosts to *Giardia* spp., *Cryptosporidium* spp, nematodes and other parasites that affect their health and that are spread in water. *Giardia* and *Cryptosporidium* cause diarrhoea in calves and lambs [14, 17, 20, 21].

Dead and decaying carcass shed the pathogens nutrients and other components that may mix up with environmental factors to affect the ground and surface waters [22]. Fungal toxins may also come in drinking water, mostly causing chronic and subclinical problems. Similarly virus may also be transmitted by drinking water.

Abiotic factors have their own influence on water quality and ultimately on animal growth and performance. Salinity or TDS is basic of them. Excessive salivation, diarrhea, vomiting, blindness, seizures, ataxia, disorientation, and paralysis are the acute effects of excessive salinity [23]. Sub-chronic effects of excessive sodium chloride level in drinking water in mammals include reduced intake of water/feed and lower weight gain [24]. Rumen provides wide range of buffer capacity for TDS but in higher concentration it lowers water intake [25]. Avian species respond to excessive salinity by showing reduced food and water intake so reproductive rates and weight gain are also reduced. Solomon, (1995) reported increased production of milk and milk constituents by improving water quality (desalination)

Nitrates (NO_3) are not common in drinking water and they are less toxic while nitrite (NO_2) is highly toxic and carcinogenic; nitrogen fertilizer and livestock operations may elevate their level [14, 16]. In case of ruminants, nitrates are ingested through oral rout to rumen and convert to nitrites. Nitrites are absorbed into bloodstream ultimately affecting oxygen transport ability of red blood cells (RBCs), so cause of death in such cases is suffocation due to lack of oxygen transport [6, 14, 16. 26].

Table 2: Levels of nitrate in water [ppm.] and expected response [22].

NO_3	NO_3-N	Comment
0-44	0-10	Safe- No problem expected
45-132	10-19	Safe- if other sources [i.e. feed] are less in N_2.
133-220	20-39	Harmful- if used for longer period
221-659	40-99	Risky- potential death loss
660-799	100-199	Not safe- high risk of death
800<	200<	Not safe- Don't use

Environmental concerns are related to phosphorus due to its ability to cause eutrophication in water bodies which makes water unpalatable and may have toxins from algae [26]. Other mineral compounds effect water quality; Zn, Fe, S, Cu, Mn, Ca, Mg, sulphates, sulphides, chlorides and other number of known factors.

Sulphates make the taste of water objectionable [3, 7], disturbs physiological parameters [27, 28] and losses the hepatic stores of Cu, Se, and Zn [29]. Water rich in sulphate influence on reproduction negatively and lower weight gain [30- 33]. Chloride and sulphate the biologically active anions have potential to negatively influence digestion, acid-base/electrolyte balance, and milk production [1]. Polioencephalo malacia [sPEM] is a condition associated with excess H_2S level and it is characterized by neuromuscular alternations in animals [29]. Excess of iron can cause toxicity in livestock. Recommended iron level in drinking water is 0.3ppm. Iron in drinking water is more absorbable than in feed [1]. Ferric iron, Fe^{+3}, usually comes from feed and it is quite insoluble while ferrous ion, Fe^{+2}, from water is highly soluble and is readily absorbed into body through drinking water. High iron level in drinking water cause cellular oxidative stress and block zinc copper absorption is so resulting in detrimental effects on heal and performance [1, 34].

There is not much research performed on effect of water quality on weight gain but still literature shows some citations. A study was performed in western Canada during 1999 to 2003 by H.A. Lardner et al., (2005) conducted an experiment with the purpose of effect of improved water quality on beef cattle performance. They divided animals into groups receiving water directly pumped from dugout, aerated, coagulated and chlorinated water. The effect of water treatments on cattle performance was related to improved palatability, intake and food consumption. The result was 9-10 % improved weight gain by animals consuming treated water.

Williams et al., (2002) reported 23% more weight gain in heifers having access to cleaner water as compare to those of accessing water directly from pond. Williams et al., (1994) reported 20% weight loss by 18 month steers drinking from dugouts in summer over 71 days period. In same report a study performed over 33 days cattle drinking from the dugout lost 0.2 kg weight and their calves acquired 26.3 kg, while cows drinking from the trough, exhibited 7.4 kg weight gain and their calves acquired 33.9 kg. Hardness of water doesn't seem to be a problem effecting water intake. Hardness of water (190-290) ppm compare to 0ppm) did not affected the water consumption by cattle so not effecting the weight gain and milk production [14, 35- 37].

We human recognize taste and odor of water depending upon blue-green algae, mineral and oxygen content, possibly animals do so but there are no slid evidences. Animals show detestation for high chlorine and other mineral contents in water and also for toxins. Flavor, smell and color effected by number of factors influence on water and feed intake [7, 18, 39].

The pH level accepted for livestock drinking water is 6-8 [6, 7]. The pH seems to effect by changing taste, efficiency of chlorination, corrosive potential and many other properties of drinking water [6]. Minor alkalinity is tolerable than acidity in herbivores. The pH less than 5.5 causes acidosis, a potential problem of weight loss and production. Other than these ranges pH may cause reduced water and feed intake, digestive alteration, diarrhea, poor feed conversion [18].

Temperature also has important impact in determining water quality for animals, subsequently affecting the water intake, feed intake, respiration rate, rectal temperature, rumen fermentation, plasma thyroid hormone concentration, milk yield weight gain and performance of animals [39, 40]. Temperature affects the quality directly by changing palatability and acceptance by animal or by disturbing the micro flora of digestive tract. Usually livestock animals alike cool water particularly in warm conditions [41]. Water in shallow ponds and small water troughs gets heats up in summer and animal cannot accomplish its appetite for water and consequently feed intake decreases resulting in decreased production and growth. Deep tanks, ponds and ground water in larger troughs generally don't heat up enough to affect intake. Similarly animals like to drink warmed water when ambient temperature is near freezing in winter. Kristula and McDonnell [1994] reported that ponies consumed 40% more water when given warm water as compare to ambient temperature water while ambient temperature of barn was -7 to 5^{o}C.

Methods for cleaning water are available. Sarkar et al (2006) described many comparative methods for treatment of water from dairy industry.

Conclusions

It is good that we are often concerned with energy, protein and dry matter intake in ration but supplying clean and fresh water for livestock is very important practice to achieve the goal of high production by considering the animal health status and requirement. Water quality is usually neglected resulting in production loss. Water quality affects livestock in number of ways. Mainly by reducing palatability and acceptance by animal; as the feed intake is related with water intake. It is also compromised and is the case of feed conversion ratio. Presence of minerals in water over acceptance level causes number of problems including toxicity, electrolyte balance, acid/base balance and interfere with other physiological parameters. Cattle are sensitive to the palatability of water and prefer to drink clean water without contamination. Water intake is closely related to feed intake and thus animal productivity. Water quality measurements usually include readings of different water properties, such as the salinity [mainly sodium chloride], hardness [mainly calcium and magnesium], pH, microbiological quality, algae, and nitrate and nitrite levels.

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