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A Review: Drinking Water and Wastewater Quality Assessment in Ruminant Farms

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ABSTRACT

Water is an essential part in any livestock production and it is more so in ruminant production that is highly water intensive. Water is not only essential as a medium of animal metabolism, but it is also an important cleaning medium. Therefore, it is important that the quality of drinking water is maintained at a certain level so as to lessen the possible adverse effects on the animals. Despite there has being some standards set by the various agencies on the minimal water quality deemed suitable for livestock consumption, they are still vague and this, combined with poor compliance and the water sourcing of dubious sources in ruminant farms makes it hard to regulate the drinking water quality in ruminant farms. This, in turn, might lead to possible adverse effects in livestock production due to water contaminants. At the same time, most ruminant farms in Malaysia do not do proper treatment of their wastewater before releasing them into water bodies such as drains, rivers and lakes which could lead to possible adverse effects to the environment.

1. INTRODUCTION

Water makes up 90% of all the molecules in the body and about 60 to 70% of the live body weight and it is considered to be the most important of all the nutrients as it is needed in the most regular basis and in the highest volume (Shils et al., 2006). It was also found that domesticated animals can live up to 60 days without food, but will perish in seven days without water (Church and Pond, 1974). As for this reason that farmers were advised to provide water in ad libitum for their livestock as they can easily suffer from stress or dehydration without sufficient drinking water (Water.usgs.gov.edu, 2005).

According to Häussinger, (1996) and Jéquier and Constant, (2010), water acts as a solvent, reaction medium, a reactant and reaction product in many of the body chemical reaction such as hydrolysis of proteins, fats and carbohydrates in the body. Water is essential for cellular homeostasis as it is the medium in which all transport medium function, allowing exchanges between cells, interstitial fluid and capillaries (Grandjean and Campbell, 2004). Due to the large heat capacity of water, it plays an important role in thermoregulation by allowing heat loss through sweating even when the ambient temperature is higher than the body temperature (Montain et al., 1996). Water that is secreted in the form of mucus, saliva and synovial fluids act as lubricants and shock absorbers in the body to increase the body's efficiency in function. Water plays an essential role in any livestock production to produce high performance animals.

The most common drinking water sources in ruminant farms are wells, rivers, lakes, ponds and rainwater and there are little to no treatment is done to the water before they are served to the animals. Besides that, feed that are high in moisture content such as green chop, silage and pasture can also fulfil part of an animal's daily water requirement while the dry feed such as grain and hay will provide very little moisture (Landefeld and Bettinger, 2000). This, coupled with the sanitation status of the farm, could lead to the presence of many different types of contaminants that have the potential to pollute the animals' drinking water supply. As of today, there are no statistical data on the sanitation status of ruminant farms in Malaysia that had been published but it can be inferred that the sanitation status to be poor from the poor Biosecurity compliance status as published by Nooraisyah et al., (2014).

These contaminants could have many different harmful effects on the animals consuming it and thus could harm the animals' performance, eventually leading to losses in terms of production to the farmers. There were very few studies that had been conducted on the effect of these contaminants on ruminants, either in Malaysia or globally, where further studies are required to be conducted on this topic for further understanding and added knowledge in this field.

There are many gray areas in this field of study when we consider the quality of the drinking water in ruminant farms, the effect of water quality on the ruminant production and the possible host cell response that can occur from drinking the contaminated water.

2. Physical physiognomies of drinking water

The appearance, taste, odor, and texture of water define what people experience when they drink or use water and how they rate its quality; other physical characteristics can suggest whether decay and scurf are expected to be significant problems in pipes or fittings. The quantifiable physiognomies that define these subjective potentials are largely:

a) true color (i.e. the color that remains after any suspended particles have been removed)
b) turbidity (the cloudiness caused by fine suspended matter in the water)
c) hardness (the reduced ability to get a lather using soap)
d) total dissolved solids (TDS)
e) pH
g) temperature
h) taste and odour
i) dissolved oxygen.

Color and turbidity influence the appearance of water. Taste can be influenced by temperature, TDS, and pH. The texture of water can be affected by pH, temperature, and hardness. Rates of decay and scurf (scale build-up) of pipes and fittings are affected by pH, temperature, hardness, TDS and dissolved oxygen (EPA and CDC, 2017).

The Safe Drinking Water Act requires EPA to regulate the level of contaminants in drinking water at which no adverse health effects are likely to occur with an adequate margin of safety. These non-enforceable health goals, based solely on possible health risks, are called maximum contaminant level goals (MCLGs). EPA has set the maximum contaminant level goal for lead in drinking water at zero because lead is a toxic metal that can be harmful to human health even at low exposure levels. Lead is persistent, and it can bioaccumule in the body over time (EPA and CDC, 2017).

Water envisioned for humanoid consumption must be free from chemical substances and micro-organisms in quantities which would provide a threat to health is globally acknowledged. Provisions of drinking water should not only be safe and free from hazards to health, but should also be as appealingly attractive as possible. Non-appearance of turbidity, colour and distasteful or detectable tastes and odours is imperative in water provisions proposed for domestic use. The location, construction, operation and supervision of a water supply, its sources, reservoirs, treatment and distribution must exclude all potential sources of pollution and contamination (EPA and CDC, 2017).

International standards of quality for a safe and acceptable water supply, and of accredited or approved methods for the examination of water, have been fully acknowledged by groups of expert hygienists and engineers concerned with matters of water sanitation. Great improvement in water quality can be achieved throughout the world if various treatment processes are made easily analogous by the acceptance of uniform methods for the examination of water and for the expression of results of such examinations (Diersing, 2009).

Water Safety Plans (WSP) and Quantitative Microbial Risk Assessment (QMRA) have been utilised as frameworks and working tools to help in the decision making progression for water quality management. QMRA is extensively useful for evaluating health risk connected to water ingestion and exposure to drinking and recreational water pathways (www.un). The risk analysis consist of risk assessment, management and communication is a valuable framework to systematically address water health risk (WHO, 2005). Nevertheless the use of WSP and QMRA remains challenging in developing countries due to the lack of capacity and their acceptance. This is specifically challenging as health goals and targets associated with pathogen and contaminant decrease associated with sanitation and wastewater treatment has not been addressed (www.un). The WSP and the risk analysis framework in particular QMRA can be used to integrate science and policy and promote the translation of science into action, applied in water quality field. The risk framework involves defining the sanitation problem at the suitable scale, recognising the hazards, and understanding and testing for pathogens found in feces and sewage, surface or groundwater's from local scales to the larger watersheds/basins for exposure assessment and linking these data to dose-response functions to provide probabilities of infection. The capacity for undertaking WSP and QMRA can be built within academic institutions and once this has been done, the skills can be used for water quality management system to effectively apply QMRA framework to assess, predict and manage risk (www.un).

3. Contaminants in drinking water and wastewater

The Safe Drinking Water Act 1974 of the Environmental Protection Agency of the Unites States defines water contaminants as any physical, chemical, biological and radiological substance or matter that is found in water, in other words, anything else besides water molecules. Some of the common water contaminants are naturally occurring minerals and chemicals, fertilizers, pesticides, sewer overflow and wastewater releases (Centres for Disease Control and Prevention, 2013). The Ministry of Health of Malaysia had set a standard for the quality of drinking water in order to ensure the absence of these contaminants above safe levels (Moh.gov.my, 2004).

As most ruminant farms do not use a conventional water source, the water quality is usually substandard and this could affect the performance of the animals in the farm. According to United States Geological Survey Agency in 2005 (Joan et al., 2009), groundwater makes up about 60% of livestock freshwater sources while the rest is made up of surface water sources such as lakes, ponds and rivers. Most of this water sources are not treated prior to providing it to the animals, there are high possibilities that the water from these sources contain contaminants that might have adverse effects on the animals.

The swine industry also suffered a similar problem previously when backyard farming was the norm for pig farming worldwide (Dvs.gov.my, 2013). The water was usually sourced from unconventional water sources and this combined with obvious poor sanitation and hygiene status of the farms gives rise to questionable water quality in these farms. This also applies to the current situation in Malaysia where most of the farms are specialized household productions with poor facilities and sanitation status (Dvs.gov.my, 2013).

This is very much different in the poultry industry where intensive system was practiced which has its own standard of water quality (Brake and Hess, 2001). This is because the birds that is reared under the intensive systems are under a lot of stress from the various factors involved in the production that they can become susceptible to changes in the water quality and cause losses to the farmers (Carter and Sneed, 1996).

Manure is the most common contaminant in the ruminant industry, especially when the water source such as a pond and well are in close contact with the animals. This, coupled with poor hygiene practices on the farm, can lead to outbreaks of coliform related diseases that is caused by *E. coli*, *E. aerogenes* and *Klebsiella sp* such as mastitis, urinary tract infection and diarrhea as water that is contaminated with manure is a rich medium for bacterial growth (Mara and Horan, 2003). Fecal contamination of the livestock drinking water can also lead to algae blooms through a process known as nutrient loading (Anderson et al., 2003). The algae bloom in the water source may cause the animals to find an alternative water source and when it is unavailable, it will decrease the animals' overall water intake, leading to a drop in their performance (Anderson et al., 2003). To date, there were no research data or information on faecal contamination or algae bloom in the water sources in ruminant farms of Malaysia.

Water also plays an effective role as carrier of certain pathogenic microorganisms and untreated water sources have higher chances of contamination with these microbes. An example of this is Leptospirosis, a disease that causes reproductive losses in cattle, that is spread by water that is contaminated with urine (Leonard et al., 1992a; Leonard et al., 1992b). There was no information available on the microorganisms that were isolated from the water sources and wastewater in ruminant farms of Malaysia.

When the mineral content in drinking water, which is described as Total Dissolved solids (TDS) exceed safe levels, it can cause the animals' performance to suffer (Patterson et al., 2004). An example of this is high levels of sodium in drinking water can reduce water intake, leading to weight loss and diarrhoea. Higher incidences of polioencephalomalacia and increased mortality rates had been observed in animals that is exposed to high levels of sodium. This phenomenon can usually be observed when there is saltwater intrusions in the water sources, especially in farms that are located nearby saltwater sources such as the sea (WHO, 2015). The knowledge on the mineral content in drinking water from the water sources in ruminant farms of Malaysia is scarce.

4. Effect of water quality on animals

In a study by Kramer et al (2009), it has been proven that there is significant correlation between the water intake and the milk yield in dairy animals. As the quality of the drinking water plays an important role in the overall water intake, it can be predicted that poor water quality will reduce water intake, thus reducing the milk yield. Meanwhile, in another study by Lardner et al (2005), it had been proven that steers that are given good quality drinking water has improved weight gain up to 10% as compared to those that were given contaminated water. This is because the better water quality increases the water's palatability and this in turn increase the water and feed consumption, allowing for increased weight gain.

It has also been found that they are associated with exposure to water contaminants such as trihalomethanes and trichloroethylene and adverse pregnancy outcomes such as small for gestational age, low birth weight, preterm birth, birth defects, spontaneous abortions and fetal deaths (Bove et al., 2002). Although the direct relationship between the contaminants and the adverse pregnancy outcomes is still unclear, the presence of a correlation between these two parameters as mentioned above warrants for the concern of preserving the quality of the drinking water in ruminant farms so as to improve the reproductive performance in the farm. Besides that, it also raises the concern of the relationship between adverse pregnancy outcomes and the other water contaminants. This shows us that there is a severe lack of information on this subject and the important need to study this further in the future.

In general, all these contaminants can affect the appearance, odour and taste of the drinking water as well as its physical and chemical properties (WHO, 2004). As adequate consumption of good quality water is associated with a good growth rate, increased milk yield, and reduced risk of diseases, therefore, to determine the water quality in the ruminant farms and the effects of drinking water of substandard quality is an essential study. The information obtained from the proposed studies may allow for better manipulation of the water provided to the ruminant livestock in terms of quality in the future that may better suit their needs.

5. Host cell response in animals

The host cell is a living organism that is capable of being invaded by a pathogenic agent and gives responses in terms of clinical signs, tissue changes, blood and serum biochemistry changes and biomarker concentrations (Michael and Ronald, 2014).

The research community had long established a set of steps to be taken when evaluating the health status of animals in a laboratory setting for easier evaluation of the endpoint in them (National Research Council, 1992). In a study done by Vodela et al (Vodela et al., 1997), it is shown that there are significant reductions in water and feed intake, weight gain and suppression of the natural, humoral and cell mediated immunity in poultry that are given drinking water contaminated with certain contaminants such as cadmium, arsenic, lead, benzene and trichloroethylene. While studies has been done extensively on the effect of water contaminants in the poultry industry but there is very little research conducted in the ruminant industry. This gives rise to the need for more study in this field as it is very important to ensure the food security where the ruminant meat are being consumed worldwide.

In an experimental study whereby male rats had been orally inoculated with different concentrations of the common heavy metals found in water had revealed that there are changes in the clinical signs, serum biochemistry and histopathology of vital organs when the concentrations are high (Jadhav et al., 2007). The most obvious clinical signs were decreased body weight and water consumption and increased weight of the brain, liver and kidneys. In this study, the concentration in the aspartate aminotransferase, alkaline phosphatase, urea and creatinine were increased while the total protein and albumin levels were reduced. Histopathology revealed that there are vascular, degenerative and necrotic changes that can be observed in the brain, liver and kidney tissues. All this indicates that the exposure to the heavy metals in the water affects the health of the rats by altering the functional and structural integrity of the brain, liver and the kidney. Despite having heavy metals such as chromium, arsenic, aluminium and antimony as some of the most common contaminants of groundwater that's extensively used in the livestock industry, there is severe gap knowledge on the effect of the contaminants in the ruminant industry in Malaysia (Water.usgs.gov.edu, 2005).

Meanwhile, inoculation of cadmium in the drinking water of mice had shown significant decreases in the IgM and IgG titer against sheep red blood cells and there was a significant decrease in IgG against bovine serum albumin (Dan et al., 2000). Besides that, cadmium accumulation in the spleen, liver and kidney cause's degenerative and inflammatory changes and it is believed that these changes are responsible for the suppression in the antibody titer, most probably due to the cytotoxic effect of cadmium. As cadmium is one of the possible water contaminants in ruminant farms, there is a need for more study to learn the possible effects of cadmium contamination in ruminants.

6. CONCLUSION

From all the information and literatures discussed above, it showed that there is the need of assessing the water quality of the water sources and wastewater from the ruminant farms particularly in Malaysia. More studies are to be carried out in order to understand the possible correlation between the water quality and animal production status in ruminant farms and also the possible host cell response exhibited in ruminants by drinking the water of substandard quality.

7. CONFLICT OF INTEREST

This manuscript has not been submitted for publication elsewhere and been approved by all co- authors. The authors declare that they do not have any conflict of interest.

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