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Assessment of Drinking Water and Wastewater Quality in Selected Dairy Cattle Farms from Malaysia

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Abstract

There is a paucity of published research information on the quality of water used in the Malaysian ruminant livestock production system. Also, there are growing concerns about the sanitation standards of ruminant farms as it affects the management of wastewater in Malaysia. This study was designed to compile preliminary data on the drinking water and wastewater quality in designated dairy cattle farms in the Klang Valley. Seven dairy farms were randomly selected and visited to collect samples of drinking and wastewater for laboratory analysis. The water samples were analyzed to determine dissolved oxygen (DO), pH, salinity, electrical conductivity, turbidity, biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), ammoniacal nitrogen, nitrate, phosphates, total coliform count, iron, and magnesium content. The means of various parameters were compared with the National Water Quality Standards (NWQS) to determine the appropriate classification. We further streamlined the rating of water quality into three broad categories, namely, good (Class I and II), moderate (Class III) and unsatisfactory (Class IV and V). Analysis of drinking water revealed 1(14.29%), 2 (28.57%), 2 (28.57%) and 2 (28.57%) farms were categorized as Class II, III, IV and V, respectively. Meanwhile, all the wastewater samples analyzed in this study were classified as Class V. This study provides preliminary data on the quality of drinking and wastewater in select dairy cattle farms in Malaysia. The obtained findings indicate that the quality of drinking water in most of the cattle farms is below the National Water Quality Standards.

KEYWORDS
Drinking water; Wastewater; Dairy cattle; National Water Quality Standards; Malaysia.

INTRODUCTION

Water is considered as the most important of all nutrients because it is needed on regular basis and in high demand (Sejian *et al*., 2012). Domesticated animals can live for about 60 days without food but can hardly survive water deprivation beyond seven days (Church and Pond, 1974). Lack of sufficient and clean drinking water quickly causes stress and dehydration in animals; for this reason, livestock must be given water *ad libitum* (Sejian *et al*., 2012). Physiologically, water is essential in the transport of nutrients between cells as well and act as a vital medium for intracellular metabolism (Gropper *et al*., 2009). Some studies have shown a positive correlation between regular access to clean drinking water and increased production outcomes such as growth, reproduction, and milk production (Ensley *et al*., 2000; Schutz, 2012). Also, animals that have access to sufficient clean water are usually less prone to illness and diseases due to reduced contact with pathogens and toxins in the water (Schutz, 2012).

The familiar sources of water in livestock farms are tap water, underground water, and surface water such as lakes, ponds, rivers, swamps and drains as well as feed that is high in moisture such as green chop, pasture, and silage (USGS, 2005). Underground water typically contains less particulate matter such as leaves, soil and bugs, and contains a higher concentration of dissolved substances such as chemical and minerals which are leached off the ground as the water moves through it (USGS, 2016). The natural composition of both groundwater and surface water can be altered by pollution through human activities, causing the infiltrations of contaminants such as pesticide, fertilizers, animal wastes and chemicals (Sasakova *et al*., 2018). As a result, there is a need to assess the quality of the groundwater and surface water sources before they are deemed suitable for livestock consumption. In the United Kingdom, the United States and Canada, strict guidelines are regulating the quality of drinking

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water in the livestock industry, including sampling, and testing procedures (Wright, 2007; Higgins *et al*., 2008). This is because most cattle farmers use groundwater and surface water sources as drinking water for their livestock without any treatment, raising a need to check for the suitability of the water sources for livestock consumption. Treatment such as filtration, chlorination or reverse osmosis must be performed in cases of substandard drinking water sources before it is deemed safe for consumption (Qadir *et al*., 2007). Wastewater is water that has been adversely affected in quality through the anthropogenic influence that originates from domestic, industrial, commercial, or agricultural activities, surface runoff or stormwater and sewer inflow or infiltration (WHO, 2015). Water is used extensively in most livestock farming for cleaning, animal cooling and sometimes for manure transfer leading to the production of a copious amount of wastewater (FAO, 2019). Wastewater used in cleaning and other farm activities is frequently released into rivers, drains and lakes without any proper treatment. These practices lead to environmental pollution and serve as a medium for disease transmission. Also, the proximity of the wastewater to the drinking water sources may increase the chances of polluting the drinking water.

To the best of the authors knowledge, there is no information on the quality of drinking water and wastewater in the ruminant livestock industry in Malaysia. Despite the importance of routine assessment in monitoring water quality in animal production, to date, there no published report related to the quality of drinking water and wastewater in livestock farming in Malaysia. Therefore, this study was designed to fill up the gap knowledge by providing preliminary data on the assessment of water quality in the ruminant livestock industry in Malaysia.

MATERIALS AND METHODS

Experimental Design

A total of seven dairy cattle farms which participated in the study were selected randomly from the Klang Valley, Selangor, Malaysia. We conducted on-site examination of the drinking water and wastewater using probes that measures the dissolved oxygen, temperature, pH, turbidity, conductivity, and salinity. Arion Star® A121 pH Portable Meter was used for pH and temperature measurements; YSI® 58 Dissolved Oxygen Instrument was used to detect the amount of dissolved oxygen; Cole-Parmer® Waterproof Turbidity Meter Kit 59200-70 was used to measure the degree of turbidity and the Arion Star® A122 Conductivity Portable Meter was used to measure the conductivity and the salinity. We further collected drinking water and wastewater samples at multiple sites on each farm in acid-washed containers packed cold for transportation to the laboratory.

Determination of Biological Oxygen Demand (BOD)

Winkler's method was used to determine the BOD of the samples. The reagents were prepared beforehand in large amounts for all the samples. The stock dilution water was prepared by dissolving 8.5 g of KH_2PO4, 21.75 g of K_2HPO4, 33.5 g of Na_2HPO4, 1.7 g of NH_4Cl, 22.5 g of MgSO4.7H2O, 27.5 g of $CaCl_2$, and 0.25g of $FeCl_3$.6H2O in distilled water and were diluted to 1000 ml. The dilution water was prepared by adding 1 ml of stock to 999 ml of distilled water that was aerated by bubbling clean-filtered compressed air for 24 hours before use. The sodium sulphate solution (0.025N) was prepared by dissolving 1.575 g of Na_2SO_3 distilled water and was diluted to 1000 ml. The manganese sulphate solution was prepared by dissolving 480 g of $MnSO_4$.4H2O in distilled water and diluted to 1000 ml. The alkali iodide-azide reagent was prepared by dissolving 500 g of NaOH, 150 g of KI and 10 g of NaN_3 in distilled water and was diluted to 1000 ml. The starch indicator was prepared by mixing 2.0 g of soluble starch powder and 0.2 g salicylic acid as preservative into a paste with distilled water before being added to 100 ml of boiling distilled water. The sodium thiosulphate solution (0.025N) was prepared by dissolving 6.205 g of $Na_2S2O_3.5H_2O$ in distilled water and was preserved by adding 0.1 g of solid NaOH. The solution was then diluted to 1000 ml. Each water sample was filled into 6 BOD bottles up to the brim after dilution using dilution water (1:1 for drinking water and 1:99 for wastewater), and three bottles were labelled as BOD 1, and the other three was labelled as BOD 5. 1 ml of manganese sulphate followed by 1 ml of alkali iodide-azide solution was added to the BOD 1 bottles, making sure that the pipette tips were below the water level when adding the solutions. The bottle was stoppered immediately and was mixed well by inverting it 2 to 3 times. At this time, the precipitate was observed in the bottle and was allowed to settle before adding 1 ml H_2SO4. The stopper was replaced, and the bottle was mixed well to allow the precipitate to dissolve. 201 ml of this solution was then measured out in a conical flask and was titrated using sodium thiosulphate solution using 2 ml of the starch indicator. The DO was calculated using the following formula:

DO (mg/L) = [(0.2 × 1000) × ml of sodium thiosulphate] / 200

The average of the three samples was taken as the DO of the samples. In the meantime, BOD 5 bottles were incubated at 20°C for five days before the average DO was determined. The average BOD of the water sample was calculated using the following formula:

BOD (mg/L) = [(DO_1- DO_5) × 100] / % Dilution

Determination of Chemical Oxygen Demand (COD)

The open reflux method was used to determine the COD of the water samples obtained. The reagents were prepared in large amounts beforehand for all the samples. The standard potassium dichromate solution (0.25 N) was prepared by dissolving 12.259 g of $K_2Cr_2O_7$ in distilled water and was diluted to 1000 ml. The sulphuric acid reagent was prepared by adding 10 g of Ag_2SO4 to 1000 ml of concentrated sulphuric acid and was left to stand for 1-2 days for complete dissolution. The standard ferrous ammonium sulphate solution (0.25 N) was prepared by dissolving 98 g of $Fe(NH_4)_2(SO_4)_2.6H_2O$ in 400 ml of distilled water. 20 ml of concentrated sulphuric acid was added, and the solution was diluted to 1000 ml. The potassium hydrogen phthalate standard solution was prepared by dissolving 425 mg of potassium hydrogen phthalate ($HOOC.C_6H_4.COOK$) in distilled water and diluted to 1000 ml. 0.4 g of $HgSO_4$ was placed in a 250 ml reflux flask. 20 ml of sample was added to the reflux bottle and was mixed well. Clean glass beads were also added at the same time. 10 ml of standard potassium dichromate solution was added to the solution and was thoroughly mixed. 30 ml of the sulphuric acid reagent containing Ag_2SO_4 was then added slowly into the reflux flask while mixing thoroughly by swirling the bottle slowly. The flask was connected to a condenser, and the solution was refluxed for 2 hours. The solution was then cooled, and the condenser was rinsed with distilled water before the condenser was disconnected from the flask. The mixture in the flask was then diluted to approximately twice the original volume using distilled water. The solution was then cooled to room temperature and was titrated using ferrous ammonium sulphate solution using 2 to 3 drops of ferroin indicator. The sharp colour change from blue-green to reddish-brown indicates the endpoint of titration.

The above steps were then repeated using distilled water to obtain the blank. The COD was obtained using the following formula:
COD (mg/L) = [(A – B) × 0.25 N × 8000] / ml of sample
A: ml of ferrous ammonium sulphate for blank
B: ml of ferrous ammonium sulphate for sample

Determination of Total Coliform

Total coliform was determined using the membrane filtration technique. Agar plates containing endo medium was prepared beforehand following standard preparation. Each sample was prepared and diluted to 100, 10-1, 10-2, 10-3, 10-4, 10-5 and 10-6. 100 ml of each dilution was then filtered using a gridded cellulose membrane filter with uniform 0.45 µm diameter pores and a sterile membrane filtration apparatus. Blunt tipped forceps that was sterilised through alcohol flaming was then used to transfer the membrane filter onto the endo agar plates. Caution was taken to avoid trapping air bubbles between the membrane filter and the agar. The agar plates were then incubated at 37°C for 24 to 48 hours, and plates with less than 200 colonies were counted. The following formula was used to determine the total coliform:
Total coliform (CFU/L) = (number of colonies × 1000) / (dilution × 100).

Determination of Total Soluble Solids (TSS)

An evaporating dish was dried in a desiccator and then weighed using an electronic balance. The reading was repeated after a period of drying in the desiccator until a constant reading was achieved. A piece of membrane filter was weighed using the electronic balance, and the reading was recorded. 100 ml of the sample was filtered using the membrane filter. The membrane filter was then placed in the evaporating dish, and both were placed in an electronically heated temperature-controlled oven at 103 to 105°C for evaporation for 24 hours. It was then dried in an oven for an hour 180±2°C. Both the membrane filter and the evaporating dish was cooled in a desiccator and weighed. The drying was repeated until a constant reading was obtained. The TSS was calculated using the following formula:
TSS mg/L = [A- (B+C)] × 1000/100
Where:
A = weight of dried residue + evaporating dish + filter paper
B = weight of the evaporating dish
C = weight of the filter paper

Determination of Total Dissolved Solids (TDS)

An evaporating dish was dried in a desiccator and then weighed using an electronic balance. The reading was repeated after a period of drying in the desiccator until a constant reading was achieved. 100 ml of samples was filtered using a membrane filter. The filtrate was then placed in the evaporating dish before being placed in an electronically heated temperature-controlled oven at 103 to 105°C for evaporation for 24 hours. It was then dried in an oven for an hour 180±2°C. The evaporating dish was then cooled in a desiccator and weighed. The drying was repeated until a constant reading was obtained. The TDS was calculated using the following formula:
TDS mg/L = (A- B) × 1000/100
Where:
A = weight of dried residue + evaporating dish
B = weight of the evaporating dish

Determination of Magnesium and Iron

Magnesium and iron concentration were determined using inductively coupled plasma (ICP) method. Before that, all the samples were digested using the nitric acid-sulphuric acid digestion method. 50 ml of 1:9 diluted, acid -preserved sample was transferred to a conical flask. 3 ml of concentrated nitric acid was added to the solution before it was placed on a hot plate and was cautiously evaporated until there are 15-20 ml of solution left in the flask. 5 ml of concentrated HNO3 and 10 ml concentrated H_2SO_4. Evaporation was continued until dense white fumes of SO_3 just appear. Additional 10 ml of concentrated HNO_3 was added and evaporation was repeated if the solution does not clear. Cool and dilute to about 50 ml with deionized water. Filter the final solution if necessary. The final solution was then used to determine the magnesium and iron concentration by comparing it with the standards and the blank reading on the ICP.

Determination of Nitrate

Nitrate concentration was determined using the HACH Kit method. The provided reagent was added to 10 ml of sample and mixed well. The resulting solution was then transferred to the spectrophotometer cell before the absorption was read using the DR6000TM UV VIS Spectrophotometer using the preprogramed method.

Determination of phosphate

Phosphate concentration was determined using the HACH Kit method. The provided reagent was added to 10 ml of sample and mixed well. The resulting solution was then transferred to the spectrophotometer cell before the absorption was read using the DR6000TM UV VIS Spectrophotometer using the preprogramed method.

Determination of Ammoniacal Nitrogen

The ammoniacal nitrogen concentration was determined using the Nessler's method using a HACH Kit. The sample was mixed with the reagents, and the final solution was then read for absorption using the DR6000TM UV VIS Spectrophotometer using the preprogramed method at 410 nm.

Statistical analysis

All data in this study were descriptively analysed using Statistical Analysis Software (SAS) version 9.4. The values of individual water quality parameters from different farms were presented as Mean±SD and classified according to the National Water Quality Standards.

RESULTS

Drinking Water Quality Analysis

The results of drinking water quality assessment tests conducted on samples collected from various farms in the Klang Valley are presented in Table 1. According to the National Water Quality Standard. Drinking water samples were classified into five categories (Class I, II, III, IV and V) and then further divided into three sub categorized categories of the NWQS: good quality (Class I and Class II), moderate quality (Class III) and unsatisfactory quality (Class IV and Class V).

When compared with the National Drinking Water Quality Standards, the obtained results showed that none of the drinking water samples qualified as Class I. However, drinking water sample from one farm (14.28%) qualified as Class II, while drinking water samples from 2 (26.57%) other farms qualified as Class III. Also, there were 2 (26.57%) farms with Class IV quality and 2 (26.57%) other farms with Class V quality of drinking water. According to the National Water Quality Standards, only drinking water with at least Class III quality is deemed safe for livestock consumption. Therefore, results from this study indicated that only 3 (42.86%) farms sampled in this study had safe drinking water standard for livestock consumption while the rest of the farms had substandard drinking water quality.

Wastewater Quality Analysis

The results of wastewater quality assessment tests conducted on samples collected from various farms in the Klang Valley are presented in Table 2. The wastewater samples collected from the selected cattle farms in this study were analysed and compared with the National Water Quality Standards to categorise according five different classes (Class I to Class V). According to results

Table 1. The results of parameters tested for samples of drinking water collected from selected cattle farms.

Parameter	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6	Farm 7
Source	Groundwater	Groundwater	Well	Groundwater	Well	Tap	Tap
pH	7.36±0.01 (I)	6.28±0.01 (I)	6.61±0.01 (I)	6.99±0.03 (I)	7.03±0.02 (I)	7.95±0.05 (I)	7.31±0.02 (I)
Temperature (°C)	28.63±0.15	30.47±0.15	33.00±0.10	28.07±0.06	32.30±0.20	29.40±0.10	28.57±0.21
Turbidity (NTU)	0.55±0.03 (I)	0.38±0.02 (I)	9.07±0.15 (II)	2.82±0.02 (I)	0.16±0.00 (I)	0.97±0.02 (I)	0.74±0.01 (I)
Conductivity (µS/m)	205.07±1.27 (I)	326.97±3.90 (I)	518.00±2.65 (I)	96.17±0.61 (I)	316.00±1.41 (I)	652.67±18.35 (I)	186.00±2.26 (I)
Dissolved Oxygen (mg/l)	6.36±0.06 (II)	6.35±0.05 (II)	6.41±0.25 (II)	6.47±0.04 (II)	6.50±0.09 (II)	7.15±0.02 (I)	7.22±0.05 (I)
Salinity (ppt)	0.10±0.00 (I)	0.10±0.00 (I)	0.27±0.06 (I)	0.03±0.06 (I)	0.07±0.06 (I)	3.17±0.06 (V)	0.10±0.00 (I)
Total Soluble Solid (mg/l)	36.33±3.21 (II)	42.67±8.74 (II)	71.67±4.62 (III)	17.67±3.79 (I)	12.33±0.58 (I)	12.33±1.53 (I)	10.33±1.15 (I)
Total Dissolved Solid (mg/l)	445.33±1.53 (I)	651.00±3.46 (II)	1615.67±3.21 (II)	561.00±2.65 (I)	651.00±0.58 (I)	450.67±3.06 (I)	659.67±3.06 (I)
Biological Oxygen Demand (mg/l)	3.07±0.23(III)	1.73±0.12 (II)	3.80±0.35 (III)	3.33±0.12 (III)	2.17±0.32 (II)	1.40±0.20 (I)	1.33±0.23 (I)
Chemical Oxygen Demand (mg/l)	16.67±5.77 (I)	23.33±5.77 (I)	70.00±10.0 (III)	66.67±5.77 (III)	26.67±5.77 (II)	23.33±5.77 (I)	16.67±5.77 (I)
Total Coliform (CFU/l)	1883.33±76.38 (II)	30333.33±1755.94 (III)	8266.67±416.33 (III)	53.33±45.09 (I)	2.67±2.52 (I)	110.00±10.00 (II)	251.33±8.33 (I)
Ammoniacal Nitrogen (mg/l)	0.36±0.01 (II)	0.55±0.01 (II)	2.53±0.15 (IV)	1.62±0.08 (V)	0.13±0.02 (I)	0.88±0.03 (IV)	0.27±0.03 (I)
Phosphorus (mg/ml)	0.22±0.02 (II)	0.16±0.02 (II)	0.58±0.03 (V)	0.05±0.01 (I)	0.63±0.01 (II)	0.23±0.03 (II)	0.09±0.01 (I)
Nitrate (mg/ml	2.43±0.03 (I)	1.35±0.04 (I)	2.65±0.02 (I)	0.31±0.02 (I)	1.43±0.01 (I)	1.22±0.03 (I)	1.54±0.04 (I)
Manganese (mg/l)	2.07±0.02 (I)	1.16±0.01 (I)	1.47±0.01 (I)	2.23±0.02 (I)	2.17±0.02 (I)	2.21±0.00 (I)	3.65±0.01 (I)
Iron (mg/l)	1.33±0.00 (II)	2.59±0.00 (II)	10.19±0.03 (V)	3.04±0.04 (V)	2.38±0.01 (IV)	3.88±0.02 (IV)	1.18±0.00 (II)
Overall Class	III	III	V	V	IV	IV	II

*Values in parentheses refers to the class of parameter according to the National Water Quality Standards.

Table 1. The results of parameters tested for samples of drinking water collected from selected cattle farms.

Parameter	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6	Farm 7
pH	6.57±0.04 (III)	8.70±0.05 (III)	8.04±0.01 (IV)	7.18±0.03 (IV)	6.20±0.02 (IV)	7.20±0.01 (IV)	6.14±0.01 (IV)
Temperature (°C)	27.9±0.10	32.30±0.17	33.67±0.21	26.73±0.15	30.57±0.06	29.67±0.15	27.27±0.15
Turbidity (NTU)	142.33±0.58 (III)	771.00±2.65 (IV)	388.67±3.21 (III)	105.67±1.53 (III)	648.00±4.58 (IV)	1511.00±5.57 (V)	454.00±2.65 (III)
Conductivity (µS/m)	1273.00±11.79 (II)	681.67±11.93 (I)	1561.33±18.82 (II)	556.00±7.94 (I)	276.07±2.11 (I)	3241.67±30.92 (III)	2732.67±14.47 (III)
Dissolved Oxygen (mg/l)	5.46±0.04 (II)	5.05±0.42 (II)	6.15±0.12 (II)	6.88±0.06 (II)	6.02±0.04 (II)	5.88±0.07 (II)	5.94±0.08 (II)
Salinity (ppt)	0.63±0.06 (II)	0.23±0.06 (I)	0.70±0.10 (II)	0.33±0.06 (I)	1.57±0.06 (III)	2.43±0.15 (V)	2.27±0.21 (V)
Total Soluble Solid (mg/l)	3116.67±26.16 (V)	416.67±185.56 (V)	4646.67±75.72 (V)	3003.33±104.08 V)	273.33±20.82 (IV)	6866.67±208.17 (V)	596.67±15.28 (V)
Total Dissolved Solid (mg/l)	3326.67±41.63 (III)	2296.67±30.55 (III)	7756.67±20.82 (V)	4380.00±26.46 (V)	4480.00±26.46 (V)	11200.00±200.00 (V)	3566.67±15.28 (III)
Biological Oxygen Demand mg/l)	16.67±5.77 (V)	13.33±5.77 (V)	13.33±5.77 (V)	23.33±5.77 (V)	26.67±5.77 (V)	36.67±5.77 (V)	20.00±10.00 (V)
Chemical Oxygen Demand (mg/l)	193.33±5.77 (V)	100.00±10.00 (IV)	296.67±5.77 (V)	106.67±5.77 (IV)	203.33±15.28 (V)	410.00±10.00 (V)	96.67±5.77 (IV)
Total Coliform (CFU/l)	796666.67±4163.33 (V)	64000.00±3774.92 (III)	264500.00±6062.18 (V)	100333.33±3752.78 (V)	88166.67±3013.86 (III)	423166.67±10128.34 (V)	118833.33±4804.51 (V)
Ammoniacal Nitrogen (mg/l)	25.70±0.17 (V)	4.98±0.03 (V)	68.50±0.53 (V)	48.23±0.35 (V)	12.63±0.15 (V)	97.47±0.75 (V)	12.77±0.15 (V)
Phosphorus (mg/ml)	0.91±0.02 (V)	0.72±0.03 (V)	2.35±0.04 (V)	1.25±0.02 (V)	1.13±0.03 (V)	3.54±0.07 (V)	1.23±0.02 (V)
Nitrate (mg/ml	42.37±0.15 (V)	10.71±0.06 (V)	80.43±0.12 (V)	71.23±0.46(V)	62.82±0.27 (V)	152.73±1.03 (V)	53.00±1.15 (V)
Manganese (mg/l)	34.97±0.03(I)	9.55±0.03 (I)	23.18±0.12 (I)	56.22±0.06 (I)	27.36±0.33 (I)	20.00±0.31 (I)	30.25±0.13 (I)
Iron (mg/l)	58.51±0.20 (V)	19.36±0.03 (V)	15.45±0.03 (V)	30.15±0.05 (V)	79.96±0.06 (V)	36.93±0.04 (V)	17.45±0.05 (V)
Overall Class	V	V	V	V	V	V	V

*Values in parentheses refers to the class of parameter according to the National Water Quality Standards.

from the present study, all the wastewater samples collected from cattle farms in the Klang Valley were classified as Class V.

DISCUSSION

The obtained results has shown that only 3 (42.86%) samples of drinking water out of 7 (100%) were within or below class III, which is considered suitable for livestock consumption. Although many factors may affect the quality of the drinking water on the farm, the source of water is the foremost factor (MOH, 2004). Furthermore, data from the current study revealed that only 2 (28.57%) out of the 7 (100) farms provided treated tap water as livestock drinking water while 5 (71.42%) sourced their drinking water from substandard underground wells and ponds. As previously observed by Knight *et al*. (2000), we also found out that the cost of operation influenced the use of substandard water sources in most farms because farmers are mostly small-scale resource-poor producers. The water obtained from ground sources is given directly to the animals without any prior processing to eliminate contaminants, which could increase the likelihood of poisoning and disease outbreaks in livestock and human populations quality (Nakade *et al*., 2015). According to the world health organization, underground water contains high levels of metals and metal particles acquired from the rich mineral content of soil and saltwater intrusions (WHO, 2015). The metal content of underground water affects its salinity and electrical conductivity, which in turn influence biological processes in animal tissues. Although farms 1-5 all used underground water sources of drinking water, the amounts of iron present in samples collected from farms 3, 4 and 5 were different from those in farms 1 and 2, which could be due to variations in the amounts of the metal elements present in soils across different geographical locations as these farms in different parts of the Klang Valley. Also, according to Mako *et al*. (2017), variations in the filtration properties of some porous materials as the groundwater travels from one place to another could account for differences in concentrations of iron and other metal in different drinking water samples tested. Besides, Rzymski *et al*. (2016) and Su *et al*. (2017), linked the high levels of heavy metal in drinking water to corrosion due to ageing of metal pipes on farms and this also agrees with the obtained results of relatively higher salinity and iron concentration in water samples from 6 farms even though they used treated tap water.

All the water samples analysed in this study revealed a BOD value within or below Class III, which lies within the safe range for livestock consumption. The BOD level of a water sample refers to the amount of oxygen needed to degrade the degradable organic materials present in the water sample; thus, a higher BOD level directly reflects a higher amount of degradable organic material in the water sample (Ahuja, 2019). The organic materials affecting the BOD could be originating from flora and fauna living in or near the water source as well as the microorganism contamination present in the water sources (Ahuja, 2019). According to Ibrahim (2014), most untreated water sources have a higher than standard organic matter content. According to Wen *et al*. (2017), livestock generally has a higher tolerance of organic material in the water samples, and it is therefore unlikely for a BOD level of Class III or below to exhibit any adverse effects. COD refers to the amount of oxygen needed to oxidize organic water contaminants to inorganic waste products and is used to measure the organic content in the water sample (Lenore *et al*., 1998). The COD level of all the drinking water sampled in this study was within or below Class III, making it safe for livestock consumption according to the National Water Quality Standards.

TDS in water samples refers to the amounts of dissolved inorganic salts and organic matter which are less than 2 µm in diameter of (Lenore *et al*., 1998). All the water samples analyzed in this study are within or below the range of TDs Class II, which lies within the safe levels for livestock consumption (WHO, 2015). According to the World Health Organization in 2015, there is no significant health risk associated with drinking water with a TDS lower than 2000 mg/L. A higher level of TDS in water will make it bitter, brackish, or salty and therefore less palatable (WHO, 2015). As a result, there may be less consumption of water by livestock, leading to dehydration and disruption in physiological processes of the host cell. According to Lenore *et al*. (1998), TSS refers to the dry weight of all the inorganic and organic substances materials present in the drinking water sample. Results in this study indicates that the TSS values of all the sources of drinking water are within or below Class III, which according to the National Drinking Water Quality Standards, is considered safe for livestock consumption. According to Bilotta and Brazier (2008), TSS is an essential parameter used in the assessment of drinking water quality because it affects turbidity and palatability the water.

The total coliform refers to the concentration of faecal and non-faecal sources of coliform bacteria in a sample of drinking water (Lenore *et al*., 1998). In this study, we found that the total coliform count from all drinking water sources was within or below Class III, which is in the safe range for livestock consumption. According to Sejian *et al*. (2012), the presence of competitive bacteria action in the microbial rich ruminant forestomach enables them to tolerate a certain amount of the coliform bacteria. On the other hand, Tyrrel and Quinton (2003) reported that the presence of minute amounts of some faecal coliforms such as Campylobacter, Listeria, Salmonella, and specific serotypes of E. coli could be highly pathogenic, leading to reduced production outcomes in ruminants. In the future, further studies, including the analysis of faecal coliforms, may fully elucidate the potential effects of these waterborne pathogens on livestock drinking water quality and hence their overall health and productivity.

Ammoniacal nitrogen refers to the concentration of ammonia in the drinking water samples (Luo *et al*., 2015). In the present study, we found that 42.86% of the water samples had ammoniacal nitrogen concentration of Class IV and V, which according to National Drinking Water Quality Standards, are unsuitable for livestock consumption. The source of ammonia polluting water sources could be sewage, infiltration of animal manure and leeching of inorganic fertilizers during landfills after a torrential downpour. Kenny *et al*. (2002) reported that even though cattle could tolerate small amounts of ammonia, higher concentrations may pose some health risks and reduced livestock production, and acute concentrations of ammonia could be fatal. Therefore, the amount of ammoniacal nitrogen in drinking water meant for livestock consumption must be monitored continuously to avoid economic losses. Phosphorus refers to the concentration of phosphorus in each sample of water (Lenore *et al*., 1998). From the results of water analysis in the present study, we found that drinking water undesirably contain high phosphorus concentration in the range of Class V in one of the farms under study. Although Sejian *et al*. (2012) have reported that excessive ingestion of phosphorus in the diet is not related to any direct health impact, if the amount of calcium consumed is up to 6 times the amount of phosphorus, it can lead to leaching of calcium from the bones and cause clinical conditions such as osteoporosis and osteomalacia. Generally, the source of phosphorus in drinking water may come from agricultural run-off, natural decomposition of the element from the ground, atmospheric deposition, and soil erosion (Fadiran *et al*., 2008).

According to Knight *et al*. (2000), wastewater consists typically of animal organic wastes such as manure and food residues. In this study, all wastewater samples had a quality score of Class V on the National Drinking Water Quality Standards scale. As previously reported, we attribute this finding to the lack of wastewater treatment in all the farms before releasing effluent into the environment (Ming *et al*., 2007; Jafarinejad, 2016). All the water samples analyzed in this study produced BOD and COD values within the range of Class V based on the National Drinking Water Quality Standards, which conforms with the characteristic of wastewater effluent. Class V wastewater is a rich source of nutrient that can act as a precursor for the algae bloom and may inadvertently lead to eutrophication of adjacent water bodies (Anderson *et al*., 2003). In attempts to reduce the organic waste in the wastewater

from the farms, Chew *et al*. (2019) recommended reutilization as natural fertilizer for farming either directly or through composting. Furthermore, Chew and co-worker suggested to filter the organic wastes and used as an alternative source of energy through biomass energy production.

The 57.14% TDS and 71.42% total coliform count present in wastewater samples analyzed in this study are consistent with characteristics of Class V of the wastewater standard in the National Drinking Water Quality Standards. According to Sanders *et al*. (2013) the rich nutrient medium in wastewater provides a suitable culture for bacterial growth which might be detrimental to the environment, especially in situations that permit the spread of pathogenic faecal coliforms. Outbreak of severe clinical cases of colibacillosis may occur when wastewater contaminates adjacent sources of drinking water. The concentrations of ammoniacal nitrogen and phosphorus present in all wastewater samples collected in this study correspond to Class V, which may be due to high content of manure in the wastewater (Knight *et al*., 2000). The contamination of surface water sources by ammonia released from farm effluents can be detrimental to aquatic fauna because as they are unable to efficiently metabolize the toxicant, which may result to ammonia toxicity and mortality (Kenny *et al*., 2002).

CONCLUSION

The data obtained from the preliminary assessment of drinking and wastewater quality of selected ruminant farms in Malaysia revealed that the drinking water used on many dairy farms is below the standard requirements of the National Drinking Water Quality Standards. The use of substandard drinking water on farms may be associated with some negative impacts on the health and productivity of livestock. In addition, the practice of releasing untreated livestock effluent from farms may lead to serious environmental and public health hazards which can otherwise be prevented by converting wastewater into usable biomass or fertilizer. We recommend the periodic assessment of livestock drinking water quality and proper livestock wastewater management to contain the economic, public health and environmental impacts of poor water quality.

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CONFLICT OF INTEREST

The authors declared that no conflict of interest exits.

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