MONITORING OF WATER AMOUNT GOING TO MANURE REMOVAL SYSTEM FROM MILKING PARLOUR

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Abstract. Under a loose cow housing practice with automated milking installations, the manure removal system receives both manure from the barns and manure-bearing wastewater from the milking parlour. This is a mixture of animal excrement and washing water of frames and partitions in the milking installation and the manure-soiled floors and walls. The purpose of the study was to monitor the amount of washing water actually consumed in the milking parlour and subsequently entering the manure removal system. The monitoring was conducted on a farm in the Leningrad Region with an average dairy herd of 596 cows and three milkings a day in a Parallel 2x20 parlour. Electronic flowmeters were installed in the connection points of the washing equipment to the water supply system. They automatically recorded the water consumption every hour in the internal memory. The area, including the cow passages, was 255 m2 (milking parlour) and 267 m2 (holding area and sanitary zone). The holding area and the milking parlour were washed after each milking using high-pressure equipment. During the monitoring, the daily water consumption in the milking parlour varied from 11.3 to 17.5 m3. The average daily water consumption was 14.4 m3. The main amount of water was used in the milker's pit and averaged 64.6% of the total; 10.6% of the total water was used for washing the floor and walls with high-pressure equipment. The maximum water consumption was observed at the end of each milking, when the holding and milking areas were cleaned. The average amount of consumed water was 24 l cow-1·day-1, i.e. 8 l·cow-1 per milking. The study results are needed for correct dimensioning of manure storage facilities. They can be also used to calculate the moisture content of manure produced and, in case of its further separation, to determine the amount and moisture content of resulting fractions.

Keywords: wastewater, milking parlour, water, washing, consumption.

Introduction

To increase milk production efficiency, modern agricultural enterprises switch to a loose housing system of cows and milking in automated milking parlours.

In the milking parlour manure is removed by washing the floor and dirty surfaces. In most farms this is done after each milking. Walls and floors are usually rinsed with water using medium or high-pressure hoses, combining with brushing, if required [1]. The resulting manure-bearing wastewater, as a rule, enters a manure storage facility. It is stored there for at least 6 months before the field spreading. Understanding the exact amount of such wastewater allows for an accurate estimation of the required volume of manure storages.

The water in the milking parlour can also be used to wash the cow udders. The modern farms, however, use disposable wipes.

Many factors influence the amount of water entering the manure removal system from the milking parlour [2].

1. The size of the dairy herd. With more cows visiting the milking parlour, the amount of excrement increases, which, by various estimates, is 1.6-3.0% of the average daily output [3; 4]. Consequently, more water is required to remove it.
2. The size of the milking, holding and exit areas. They depend on the size of the overall dairy herd and a single technological group. Since these areas are to be cleaned after each milking, they have a big effect on the total volume of wastewater.
3. A number of washings of manure-soiled floor and surfaces. They can be three times a day, but, as a rule, they coincide with the number of milkings. The more times the floor is washed, the more manure-bearing wastewater exits the milking parlour.
4. Floor cleaning equipment. For example, washing the floor with a hose requires ten times less water than using a flush-cleaning system [6]. The high-pressure cleaners with increased water supply speed improve the hose usage efficiency in removing manure and dirt from cow hooves in the holding area [7]. At the same time, the authors of [7] note that floor cleaning with high-pressure units takes more time and is usually used for small areas or together with other equipment. The use

of special floor pre-cleaning devices and high-pressure washers results in significant water saving [8], and, consequently, in a smaller output of manure-bearing wastewater from the milking parlour.

5. Floor type (slotted or fully solid (concrete)) and floor covering. They affect the dirt removal efficiency.
6. The work of the personnel. As is the case with any process performed by a person, it affects the output of manure-bearing wastewater. High quality of work (timely elimination of leaks, economical use of water, etc.) contributes to a smaller amount of manure-bearing wastewater exiting the milking parlour.

According to the current regulatory documents, the water consumption for regular floor cleaning in the holding and exit areas is 5 $l \cdot m^{-2}$ [9], and the amount of manure-bearing wastewater generated per head in the milking area is 20 $l \cdot m^{-2}$ [4].

According to [10], the amount of water used for cleaning and operation of the milking parlour accounted for 14% of the total water consumption of the farm.

The authors of [11-13] report on the water total amount used in the milking parlor, which may include water for washing the milking machines, cleaning the udder, milk cooling and other operations. The data on the ranges of manure-bearing wastewater generated in the milking parlour are given for specific conditions and vary greatly.

The investigations [10; 14-16] performed in an automated milking parlour and Herringbone and Parallel milking parlours are the most similar to our study in terms of the problem of water consumption for the milking parlour cleaning.

Our previous theoretical studies allowed determining the output of manure-bearing wastewater from milking parlours and the volume of required manure storages at the designing stage [2]. However, all calculations were based on the current regulatory documents and required certain clarification.

The purpose of this study was to monitor the amount of water actually consumed in the milking parlour and subsequently entering the manure removal system.

Materials and methods

The monitoring was conducted on a farm in the Leningrad Region with three-shift milking in a Parallel 2x20 milking parlour with two operators per shift. The total dairy herd was 663 cows, of which 522 cows were milked three times a day, 81 cows – two times and 60 cows – once a day. Disposable wipes were used to clean the cows' udders prior to milking. The average daily productivity of cows during the study period was 37.2 kg $head^{-1}$.

The holding area and the milking parlour were cleaned after each milking with high-pressure washers. During milking, cow excrement was scraped off from the floor with a shovel into a manure channel after each group of animals. The area, including the cow passages, was 255 m^2 (milking parlour) and 267 m^2 (holding area and sanitary zone at the exit from the milking parlour). The floor was solid concrete, covered with rubber mats. The cow passages had the fences made of metal pipes 57 mm in diameter. The milking parlour conditions were in line with the general animal welfare requirements.

Three times a week the cow hooves were treated in the milking parlour. For this purpose, a 200 l walk-through animal-friendly Suevia footbath (Italy) was installed at the exit. The honeycomb design guaranteed the safe and high-quality disinfection. The solution was changed 4 times during the treatment of the whole herd. The used solution entered into the manure removal system.

The electronic flowmeters Pulsar M DU-15 (Russia) installed directly before the connection points of applied washing equipment (Table 1) recorded the amount of water used for washing the floor and surfaces soiled with manure in the milking parlour and subsequently entering the manure removal system.

The readings of the flowmeters were automatically recorded every hour and stored in internal memory. Reliable margin of error of flowmeters was 2-5%. The data for 72 days in November 2020 to February 2021 were analysed. *Microsoft Office Excel 2007* was applied to obtain statistical averages and to plot the charts.

Table 1

Connection points of electronic flowmeters

Connection points and location	Equipment and devices used	Purpose of water use
Connection point 1 – the milker's pit	Washing handguns and hoses Automatic valve	Washing the floor, walls, outside of milking machines, washing off excrement from the floor under cows in milking stations. Automatic rinsing of the protective tray under cows' tails in the milking installation after milking each group of animals.
Connection point 2 – holding area	High-pressure washer Karcher HD 6/15 C	Washing the frames and partitions of the milking installation, the floor and walls of the holding area, cow passages and the sanitary zone.
Connection point 3 – milking parlour	High-pressure washer Karcher HD 6/15 C	Washing the frames and partitions of the milking installation, the floor and walls of the milking parlour and cow passages.
Connection point 4 – holding area	Hose with B 20 mm	Washing the heavily soiled areas and/or letting the floor, walls of the holding area, milking parlour, cow passages and sanitary zone stay wet for some time. Preparation of solutions for hoof treatment.

Results and discussion

During the morning milking, 663 cows passed through the milking parlour; during the afternoon milking – 522 cows, and during the evening milking – 603 cows. It means, the average dairy herd was 596 cows. During the monitoring period, the total daily water consumption in the milking parlour varied from 11.3 to 17.5 m^3 (Table 2).

Table 2

Daily water consumption, m^3

Values for the monitoring period	In connection points of flowmeters				Total	Per cow per milking, m^3
	1	2	3	4		
Average ± SD	9.285 ± 1.068	0.625 ± 0.325	0.904 ± 0.736	3.570 ± 0.852	14.384 ± 1.601	0.008
Maximum	12.092	1.024	1.719	5.381	17.447	0.010
Minimum	7.009	0.028	0.302	1.923	11.262	0.006

The average daily water consumption was 14.4 m^3. The main amount of water was used in the milker's pit (connection point 1) and averaged 64.6%; 10.6% of water were used to clean the floor and walls with high-pressure washers (connection points 2 and 3).

Within 24 hours, the water in the milking parlor was used unevenly (Fig. 1) and depended on the work performed.

The maximum water consumption was observed at the end of each milking, when the holding area and the milking parlour were cleaned: at 10.00 – 11.9%, at 17.00 – 9.4% and at 24.00 – 6.8% of the daily water consumption. The increased water consumption at 10.00 might be explained by the work schedule on the farm. The time interval between morning and afternoon milkings was longer that allowed for a more thorough cleaning.

The monitoring revealed the effect of the human factors on the performed technological process. The water consumption varied within 11% depending on the shift. More significant variations were observed depending on the day of the week (Fig. 2).

Depending on the day of the week, the average daily water consumption could vary up to 18%. Friday was a cleanup day on the farm when workers did the most thorough cleaning. It was on that day that the biggest average daily water consumption was recorded. On Saturday and Sunday, there was a 13% decrease average in water consumption compared to weekdays.

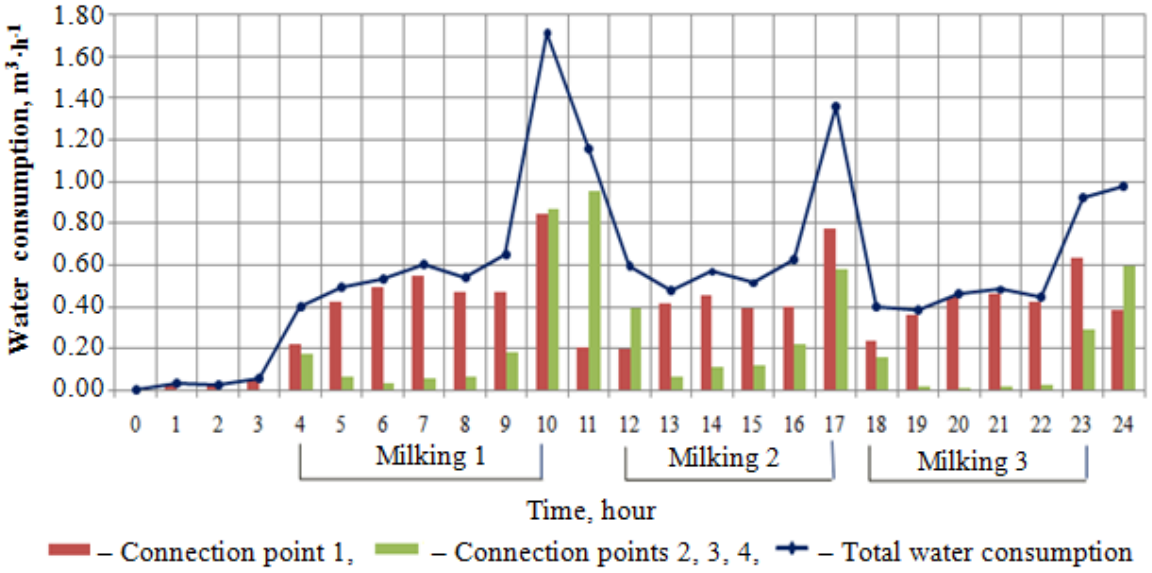

Fig.1. **Distribution of water consumption by hours**

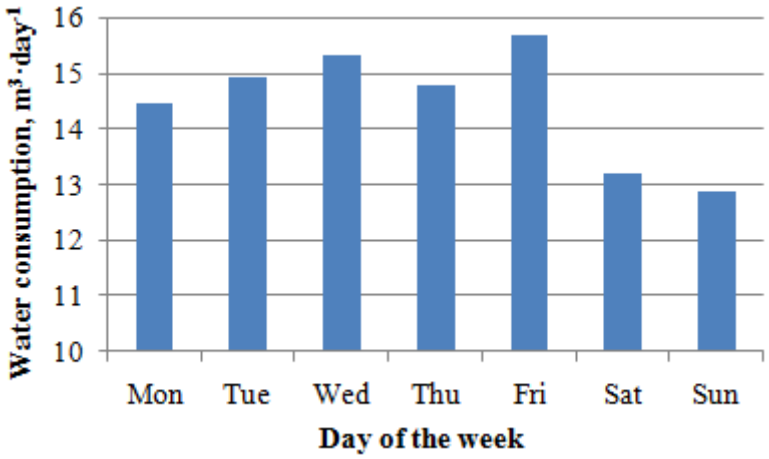

Fig. 2. **Average daily water consumption by days of the week**

The study in one of the US states found that from 13.2 to 25.2 l·cow^{-1}·day^{-1} of manure-bearing wastewater was generated in the milking parlor [14]. According to another study on a farm with three milkings, the floor washing with a hose resulted in 22.9 l·cow^{-1}·day^{-1} water consumption [10].

Based on the data obtained in this study, the average amount of water consumed per cow per day was close to the values in [4; 10; 14] and amounted to 24 l·cow^{-1}·day^{-1} or 8 l per cow per milking; the average water consumption in terms of 1 m^2 of the floor area in the rooms in this study per day was 27.6 l.

The authors in [15] report the average water consumption of 14 l·m^{-2} per day for cleaning a milking parlour with a Herringbone 2x7 milking installation and twice a day milking. The higher water consumption in our study is explained by the bigger number of milkings and washings (three times a day) and the use of water to clean the walls and rails of cow passages.

The study [16] compares the need for cleaning water per kg of milk. This indicator strongly depends on the milk performance of cows and, probably, is more acceptable in economic calculations. In [15], the water consumption is reported to be 0.87 l·kg^{-1} of milk, and in our study it is about 0.58 l·kg^{-1} of milk, because in our case, the milk yield is much higher than in [15].

When determining the amount of washing water in the milking parlour, which subsequently goes to the manure removal system, in our opinion, the indicator of water consumption per head or in terms of 1 m^2 of the floor area is more suited.

If the amount of water consumed is calculated by the regulatory values [9], which are 5 $l \cdot m^{-2}$ for regular cleaning of the floor in the holding and exit areas and 1 $l \cdot m^{-2}$ for washing the walls, then the average daily water consumption for washing the areas in our study and the water to prepare the hoof treatment solution will amount to 8.887 $m^3 \cdot day^{-1}$.

The monitoring values are more than 1.6 times higher than the current norms. The difference may be explained by the various layouts of the milking parlours, which specify the amount of water for washing the rails of cow passages, walls, and milking machines. This issue needs a more detailed study.

The study results are needed for correct dimensioning of the required manure storage facilities. They can be also used to calculate the moisture content of manure produced, the amount and moisture content of its fractions after the separation depending on the farm conditions and targets. These indicators can be calculated by the methodology from [17].

Conclusions

The conducted monitoring revealed that the average daily water consumption in the milking parlour getting later to the manure removal system was 14.4 m^3. The main amount of water was used in the milker's pit for washing the floor, walls and the outside of the milking machines, as well as for washing down the excrement from the floor under cows and the under-tail protective tray in the milking installation. It averaged 64.6% of the total. 10.6% of the total water was used for washing the floor and walls with high-pressure equipment. The maximum water consumption was observed at the end of each milking, when the holding area and the milking parlour were cleaned. The average amount of the consumed water was 24 $l \cdot cow^{-1} \cdot day^{-1}$, i.e. 8 $l \cdot cow^{-1}$ per milking.

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