MANEJO DOS RESÍDUOS DA BOVINOCULTURA LEITEIRA CONDUZIDA EM SISTEMA *FREE STALL* EM PROPRIEDADE FAMILIAR NO SUL DO BRASIL

GESTIÓN DE RESIDUOS DE CULTIVO DE GANADO LECHERO EN SISTEMA DE ESTABLO LIBRE EM PROPRIEDAD FAMILIAR EN EL SUR DE BRASIL.

MANAGEMENT OF BOVINE WASTE FROM DAIRY FARMING CONDUCTED IN A FREE STALL SYSTEM ON A FAMILY PROPERTY IN SOUTHERN BRAZIL

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PALAVRAS-CHAVE
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PALABRAS CLAVE
Residuos Agroindustriales; Consumo de Energia; Consumo de Agua.

KEY WORDS
Agro-industrial waste; Energy Consumption;Water Consumption.

RESUMO
A bovinocultura leiteira é considerada atividade geradora de renda e importante para a economia do país, sendo que o Rio Grande do Sul produz cerca de 4,5 bilhões de litros de leite/ano, posicionando-se como terceiro maior produtor brasileiro. O sistema *Free Stall* tem sido adotado por algumas propriedades familiares no estado, para condução do gado em confinamento, que apesar de vantajoso exige manejo adequado dos resíduos para evitar contaminação das águas e do solo. O objetivo do presente trabalho foi descrever a condução do sistema em propriedade familiar no Rio Grande do Sul, principalmente quanto ao manejo dos resíduos sólidos gerados nesse processo produtivo, bem como quantificar o consumo de água e energia na atividade. A propriedade em estudo está localizada em Soledade/RS e foi acompanhada entre abril e maio de 2019 para a caracterização física, econômica e ambiental da mesma, com ênfase na produção leiteira. Para quantificação da demanda de água e energia na atividade realizaram-se leituras diárias, com auxílio de hidrômetro do tipo Unimag e Contador de Luz da Landis+Gyr. Com uma área de 20 ha destinados a bovinocultura e um plantel de 45 cabeças em lactação confinadas em *Free Stall* a produtividade média atual foi de 21,6 L/vaca/dia com um consumo de 88,9 L/cabeça/dia de água e de 57,3 kWh/dia de energia. Os resíduos sólidos gerados na propriedade classificam-se como domésticos (Classe II A), embalagens de agrotóxicos (Classe I), embalagens de detergentes (Classe I), dejetos bovinos (Classe I), e água residual proveniente de limpeza (Classe I). A propriedade encontra-se em período de adequação para atender plenamente a legislação ambiental.

RESUMEN
La ganadería lechera es considerada una actividad generadora de ingresos e importante para la economía del país, con Rio Grande do Sul produciendo cerca de 4,5 mil millones de litros de leche/año, posicionándose como el tercer mayor productor brasileño. El sistema de Establo Libre ha sido adoptado por algunas propiedades familiares del estado, para el arreo de ganado en confinamiento, lo que, a pesar de ser ventajoso, requiere un manejo adecuado de los desechos para evitar la contaminación de aguas y suelos. El objetivo del presente trabajo fue describir la conducción del sistema en una propiedad familiar en Rio Grande do Sul, principalmente en lo que respecta a la gestión de los residuos sólidos generados en este proceso productivo, así como cuantificar el consumo de agua y energía en el actividad. La propiedad en estudio está ubicada en Soledade/RS y fue monitoreada entre abril y maio de 2019 para su caracterización física, económica y ambiental, con énfasis en la producción lechera. Para cuantificar la demanda de agua y energía en la actividad, se realizaron lecturas diarias, con la ayuda de un hidrómetro Unimag y un contador de luz Landis+Gyr. Con un área de 20 ha para ganado y un rebaño de 45 cabezas lactantes confinadas en Establo Libre, la productividad promedio actual fue de 21,6 L/vaca/día con un consumo de 88,9 L/cabeza/día de agua y de 57,3 kWh/día de energía. Los residuos sólidos generados en la propiedad se clasifican en domésticos (clase II A), envases de pesticidas (clase I), envases de detergentes (clase I), estiércol de ganado (clase I) y aguas residuales de limpieza (clase I). El inmueble se encuentra en un periodo de adecuación para cumplir íntegramente con la legislación medioambiental.

ABSTRACT

The activity of dairy cattle farming has been considered an important generator of income for the economy of the country, having the state of Rio Grande do Sul producing about 4.5 billion liters of milk/year, positioning the state as the third largest *milk* producer *in* Brazil*. The Free Stall system has been adopted by some family properties in the state, which, although advantageous, requires adequate management of residues in order to avoid contamination of water and soil. The objective of this study was to describe the conduction of Free Stall system carried out in a family property of Rio Grande do Sul, regarding management of solid waste generated by the process, as well as to quantify the demand for water and energy consumption in the activity. The property defined for the study was located in the interior of the municipality of Soledade/RS. The dairy cattle farm was monitored during April and May 2019 for its physical, economic and environmental properties, with emphasis on dairy production. In order to quantify the demand for water and energy in the activity, daily readings were performed during 60 days, with the help of a Unimag-type hydrometer and a Landis + Gyr light meter respectively. With an area of 20 ha designated for cattle farming and a herd of 45 cattle confined in lactation, the current average productivity was 21.6 L/head/day with a consumption of 88.9 L/head/day of water and 57.3 kWh/day of energy. The solid waste generated in the property was classified as domestic residues (class II A), pesticide packaging (class I), detergent packaging (class I), bovine waste (class I) and residual water from cleaning purposes (class I). The property has been in an adapting period in order to completely meet the requirements of the environmental legislation.*

1 INTRODUCTION

Milk represents one of the main sources of protein and calcium for the Brazilian population, specifically for the lower income classes, characterizing the dairy activity as a major generator of employment, income and currency exchange for the country (JUNG e JÚNIOR, 2017). According to the U.S. Department of Agriculture (USDA), Brazil's national milk production reached 32.1 million tons in 2016, making it the fifth largest in the world, second only to the European Union, United States, India and China. Brazilian regional production in 2016 was 35.1% in the Southeast; 34.4% in the South; 14.6% in the Center-West; 10.5% in the Northeast and 5.4% in the North of the country (IBGE, 2017).

Currently, Rio Grande do Sul produces about 4.5 billion liters of milk per year, positioning the state as the third largest producer, with approximately 13% of national production, being the chain formed by 65,202 producers linked to the industries and other 11,339 obtaining their income through the sale of the raw product or its homemade derivatives, directly to the consumer, totaling 76,541 producers in the state of Rio Grande do Sul (RIES, 2018). Milk production in the referred state has a high development potential, due to favorable soil and climate conditions, the genetic quality of the herd, the possibility of growing excellent quality fodder in summer and winter, as well as available labor (JUNG and JÚNIOR, 2017).

The milk production chain has an important share of small producers, directly linked to the preservation of the historical and cultural heritage of the interior of Brazil. Family production constitutes a resource source for families with lower income and contributes expressively to the generation of wealth, considering the economy of the agricultural sector in the country. The State of Rio Grande do Sul stands out from other states in this type of production due to the use of available technologies and professionalization of the activity in the area of dairy cattle farming (SCHUCH, 2010).

Among the most widely used dairy cattle production systems is the Free Stall, which is characterized by keeping the animals in confinement, thus drastically, reducing the requirement for grazing areas needed to drive the flocks when compared to continuous grazing. The term "'free stall' refers to the bedding area where cattle are provided cubicles (stalls), where they may lie down. The herd remains free in a delimited area, with individual stalls and litter, which can be lined with sand or crushed rubber, intended for resting the animals and the remaining facilities is used for feeding and exercise. The length of the stalls should correspond to the size of the animal, which when lying down, remains with the udder and legs housed inside the cubicle, while the waste is thrown into the cleaning corridor (CAMPOS *et al*., 2004).

The construction complex of a Free Stall system consists of four areas interconnected and independent, being the resting, feeding, milking and exercise areas. In the resting area individual bays are built, with a bed made of dry and soft material, about 10 cm thick. In the exercise area the animals should have an outdoor area of 10 m² per cow, built of concrete flooring, to facilitate cleaning and improve the hygiene of the animals (SILVA *et al*., 2019).

The system became very popular among farmers due to its management, allowing cows that are not being milked to remain free in a large open space with earth or concrete floors and easy access for feeding with hay or silage. At the time of milking, the cows move to the waiting room and afterwards to the separate milking parlor where they will have access to concentrated food while they are milked.

Due to the great impacts of animal production management practices to the environment, livestock farming has become the object of several surveys. Knowing the factors that affect and determine the emission of pollutants is a fundamental condition for seeking to reduce the environmental impacts caused by the cattle production system. This has been one of the factors contributing to the degradation of environmental quality, since it has been generating vast areas of production and heat reflexes, due to the inappropriate use of the soil. Some alternatives that can reduce the level of pollutants are related to the correct treatment of waste generated and in the mixing of animal feed (MATOS, 2005).

The removal of the forest cover for pasture formation, besides compromising biodiversity, it influences the hydrological cycle by reducing water infiltration and storage, it contributes to climate change and also results in impacts on the soil by increasing the leaching speed, which contributes to soil compaction and erosion (FAO, 2006). According to the 2017 Agricultural Census, the national expansion area for the use of agriculture and livestock grew by 5%, from 333.6 million hectares to 350.2 million hectares, corresponding to an additional area of 16.5 million ha (IBGE, 2017).

The main sources of pollution from cattle farming are animal waste, antibiotics and hormones, fertilizers and pesticides used on arable land and sediments from eroded pastures. Global figures are not available, but in the United States it is estimated that cattle are responsible for 55% of erosion and sediment on arable land, 37% of pesticide use, 50% of antibiotic use and 1/3 of nitrogen and phosphorus loads in freshwater resources. Cattle farming also affect the replenishment of fresh water through soil compaction, decreasing infiltration into the groundwater and degradation of river banks (SOUZA, 2010).

A dairy cow (with an average weight of 400 kg) produces 28 to 32 kg of faeces daily in excreta, but if urine production is also considered, this figure reaches the range of 38 to 50 kg. Animal manure (fresh or dried solid manure) has variable constitution among species, stage of development, feeding habits and season. The amount of liquid waste produced in dairy cattle facilities depends on the management adopted and thus water consumption can vary from 40 to 600 liters per cow milked (MATOS, 2005).

Among the recommended waste treatment techniques, easy to operate and low cost, are the disposal on the ground (PELISARI, 2013; ERTHAL, 2008) stabilization ponds (SILVA & ROSTON, 2010); biodigesters (AIRES *et al*., 2014); Constructed wetland (RODRIGUES *et al*., 2010) and also USAB reactors (Up flow Anaerobic Sludge Blanket) (DANIEL, 2015).

The total amount of daily organic effluent produced in dairy cow confinements varies from 9% to 12% of the live weight of the herd, and depends on the volume of water used for cleaning and disinfecting the installations and equipment of the production unit (CAMPOS *et al*., 2002). With regard to the qualitative characteristics of the residuary water of dairy cattle, it can be stated that this water is rich in organic material, total solids and nutrients such as nitrogen and potassium (ERTHAL *et al*., 2010).

The National Council for the Environment (CONAMA), through its Resolution No. 430/2011, provides for the discharge of effluents into water receiving bodies. According to Article 3 "effluents from any polluting source may only be discharged directly into the receiving bodies after proper treatment and provided that they comply with the conditions, standards and requirements set forth in this Resolution and other applicable norms". Article 5, § 2 of the same Resolution states: "For parameters not included in the mandatory targets and in the absence of progressive intermediate targets, the quality standards to be obeyed in the receiving body are those included in the class in which the receiving body is framed". Article 11 defines that in waters of special class, it is forbidden to discharge effluents or dispose of domestic, agricultural, aquaculture, industrial and any other polluting waste, even if it is treated. Article 2 of the Resolution states that "the disposal of effluents in the soil, even if treated, is not subject to the parameters and discharge standards set out in this Resolution, but may not cause pollution or contamination of surface and groundwater" (BRAZIL, 2011).

Brazil still does not have a specific legislation for disposal of dairy cattle manure in the soil, but according to Matos (2007), the application of manure can be based on the amount of reference nutrients, usually nitrogen or phosphorus.

The aims of the present study were to describe the management of the residues of dairy cattle, conducted in a Free Stall system, in a small property, in the municipality of Soledade (Rio Grande do Sul, Brazil), as well as to quantify the consumption of water and electricity for the activity in the property.

2 MATHERIAL AND METHODS

The family property Recanto do Vento, dedicated to agricultural and livestock sector, is located at roadway BR 386, Km 242 - in the municipality of Soledade, in the physiographic region of the Middle Plateau of the State of Rio Grande do Sul.

For the development of this study, a monitoring was carried out in the property during April and May, 2019 for physical, economic and environmental characterization, with emphasis on milk production. During this period, structured interviews were applied to the owners as one of the methods used to obtain the data.

The milk activity was characterized through the survey of data regarding the production system, herd size, total production, herd productivity, waste generated in the property, water and electric power consumption. The quantification of the productivity was measured obtained through the control in spreadsheets and the milk storage equipment.

For the quantification of water consumption, a Unimag type water meter (Itrón) was installed and the daily consumption was read during 60 days, while the quantification of the daily electric energy consumption was obtained using a biphasic, neutral Landis+Gyr electricity meter.

3 RESULTS AND DISCUSSION

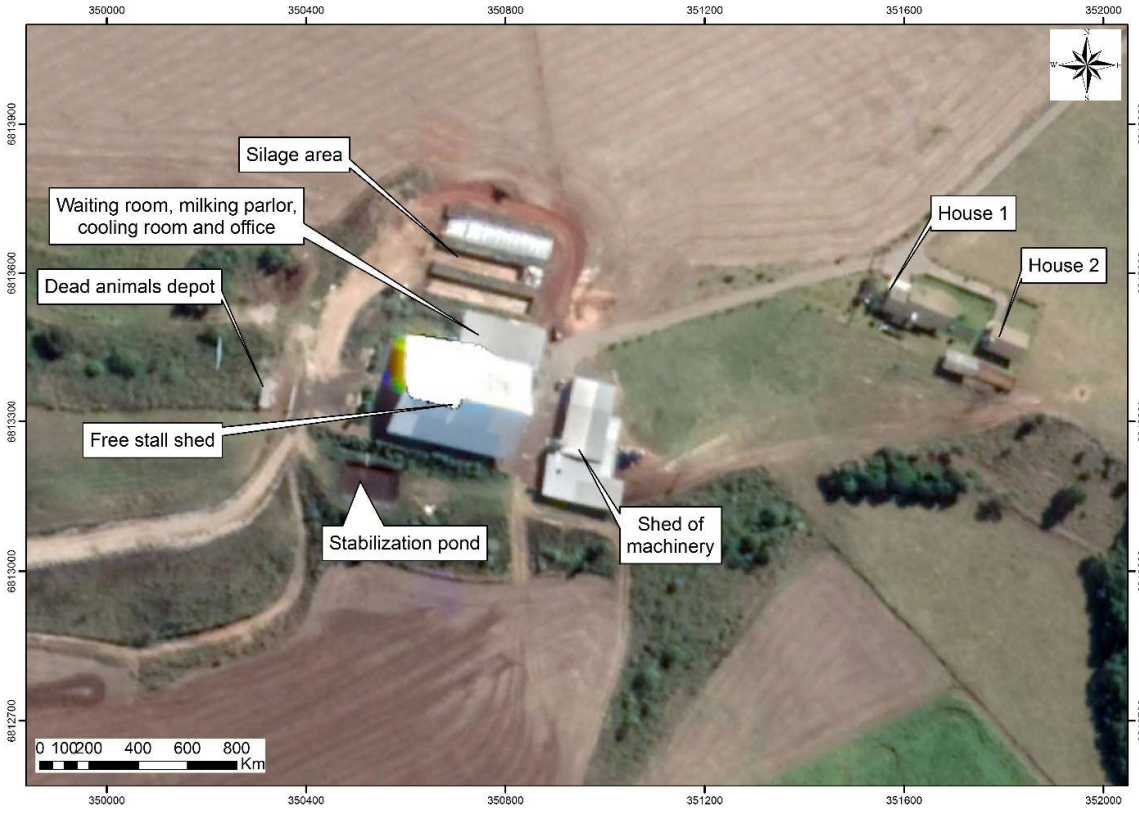
3.1 Physical characterization of the property

The property is characterized as a family exploitation, composed by five adults of whom four have higher education. The total area of the property is 154 hectares (ha), equipped with machinery for conducting farming, being 20 ha for dairy and beef cattle and 85 hectares for winter and summer crops. During the winter the property has seasonal employees who work approximately 15 days each. In addition to dairy cattle, the property has subsistence activities such as growing vegetables, cassava, fruit trees and raising rustic chickens.

The property facilities are divided into a Free Stall system shed, waiting room, milking parlor, machine shed, cooling room, office, dead animal's depot, silage area, manure and two houses (Figure 1).

For the conduction of the dairy cattle activity the property has a tractor, a de-stemmer machine, a manure distributor tank, a planter, a tractor with a dry waste scraping blade, a side-by-side Dairly Parlor P7550 milking machine, a TCool cooling tank, six standard troughs, an Electromix agitator, a Transsen water heating tank and a product distributor system for the cleaning of general equipment.

Figure 1 - Physical installation of the property under study. Soledade/RS. 2020.



Source: Google Earth (2019).

The confined dairy cattle are fed with mineral salt, dairy cattle ration and silage produced on the property. As for the heifers, the feeding varies according to the season, because during summer they are fed with mineral salt, feed and silage, and in winter with pastures of the season such as oats, ryegrass and wool grass.

The Free Stall is conducted with a herd of 45 lactating cows; 28 heifers and 05 dry cows of the Holstein milking cattle race with the capacity of physical structure to reach up to 100 animals, without losing the main characteristic of a family beaseness. The collection and transport of refrigerated raw milk by the collecting company, takes place every two days. The property is divided into four interconnected areas, as indicated by the literature, in order to ensure that the Free Stall works well on the property.

The animals' beds are lined with sawdust and changed daily. The animals remain confined with available food directly arranged in the troughs, space for exercise, lined beds and cemented floor for a better cleaning of the waste and access linked to the waiting room and milking.

3.2 Economic characterization of the property

In 2019, the production of the herd (45 cows in lactation) generated 29.3 thousand L/month or 976 L/day, with a current average productivity of 21.6 L/head/day (Table 1). The average productivity was well above the state average (Rio Grande do Sul – RS, Brazil), according to the last agricultural census of 2017 which was 9.0 L/cow/day (IBGE, 2017) and also well above the national average which was 4.7 L/head/day (EMBRAPA, 2018), indicating the superiority of the use of technologies to increase productivity of the herd. The gross revenue of the dairy activity on the property in April and May, 2019 was US$ 12,750 with a cost of approximately US$ 9,450 monthly.

Table 1 - Economic characterization of dairy cattle in a Free Stall System on the family property under study. Soledade/RS. 2020.

Features	Production/Productivity
Herd	45 dairy cows
Total production	976 L/day
Productivity	21.6 L/head/day
Area used for the activity	20 ha
Workforce	05
Income (monthly)	US$ 12,750
Expenses (monthly)	US$ 9,450

The solid residues generated on the property are classified as domestic (Class II A), pesticide packaging (Class I), detergent packaging (Class I) used in the cleaning of areas intended for cattle farming, bovine waste (Class I), and residual water from cleaning activities (Class I), according to law 12.305/2010 (BRAZIL, 2010).

The packages of pesticides and detergents are stored in the shed of machines, and then returned to the supplier companies, in a process of reverse logistics, in compliance with the current legislation.

The Free Stall management, is in general, superior to others systems regarding productivity and low area requirements; however, it results in higher production costs and a higher volume of waste generated, due to the confinement of the animals (POHLMANN, 2000). In this sense, the system

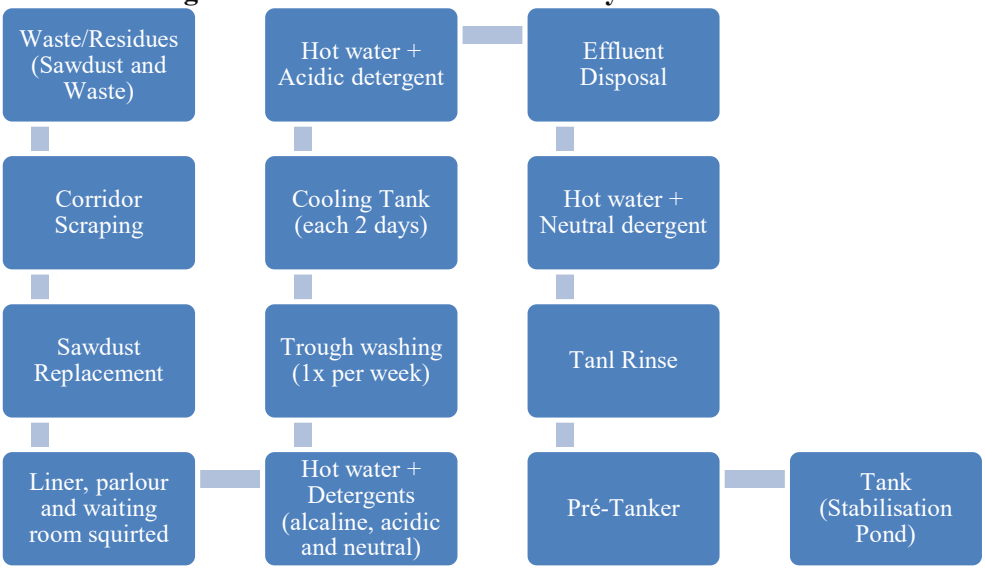
requires special care in the planning of its facilities and management, in order to overcome such difficulties.

The environmental project of the property elaborated for the Free Stall foresees the construction of two ponds with a volumetric capacity of 432 m³ each, (measures of 17 m x 13.5 m x 3 m) and with fermentation time of at least 120 days, period necessary to reduce the polluting power of the effluent in order to make it possible to use it as fertilizer, with one of the ponds being built so far and a second one is under construction.

For the treatment of the residues generated in this kind of system, the property under study has two collecting structures: a pre-storage plant and a manure plant, located next to the Free Stall shed. This type of structure represents a viable alternative for small properties, due to the low cost and prevents the occurrence of percolation and leaching of waste in soil and groundwater, protecting these environmental resources from contamination.

The waste generated by animal waste and washing water from the Free Stall corridors, liners, waiting room and storage tank are directed to the pre-tester and then to the stabilization pond (Figure 2).

Figure 2 - Waste Management Flowchart in Free Stall System. Soledade/RS. 2020.



The removal of waste begins in the containment area by removing the sawdust conditioned in the beds, with the aid of a shovel, and deposited in the corridors of the Free Stall, together with the dry waste. Afterwards, sawdust and dried manure are scraped with a suitable blade tractor used for the purpose. At the end, new sawdust is added to the beds. Then the liner, parlour and waiting room are squirted.

The whole process of washing these areas is carried out using hot water and alkaline, acidic and neutral detergents, automatically dosed by specific equipment for this type of cleaning which pumps the detergents through hoses, connected to the gallons, in a quantity of 400 ml of product for every 80 liters of water. The troughs are washed once a week, avoiding the accumulation of residues and the possible infection of dairy cattle.

The last cleaning process is the washing of the cooling tank, which is carried out every two days after the collection of the stored milk, using hot water and acid detergent. Afterwards, the tank is emptied and receives a last wash with neutral detergent and finished with a rinse.

The liquid waste generated from the washes is directed to the pre-storage area, through channels on the floors. The dry waste is transported by the scraping tractor and deposited in the pre-tanker as well. From this, the residues are released to the stabilization pond, where they are submitted to the anaerobic fermentation process.

Stabilization ponds are used to treat wastewater by predominantly biological mechanisms, constituting the most recommended system for the treatment of manure and effluent from dairy cattle facilities, as it is based on direct contact of microorganisms and organic materials contained in the effluent, thus converting it into carbon dioxide, water and food for microorganisms, being this the most recommended (CAMPOS, 1997). According to Jordão and Pessoa (2014), the stabilization ponds have had an important application, besides environmental and public health protection, they have been used in the preparation of the effluent for use in agriculture.

3.3 Electric power consumption

The quantification of the daily consumption of electric energy of the dairy cattle activity in the property indicated an average consumption of 55.9 kWh/day in April and 58.6 kWh/day in May. The total consumption of the activity in the month of April being 1,733 kWh and in the month of May 1,759 kWh.

3.4 Water consumption

The quantification of water use on the property, aimed at dairy cattle, with a herd of 45 heads, indicated a daily consumption of 4.00 m³ in April and 3.53 m³ in May, making an average of 3.76m^3/day, resulting in a consumption of 112.8 m³/month. Thus, the consumption was 83.56 L/head/day. According to data in the literature, this consumption is lower compared to the study presented by Ricardo (2016), who, observing the water consumption in a herd of 30 lactating cows in Minas Gerais, reported a daily water consumption of 4.14 m³, that is, 138.0 L/head/day. This difference may be related to weather conditions and/or the management of the system.

In order to reduce costs, it was suggested the installation of a rainwater harvesting equipment to collect water and use it for washing the floor. It has also been considered as a way to use water correctly, taking into account economic feasibility and respect for the environment (MAY, 2004). The rainwater collection system and its use, when correctly dimensioned and executed, provides water of adequate quality, preserving water and energy resources of the environment.

The rainwater harvesting system generally consists of collecting water from waterproof areas, usually roofs. It is then filtered and stored in an accumulation tank, and later this kind of water will be designated to less demanding uses, such as vehicle washing and garden irrigation (JO, 2011). However, the water of simple collection should be used only for washing the floors, because according to the standards for dairy cattle, the water used for the deaeration of animals and washing equipment should be chlorinated and be in good condition to avoid infections in the animals or in the raw product itself. On small properties, the rainwater harvesting mechanism can be adapted and transformed into a small water treatment plant (WTP), allowing the use for more noble purposes.

The Brazilian Association of Technical Standards (Associação Brasileira de Normas Técnicas - ABNT), through its NBR 15.527/2007, indicates the requirements for the use of rainwater from roofs in urban areas for non-potable purposes and presents methodologies for sizing the system, cleaning procedures and its conservation. The referred norm also defines quality standards for

collected and stored water, as well as the system components and their maintenance frequency (ABNT, 2007). Hydraulic installations have to be totally independent from the treated water and must obey NBR 5.626/1998, on cold water building installation (ABNT, 1998).

4 FINAL CONSIDERATIONS

The property studied showed a modern milk production system regarding the use of technologies, presenting high productivity of the herd when compared to the state and national average, with the advantage of a low demand of area for its milk production.

The herd of 45 lactating cows showed an average productivity of 21.6 L/cow/day, which was a lot higher than state and national average.

The manure installed proved to be insufficient for the treatment of the volume of residues from the dairy cattle activity, because even after the acquisition of the mixer, which minimizes the problem, it still does not satisfactorily meet the demand.

Free Stall system has a high cost; however, it can be reduced through the use of technologies such as the installation of solar panels and rainwater collection system.

With the implementation of improvements, the property will be able to obtain significant environmental and better financial gains, thus becoming a reference in the conduct of Free Stall system, as described above.

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