

## TECHNICAL ARTICLE

### **RATIONAL USE OF WATER IN A POULTRY SLAUGHTERHOUSE IN THE STATE OF PARANÁ, BRAZIL: A CASE STUDY**

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**ABSTRACT:** Agroindustries are major consumers of water. However, to adapt to environmental trends and be competitive in the market, they have sought rational use of water through water management in their activities. Cleaner Production can result in economic, environmental and social benefits, and in actions that promote reduction in water consumption. This case study was conducted in a slaughterhouse and poultry cold storage processing plant and aimed to identify points of excessive water consumption, and to propose alternatives for managing water resources by reducing consumption. Consumption data are presented in relation to the processing stages with alternatives proposed for the rational use of water, such as closure of mains water during shift changes. Following the implementation of recommendations, a reduction in water consumption of approximately 11,137 m<sup>3</sup> per month was obtained, which equates to a savings of US\$ 99,672 per year. From this study, it was concluded that the company under review could develop various improvement actions and make an important contribution to the preservation of water resources in the region where it operates.

**KEYWORDS:** Water consumption, cleaner production, poultry processing.

### **USO RACIONAL DE ÁGUA EM UM ABATEDOURO DE FRANGO NO ESTADO DO PARANÁ, BRASIL: UM ESTUDO DE CASO**

**RESUMO:** As agroindústrias são as maiores consumidoras de água. Entretanto, para se adaptarem às tendências ambientais e manterem-se competitivas no mercado, elas têm que trabalhar com o uso racional da água através da gestão hídrica em suas atividades. A Produção Mais Limpa pode possibilitar benefícios econômicos, ambientais e sociais, incluindo ações que promovam a redução no consumo de água. Este estudo de caso foi conduzido em um frigorífico de frango e teve por objetivo identificar pontos de consumo excessivo de água e propor alternativas de gestão das fontes de água através da redução do consumo. Os dados de consumo de água aqui apresentados estão relacionados às etapas de processo, com ênfase nas alternativas de uso racional da água, como fechamento das torneiras durante as trocas de turno. O uso das medidas propostas possibilitou a redução no consumo de água de, aproximadamente, 11.137 m<sup>3</sup> por mês, o que equivale a uma economia de US\$ 99.672 por ano. A partir deste estudo, foi possível verificar que a empresa em questão pode desenvolver ações simples que resultam em importantes contribuições para a preservação das fontes de água na região onde está inserida.

**PALAVRAS-CHAVE:** Consumo de água, produção mais limpa, processamento de frango.

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## INTRODUCTION

Water is a resource widely used for human consumption and in industry, agriculture, power generation, transportation, leisure, assimilation, and the transportation of effluent (MEDEIROS et al., 2010; MUTHUKUMARAN et al., 2011; SA-NGUANDUAN, NITITVATTANANON, 2011; DOLNICAR et al., 2012). Many countries suffer from a lack of drinking water, thus generating conflicts due to the appropriation of this scarce resource. These conflicts about water are based on three needs: quantity, quality, and control (SWAIN, 2001). Two of these three needs are susceptible to resolution: quality and control. Water quality can be improved with the use of appropriate technologies for the treatment and control of its use by policy agreements.

Brazil is the third largest producer of poultry meat in the world, behind the United States and China. Throughout the year of 2011 alone, 5.3 billion poultry were slaughtered in Brazil (IBGE, 2011). The main producing states were Paraná (26.3% of the national total), Santa Catarina (18.0%), Rio Grande do Sul (14.5%), São Paulo (14.5%), Minas Gerais (6.9%), and Goiás (6.1%) (IBGE, 2011). In 2010, the slaughterhouse and poultry cold storage processing plant featured in this study slaughtered 81 million poultry, 250,000 poultry per day, six days a week, which were sold as whole chickens, cuts and giblets to the foreign and domestic markets.

Besides consuming large volumes of water (between 8 and 20 liters of water per slaughtered poultry), the slaughterhouse and poultry cold storage processing plant are responsible for the deterioration of the main water sources, which justifies this study on the rational use of this natural resource (MATSUMURA, MIERZWA, 2008; AVULA et al., 2009; FARIA et al., 2009; KIST et al., 2009; MEES et al., 2009; DE NARDI et al., 2011).

Cleaner Production (CP) is a continuous and preventive application of an integrated environmental strategy to processes, products and services. It is intended to minimize waste and emissions, maximize product output, and reutilize waste and emissions. The implementation of CP programs facilitates waste avoidance and, consequently, leads to increased profits. The reduction of water consumption results in less wastewater and costs associated with this (LOPES SILVA et al., 2013). The priority of Cleaner Production is to reduce consumption and pollution at source and, for this to occur, modifications are required to the product or process. Process modifications involve housekeeping, substitution of raw material, and modification of technology employed (DOBES, 2013). Housekeeping is the simplest method to implement Cleaner Production because it does not require investment and it can be implemented as soon as alternatives are identified. The replacement of raw materials for better quality materials helps to reduce waste and improves process efficiency. There is also the possibility of replacing difficult-to-recycle materials by others, more environmentally friendly materials. Modifications in technology can include installing more efficient and modern equipment, however, these are, generally, modifications that require high investments and should only be employed if they are favorable in cost-benefit terms (KUPUSOVIC et al., 2007; PEREIRA et al., 2012).

The options for waste management are, in order of best to worst: prevention, minimization, recycling, and disposal. Practices for waste management that can be adopted, in order of high to low priority, are: waste disposal, source reduction, recycling, treatment, and disposal (CRITTENDEN, KOLACZKOWSKI, 1995).

KUPUSOVIC et al. (2007) implemented Cleaner Production in a small slaughterhouse in Bosnia and Herzegovina, with low-cost actions that included optimizing the recovery of blood, use of pressurized water for cleaning surfaces, and housekeeping measures, achieving 32% savings in water consumption per month.

In light of these findings, this case study aimed to identify the stages at which the water was used and the points of excessive consumption, and propose alternatives to reduce water consumption based on housekeeping and new technologies.

## METHODOLOGY

This case study was developed in a slaughterhouse and poultry cold storage processing plant located in Paran State, in southern Brazil, geographic coordinates 24°56'37'' S and 50°07'53'' W. The company slaughters 250,000 birds per day, which are sold whole or in cuts like breast, thigh, wing, fillet, and chicken giblets. The company works in three shifts, six days a week, and uses 10.4 liters of water per bird.

The methodology used in this study aims to reduce water consumption and is an adaptation of the Plan of Conservation and Water Reuse presented in the Manual for Conservation and Water Reuse in Industry (HESPANHOL et al., 2006). The plan proposed by HESPANHOL is based on the use of alternative water sources such as recycled water, use optimization, waste avoidance, and water consumption reduction.

In order to achieve the proposed aims, the following were produced: a detailed description of the process using a flow diagram; a survey of the descriptive documentation of the operational routines for verification of points of water consumption; an evaluation of existing information related to the need for water; a survey of the quantity of collected water for each process; identification of the stages at which water is used; an assessment of water quality used at each point; identification of the points with greater water consumption; identification of the points of water wastage; recommendations for water consumption reduction; and recommendations for water recycling.

Data survey was carried out by monitoring the process over a two month period, six days a week. Since there were no hydrometers to determine the water consumption in the sectors, the amount of water consumed during the process was measured by using graduated containers and a timer that also determined flow rate for all machines and equipment.

After the survey, data of water consumption in each sector was completed. It was clear that there were areas, in waste water, for example, with potential for consumption minimization; a plan for the management of water resources was proposed. In formulating the plan, low cost options involving minor process changes, such as housekeeping and technology modification, were preferred (KUPUSOVIC et al., 2007; MOLINOS-SENANTE et al., 2011; DOBES, 2013).

## RESULTS AND DISCUSSION

### Process evaluation and identification of points of water consumption

The slaughter process begins at reception, where animals are unloaded from trucks and hung on hooks. In the bloodletting area the animals are stunned by shock, bled, and then passed through a room where the blood is allowed to drip and largely eliminated. Then scalding occurs, when chickens are immersed in tanks of hot water (about 52 to 54 °C) and plucked. In the transfer area, chickens are moved using metal hooks from the dirty area to the clean area, the feet are cut, and ankle and head, removed. Chickens are then taken for evisceration when viscera are removed and separated. Edible viscera are subjected to cooling and then packaged. Carcasses are washed and cooled in a pre-chiller and then a chiller, reaching a final temperature of 4 °C. Carcasses also absorb water at this stage. After chilling, chickens are separated into whole chickens and chicken pieces. After being cut, they are packed in primary and secondary packaging and then frozen and shipped (Figure 1).

The solid waste produced, such as bones, heads, fat, skin, feathers, viscera, and discarded animals, is taken to a factory where they are used in the pet food industry.

In the process flow diagram, Figure 1, the points of water consumption during production and cleaning of each sector are identified. This data was obtained separately because the water for these processes is sourced from different tanks. The percentage of water consumption of each sector is presented in Figure 2.

The major points of water consumption are the scalding/plucking area and the chiller, sectors where the minimum consumption of water is regulated by the Brazilian Ministry of Health.

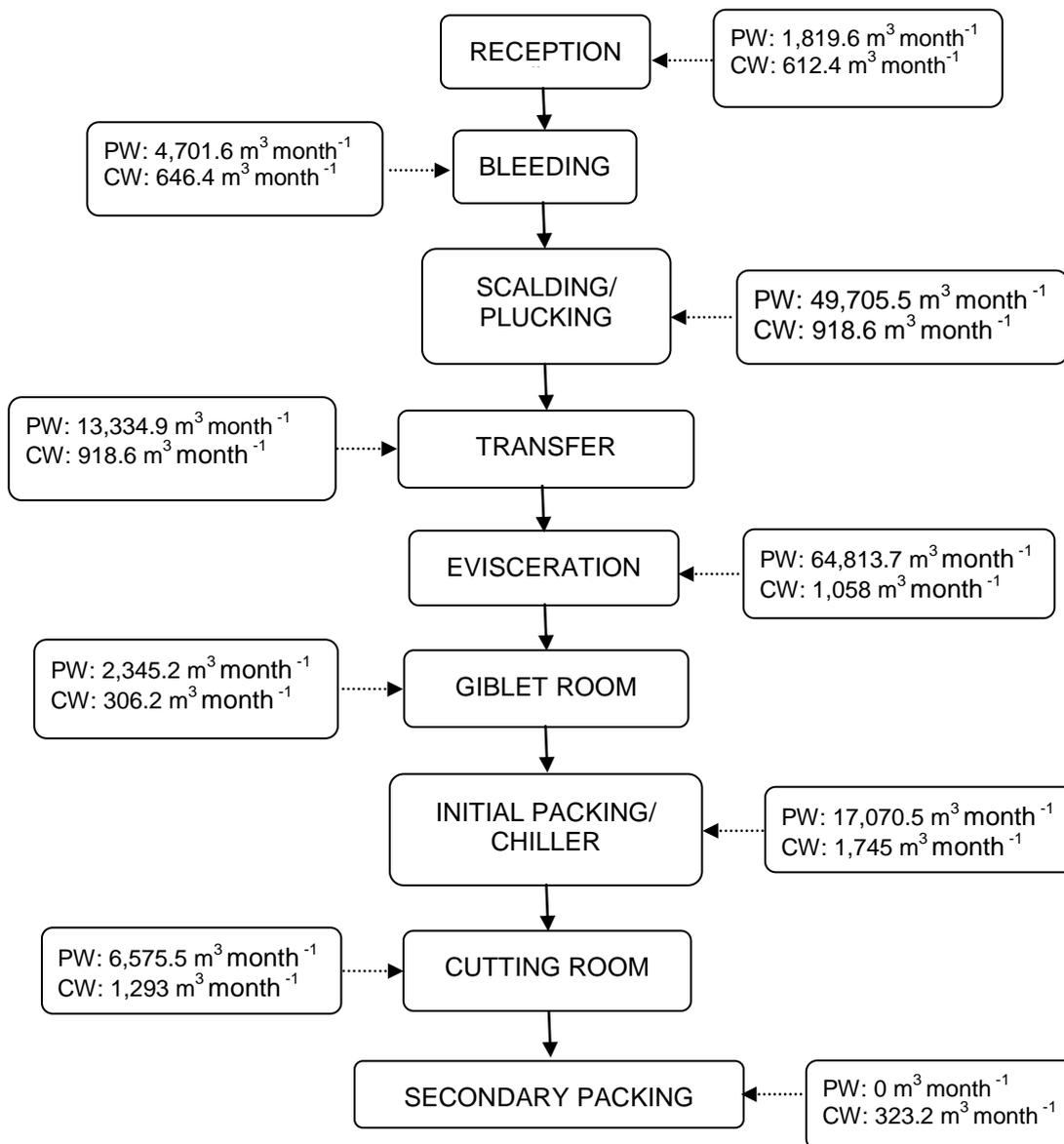


FIGURE 1. Process flowchart and data regarding consumption of drinking water in the process and cleaning of each sector (PW: process water; CW: cleaning water).

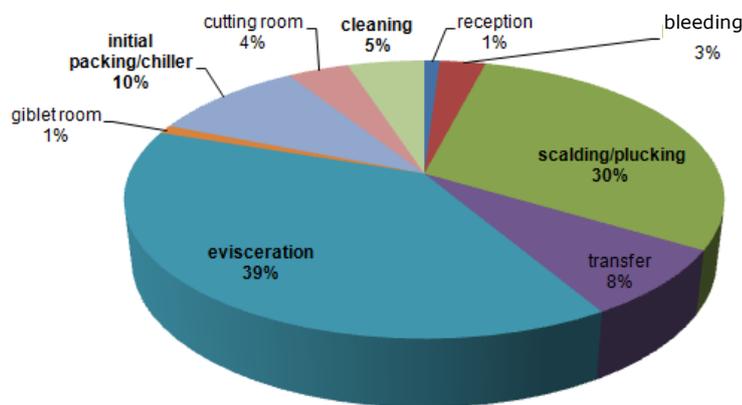


FIGURE 2. Distribution of monthly consumption of process water by sector.

## Actions to reduce water consumption

By analyzing the points of water consumption of each sector, it was found that the water flow of each process unit meets the minimum required by Brazilian law. However, the water used for the hygiene process presented a greater flow than what was needed for this purpose. It was also noticed that, in all sectors, besides the consumption of process and cleaning water, there was also water consumption during shift change (Table 1).

Thus, solutions were proposed to reduce water consumption for each identified problem. The suggested minimizations were based on process changes and are classified as housekeeping and changes in technology.

### Good housekeeping measures:

- a. Problem: unnecessary water use during plant shutdowns.

It was found that, while employees had their meals and during cleaning of the sectors, the equipment recorded water use, even when not receiving carcasses.

Modification recommended: shutdown of water outlets at times when production is stopped. Table 1 presents the volume of previously consumed water and when it was rationally consumed after application of the new measures in each sector. It appears that the non-use of water during shift change provides a saving of 4% of the water volume, or about 6,189 m<sup>3</sup> per month.

### Process modifications:

Process modifications included equipment modification. All of them aimed at reducing water consumption.

- a. Problem: excessive consumption of water during cleaning.

The opening valves of the hoses were located on the wall. As each tube measured about 30 meters, the staff had no way to close them at times when they did not need to use water. In addition, the spouts of the water hoses were too large, allowing a greater flow of water than necessary.

Modifications recommended: installation of opening valves for the hoses within reach of the employees, i.e., near the water exit point. In this way, employees could easily close the hoses when they were not in use. Also, the installation of 5 mm “duck-beak” type dispersers at the end of the hose is suggested, allowing a lower water flow, but at a higher pressure.

The use of hoses with trigger hand-operated spray nozzles was also recommended by FATTA et al. (2003) in the guidelines on best practices for the slaughter of animals in Cyprus.

- b. Problem: excessive consumption of water in the hygiene barrier.

Barrier taps had a flow of 0.36 m<sup>3</sup> h<sup>-1</sup>.

Modification recommended: installation of nozzle flow reducers on taps, reducing the flow rate to 0.115 m<sup>3</sup> h<sup>-1</sup>.

- c. Problem: high flow of water in the gutters carrying viscera.

The route for retrieval of giblets from the evisceration sector has several water outlets, which is used to wash the giblets package and, also, for its subsequent separation. This washing water also helps in the transportation of giblets along gutters until they are directed by the pumps to the giblets room. However, flow of each tap was 0.36 m<sup>3</sup> h<sup>-1</sup>.

Modification recommended: installation of nozzle flow reducers on taps, reducing the flow rate to 0.115 m<sup>3</sup> h<sup>-1</sup>.

All of the proposals were implemented by the company. It was also necessary to train the employees to adapt to the new conditions. After a month, water volumes in the different sectors were recalculated, revealing a reduction of 11,137 m<sup>3</sup> per month in water consumption (Table 2).

This volume is equivalent to the amount consumed for five days by a city with a population of 19,000 inhabitants with an average household consumption per capita, recommended by the United Nations (UN), of 110 L per day (HOSSAIN et al., 2013).

TABLE 1. Comparison between the volume of water normally consumed and when it was rationally consumed, by sector.

Sectors	Before	After	Reduction in consumption (%)
Reception (m <sup>3</sup> /month)	1,820	1,456	20.0
Bleeding (m <sup>3</sup> /month)	4,702	4,534	3.5
Scalding and plucking (m <sup>3</sup> /month)	49,706	46,839	5.7
Transfer (m <sup>3</sup> /month)	13,335	12,923	3.0
Evisceration (m <sup>3</sup> /month)	59,142	57,342	3.0
Giblets (m <sup>3</sup> /month)	2,345	2,345	0
Chiller and initial packing (m <sup>3</sup> /month)	17,071	17,036	0.2
Cutting (m <sup>3</sup> /month)	6,576	6,031	8.2
Secondary packing (m <sup>3</sup> /month)	0	0	0
<b>Total</b>	<b>154,696</b>	<b>148,507</b>	<b>-</b>
<b>Relative consumption (%)</b>	<b>100</b>	<b>96</b>	<b>4</b>

TABLE 2. Volume of water saved each month after the implementation of initiatives aimed at rational consumption.

Actions	Volume of water saved (m <sup>3</sup> /month)
- Rational consumption process	6,189
- Modification of the cleaning hoses	1,600
- Modification of the evisceration taps	3,200
- Modification of the hygiene barrier taps	148
<b>Total</b>	<b>11,137</b>

### Economic evaluation of applied water management actions

From the management of water resources used in the processing of refrigerated chickens, and implementation of the methodology adapted to the water conservation and reuse program, it was possible to verify quantities and values saved by the company.

The company confirmed that the cost for water treatment in the WTP (Water Treatment Plant) was US\$ 0.57 per cubic meter of treated water, and US\$ 1.39 per cubic meter of effluent in the WWTP (Wastewater Treatment Plant). As the water reduction savings were in effluent (there being no product or steam), for each cubic meter of water that is no longer consumed there is also a saving of a cubic meter of effluent that would have been treated, i.e., a total of US\$ 1.66 per cubic meter. With these changes, it was possible to reduce the monthly water consumption by 11,137 m<sup>3</sup>, resulting in a saving of US\$ 8,306.00 per month.

The investment in new nozzles and valves that resulted in the reduction of water flow in the assessed areas totaled US\$ 38,013.30, which was paid with economies in water expenditure within 1.74 months (Table 3).

TABLE 3. Investments in hydraulic accessories used in the modifications.

Actions	Unit cost per piece(s) (US\$)	Total of pieces	Total cost in pieces (US\$)
Replacing valves and hose nozzles	1,790.10	20	35,802.00
Removing giblets (evisceration)	56.70	26	1,474.20
Hygiene barrier	56.70	13	737.10
<b>TOTAL</b>			<b>38,013.30</b>

KUPUSOVIC et al. (2007) recommended Cleaner Production for small-scale slaughterhouse industries with low cost processes, equipment modifications, and good housekeeping measures. Their research obtained 45 m<sup>3</sup> of saved water per month, and the pay-back period, for an investment of 43 euros per year, was less than one month.

## CONCLUSION

This study resulted in a better understanding of the production process using the operational flowchart. Areas with the highest water consumption in the industry were identified; the three largest ones are evisceration (39%), scalding and plucking (30%), and cooling of carcasses by pre-chillers and chillers (10%). Analysis of water consumption in all sectors highlighted unnecessary consumption during meal breaks and, also, at times of shift changes, besides the existence of valves and nozzles on hoses and taps that allowed water flow in unnecessary quantities. Actions taken to reduce water consumption resulted in a decrease of 11,137 m<sup>3</sup> per month, what is equivalent to US\$ 99,672.00 - a figure that was no longer required to be spent on water and wastewater treatment per year. These numbers indicate that a reduction in water consumption is not only technically but also financially feasible, even for large companies.

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