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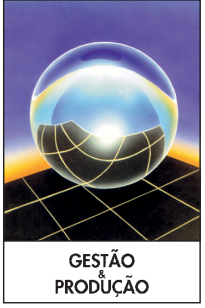

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Cleaner production options for a small bakery

Opções de produção mais limpa para uma padaria de pequeno porte

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Abstract: The implementing of a Cleaner Production program (CP) in the bakery and confectionery sector, allows the change of its industrial process through of the development of an eco-efficient system. The goals of this work were to generate CP options for a small bakery, to make the employees aware of environmental issues in order to better use raw materials and reduce waste generation, analyze the solid waste generated in the establishment, and provide a better management for a future implementation of the CP program. The methodology of implementation was based on the widespread for CNTL/SENAI, taking into account three stages with various tasks being developed in each of them. It was noted that the establishment did not have studied selective collecting or outside or inside the establishment. The results obtained were mainly good practices of CP in the manufacture of products, separation of recyclable waste from non-recyclable ones for commercialization and adequate disposal, purchase of raw materials with larger packages, and the adequacy of bread forms. Considering that the most significant generation of waste is organic, the composting was suggested as a way of recovering this waste.

Keywords: CP; Waste management; Sustainable development; Production management.

Resumo: *A implementação de um programa de Produção Mais Limpa (PML) no setor de panificação e confeitaria, possibilita a mudança do seu processo industrial através do desenvolvimento de um sistema eco-eficiente. Os objetivos deste trabalho foram gerar opções de PML para uma padaria de pequeno porte, realizar a sensibilização ambiental dos funcionários para o melhor aproveitamento de matéria-prima e redução na geração de resíduos, propiciar um melhor entendimento por parte dos gestores para uma futura implementação do programa de PML, e analisar os resíduos sólidos gerados no estabelecimento. A metodologia de execução foi baseada na difundida pelo CNTL/SENAI, levando-se em consideração três etapas com várias tarefas sendo desenvolvidas em cada uma delas. Observou-se que o estabelecimento estudado não possuía coletoras seletivas nem fora, nem dentro do estabelecimento. Os resultados obtidos foram, principalmente, boas práticas de PML na fabricação de produtos, a separação dos resíduos recicláveis dos não recicláveis para a comercialização e destinação adequada, compra de matérias-primas com embalagens maiores, e a adequação das formas de pão. Considerando que a geração de resíduos mais significativa é a de resíduos orgânicos, sugeriu-se a compostagem como forma de valorização desses resíduos.*

Palavras-chave: *P+L; Gestão de resíduos; Desenvolvimento sustentável; Gestão da produção.*

1 Introduction

The industries have been searching incessantly for new alternatives to follow the market trends as the economy develops and the competition in their sector increase. Many times, the more the economy grows the more wastes are generated and raw-materials are wasted, as a result the business does not get in line to the standards of sustainable development.

Frequently, companies adopt different strategies aiming to increase the productivity focusing on economic aspects mainly and not addressing proper attention to the environmental aspects. In such scenario, increasing productivity is related to the increasing of pollution and environmental damage (Castro et al., 2010).

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According to Fresner & Krenn (2018), two aspects are fundamental to achieve the sustainable development: the first is dissociate the economic development with the consumption of natural resources; and the second is optimize the existing processes including broader aspects in the production planning in order to maximize the productivity of these resources.

To achieve the maximization of productivity, keeping an awareness on reduction of raw-materials wastage and solid wastes generation, is required the application of Cleaner Production (CP) programs aiming the maintenance of an organized and efficient growth of the company.

As mentioned by Rahim & Abdul Raman (2017), the CP is a preventive environmental strategy applied to the production processes by: conserving feedstock and energy, eliminating environmental harmful materials and reducing the amount of wastes in the generation source, in order to minimize the environmental impact caused by industries.

In this context the CP in bakeries and confectioneries emerge. According to Brazilian Association of Bakery and Confectionery Industries – ABIP (2014), the bakery industry represents one of the six biggest industrial sectors in Brazil, representing 36.2% of the food industry and 7% of the processing industry. The bakery production is closely related to other sectors of the economy providing job opportunities and distributing income.

The most used principles of CP by Brazilian business companies are related to the implementation, controlling, and planning of the production with environmental education, considering to be important to evaluate the material intensity (control of waste destination) in the project and processing of the product (Oliveira et al., 2015).

The basis of CP is to unify the processes of environmental protection and production, towards a reduction of wastes and emissions in terms of volume and risk level. This is obtained through several strategies defined by the production manager, based on environmental, technological, and economic goals (Fonseca et al., 2013).

The implementation of a CP program in the sector of bakery and confectionery increases the knowledge of the industrial process through the constant monitoring aiming the maintenance and the development of an Eco-efficient system of production with the generation of environmental and process indicators.

The general objective of this work is to provide options of CP for a small sized bakery located in the Palmeira das Missões city. The specific objectives are: to realize the environmental awareness of the bakery employees in order to better use the raw-materials and reduce the wastes generation (good practices in manufacture); to provide a better understanding from the managers side towards a future implementation of a CP program; and to perform a qualitative and quantitative evaluation of the solid wastes generated in the commercial establishment.

2 Material and methods

2.1 Study area

This work was carried out in a bakery and confectionery in Palmeira das Missões city (Figure 1), Rio Grande do Sul, Brazil, located in the latitude 27º53'58" south and in the longitude 53º18'49" east, in an elevation of 639 meters.

According to Brazilian Institute of Geography and Statistics – IBGE (2016) the city has 34,907 inhabitants.

The establishment in which the work was carried out is a small business with 14 employees. The identification of the company's and the owner's name was not allowed in this work; therefore it is treated as Bakery X.

The establishment was chosen due the easy access to information, and receptivity of the manager, moreover it is representative of the bakery and confectioneries located in the city. After carrying out technical visits, a feeling of discouragement related to environmental measures was identified; therefore the results of this research become more necessary in the location as a way to clarify and encourage CP practices.

2.2 Cleaner production

According to the concept proposed by Fernandes et al. (2001), the Cleaner Production (CP) assumes four basic attitudes. The first, and the most important, is the avoidance of generation of wastes, throughout the reasoning of production techniques. When the first concept is not integrally applicable, the second attitude proposed by CP is minimizing the generation

Figure 1. Location of Palmeira das Missões – RS. Source: Abreu (2006).

of solid wastes. The reuse of wastes in the production process itself is the third attitude defended, and finally, the fourth alternative is recycling, with the use of the rejects or the final product itself to the generation of new materials.

The CP implementation has to be followed by considering energy efficiency, optimization methods to reduce the wastage and the production costs, improving the product quality and the reuse of wastes (Petek et al., 2016).

The CP requires not only technology improvement, but the know-how application and the attitude changes. The three factors together that make the difference when compared to other techniques related to production processes (SENAI, 2008).

The know-how application pursuit to improve efficiency, adopting better management techniques, promoting amendments via housekeeping practices or homemade solutions and reviewing policies and procedures when it is necessary. Changing attitudes implies in addressing a new approach to the interactions of industries with the environment, since via rethinking an industrial process or a product, in terms of CP, the generation of better results is possible without requiring new technologies. As a result, the general strategy to achieve the goals is continuously changing the conditions in the source instead of fighting the symptoms (CEBDS, 2005).

In the Figure 2, a flow chart presents the levels of a CP program, and goes on about what each of these levels approaches. The priority of CP is in the level 1: the avoidance of wastes and emissions generation. When the generation cannot be avoided, the wastes must be reintegrated in the production process of the company (level 2). When none of prior levels apply to the situation, recycling measures that are taken outside the company can be used.

2.3 Implementation of a cleaner production program

The first step before the implementation of a Cleaner Production (CP) program is the awareness of the target audience (entrepreneurs and managers) by visiting the company and demonstrating the cases in which CP was successful, highlighting the economic and environmental benefits.

Besides, the following items must be pointed out:

- The acceptance of prevention as prior step to Process-External (end-of-pipe) investments;
- The pressure of environmental organisms towards the objective of achieving compliance with environmental regulation;
- The purchase and maintenance costs of Process-External (end-of-pipe) equipment;

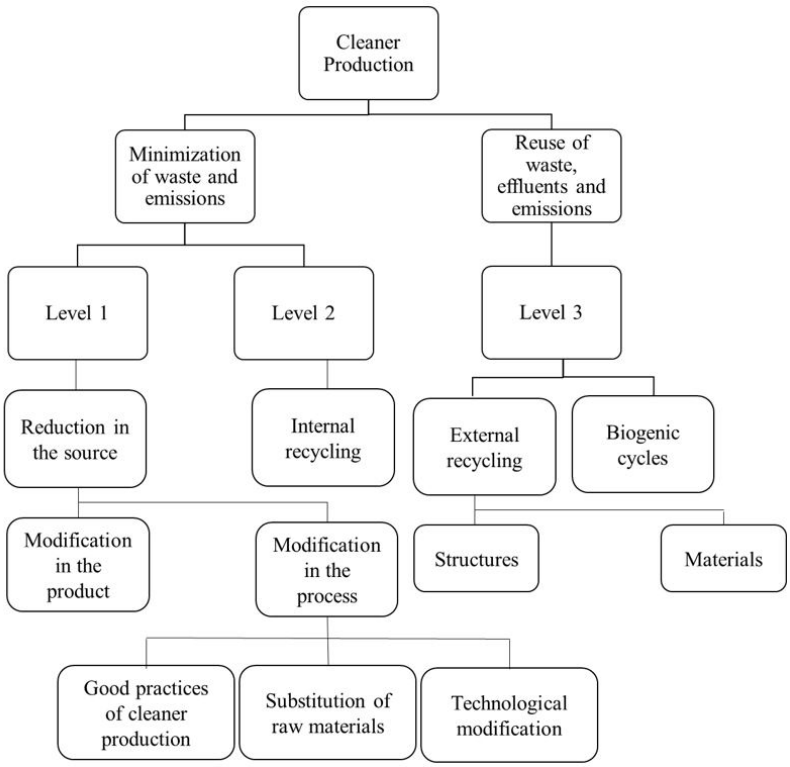

Figure 2. Levels of Cleaner Production. Source: Centro Nacional de Tecnologias Limpas – SENAI (2008).

- Other relevant factors that contribute to the target audience understanding the benefits of CP approach.

The CP Program, according to the methodology proposed by CNTL/SENAI RS (SENAI, 2008), can be categorized in five steps, which are shown in the Figure 3 and described in following topics. This methodology was applied in this work in order to achieve the results.

2.3.1 First step

In the first step, the implementation methodology of a CP Program includes the following items:

- Obtaining commitment of the managers: is fundamental raising awareness of the managers to ensure the success of the Program. The attaining of consistent results depends on the Company compromising with the Program;
- Identifying the constraints to the Program implementation and searching for solutions: in order that the Program achieves a good progress is essential the identification of constraints and limitations during the development of the Program and the search for adequate solutions to overcome them;
- Defining the area of the influence of the Program in the company: it is necessary to define together with the company the extension of the Program, whether it includes the whole company or it starts in critical branch of the company; and
- The formation of the Eco-team: is a work group formed by company staff that aims to conduct the CP Program with tasks of realizing the assessment, implementing the program, identifying opportunities and implementing measures of CP, monitoring the program, and following the program up.

2.3.2 Second step

The second step includes the study of the production process, execution of the environmental and process diagnosis and the selection of the evaluation focus, as it is described hereinafter.

2.3.2.1 Study of process flow chart

The detailed analysis of the flow chart allows the visualization and definition of the qualitative flow of raw materials, water and energy in the production process and the visualization of wastes generation during the process, being a tool to collect basic data

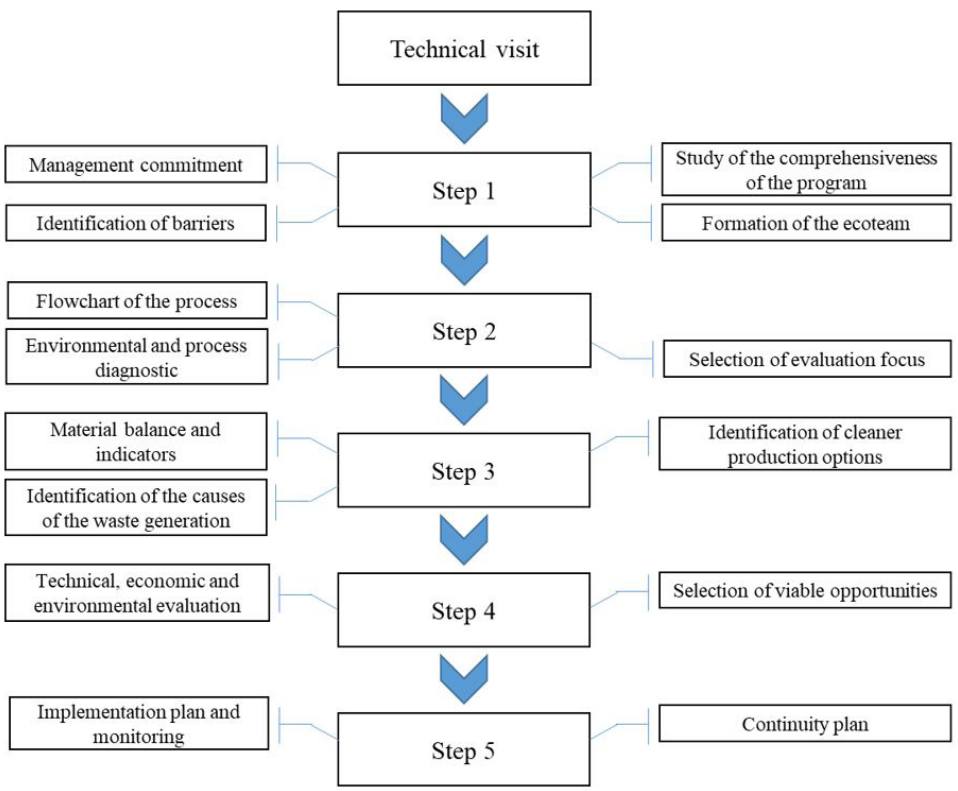

Figure 3. Steps of Cleaner Production. Source: Centro Nacional de Tecnologias Limpas – SENAI (2008).

for a strategy for minimization of wastes generation, wastewater and pollutant emissions.

After the drafting of the production process flow chart the strategies for identification and measurement of mass and energy flow in all steps of the process are determined.

2.3.2.2 Execution of environmental and process assessment

After the evaluation of the production process flowchart of the company, the Eco-team will be able to collect quantitative data of the production, using available sources, as an example, estimations of the purchasing sector, etc.:

- Input measurements (raw materials, water, energy and other inputs), focusing more on water and energy, but without details about each step of the flow chart;
- Output measurements (wastes, wastewater, emissions, by-products and products), but without details about each step of the flow chart;
- Environmental situation data;
- Stock, storage and packaging data.

2.3.2.3 Selection of evaluation focus

With the environmental diagnose and the spreadsheet with the main environmental aspects in hands, the work focus among all activities and operations of the company is selected. This information is analyzed considering the legal regulation, the amount of wastes generated, the wastes toxicity, and the costs involved.

2.3.3 Third step

In the third step the material balance is elaborated and indicators are established, the causes involved in the waste generation are identified and the CP options are then determined. Each phase of this step is detailed as follows up.

2.3.3.1 Quantitative analysis of inputs and outputs and establishing indicators

This phase starts with a more detailed quantitative data collection on each step of the process, which was given greater importance during the activity of Evaluation Focus Selection. The evaluated items are the same analyzed during the Process and Environmental Diagnosis, which makes possible a qualitative comparison between the existing data before and after the implementation of CL program and those collected by the Program:

- Quantitative analysis of the inputs and outputs;
- Input measurements (raw materials, water, energy and other inputs);
- Output measurements (wastes, wastewater, emissions, by-products and products);
- Environmental situation data;
- Stock, storage and packaging data regarding inputs and outputs.

The selection of performance indicators is fundamental to evaluate the efficiency of the methodology applied in the project and to monitor the progress of the CP measures implemented. The current indicators of the company and the indicators established during the quantification step will be analyzed. Therefore, it is possible to compare them with the indicators determined after the step of implementation of the CP options.

2.3.3.2 Identification of the causes of waste generation

In the data collection of mass balance (quantification) the causes of waste generation in the company will be evaluated by the Eco-team. The main factors that promote wastes and emissions are operational, raw materials, products, capital, causes related to the wastes, human resources, suppliers/business partners, and processes.

2.3.3.3 Identification of options of cleaner production

The execution of modifications in several levels of practice and the application of strategies towards CP actions is possible based on causes of waste generation that were already described.

The CP is characterized by actions that give priority to the Level 1, followed by the Level 2 and Level 3, in this order of hierarchy.

Priority must be given to measures that promote elimination or minimization of wastes, effluents and emissions in production process where they are generated. The main goal is to find measures that avoid waste generation at the source (level 1). These measures might include modification in the processes as well in the product manufacture itself.

2.4 Research design

This research is classified as exploratory search, according to Gil (2008). The goal is to provide a broader understanding of the problem. It can include literature research and interviews with experts.

The execution methodology is based on what was proposed by CNTL/SENAI (SENAI, 2008), detailed in the item 2.3 of this paper. This method is based in five steps with several tasks involved in each step. In order to execute this work, the step number 3 was selected as a final step, which is the generation of CP options to the Bakery X, following the sequence presented in the flow chart showed in Figure 4.

In order to evaluate the gravimetric composition of the solid wastes generated by the Bakery X, the solid wastes generated in one work day were collected during four weeks in the following dates: 03, 08, 19 and 24 of September of 2014.

For the sampling, the physical characterization of solid wastes the specifications given by NBR 10.007/2004 (ABNT, 2004) referring to solid wastes sampling were followed. The wastes were sorted, in a simple sample, and classified in the following categories: paper, plastic, metals, organics and the rejects which do not fit in the other categories.

After the sorting of wastes (Figure 5) they were weighted, and subsequently the collected data was digitized using the software Microsoft Excel 2010. With the spreadsheet containing the data, the statistics representing the percentage of each waste and the confection of graphical representation were obtained.

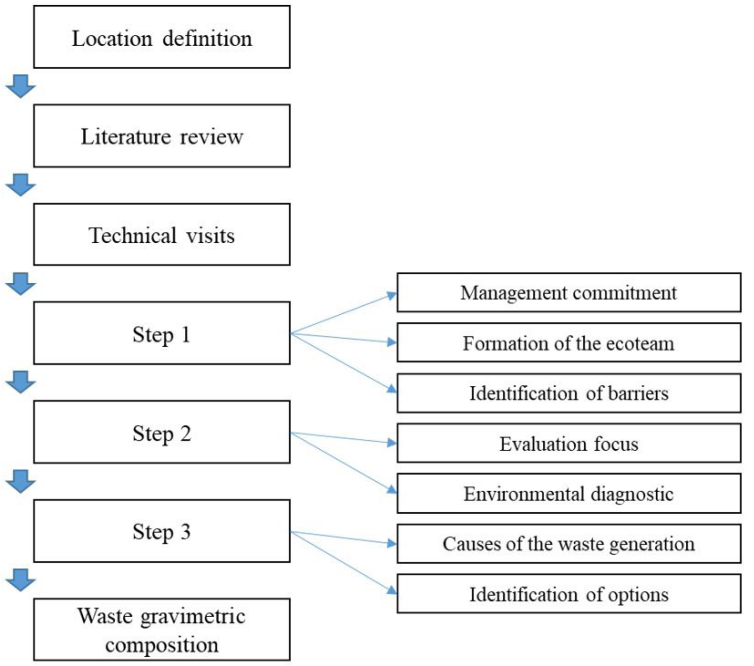

Figure 4. Steps of te development of Cleaner Production in the study. Source: Centro Nacional de Tecnologias Limpas – SENAI (2008).

Figure 5. Solid wastes sampling procedure to determine the physical characteristics.

2.4.1 Gravimetric composition of solid wastes

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2.5 Relationship with bakery sector and the environment

This sector is characterized as a generator of non-hazardous wastes, and the biggest amount is non-inert. Due to the fact that they are small enterprises, the solid waste collection is executed by the municipality.

Regarding the generation of liquid effluents it is comparable with domestic effluents, constituting effluents with relatively low organic matter content, presence of oils and grease and absence of toxic metallic compounds. As a matter of this fact, the treatment of effluents from this activity is relatively simple and the destination is the municipal sewage system (SENAI, 2008).

The air emissions are constituted mainly by water vapor that comes from the process of cooking the bread and in some cases there are also emissions from using wood as fuel for the ovens.

The type of energy source used in ovens is frequently related to the date in which the bakery was installed and its location as well. The older bakeries and the ones located in neighborhoods generally use wood as fuel. The newer ones or the ones located in city centers use gas or electric ovens motivated by smaller space available for wood storage and by the smaller sizer of the ovens (SENAI, 2008).

The Resolution RDC nº 216, of 15th of September of 2004 (Brasil, 2004), presents the Technical Regulation on Good Practices for Food Services, in terms of solid waste management:

- The establishment must provide bins identified and in good conditions, with easy access for cleaning and transporting, and in number and capacity enough to contain the wastes properly;
- The containers used for wastes disposal in the areas of FOOD preparation and storage must have lids activated without hand contact;
- The wastes must be frequently collected and stored in a locked area and isolated from food preparation and storing area, in order to avoid contamination spots and attraction of vectors and urban pests.

The resolution CONAMA nº 01 of 23rd of January of 1986 (Brasil, 1986) does not include bakeries and confectionaries in the list of activities that depend on the elaboration of Environmental Impact Assessment (EIA) to obtain the environmental license, characterizing this activity as the local impact, what allows the municipalities to execute the process of licensing, without bigger damages to the environment.

This sector is not characterized as a highly pollutant activity, nonetheless the necessary environmental control is not disregarded to any productive activity, neither reduce the possibility of improving the process via the implementation of CP programs.

3 Results and discussion

3.1 Application of cleaner production program methodology

During the work execution of Bakery X the steps of the Cleaner Production (CP) Program methodology were discussed and executed, aiming to generate options for future implementation by the establishment. The results of completed steps, according to the objectives of the work, are described in the following.

3.1.1 First step

The first step was developed by technical visits at the company, looking for managerial commitment, via comprehensiveness that would have been taken in the company and the Eco-team formation, with the employees and the managers.

First of all, the CP methodology was exposed to the management of Bakery X. After the real necessities of the study were justified and the benefits that could be obtained to the company via Program application.

The management supported the study and gave authorization to data collection on local, the technical visits, the consequent awareness of the employees and the training about CL practices. Considering that the CP is part of environmental management, it is extremely necessary and vital the support from the directors in the training and awareness of the practices of the employees.

In order to disseminate the CP program in the company, a group of employees was created, the Eco-team, which was trained in relation to the methodology which would be applied. The training about CP was executed explaining the necessities of its implementation and the benefits for the company and the environment. As the work progressed, a shift in the motivation of the employees was perceived, since now they feel as part of the solution, rather than part of the problem.

After giving information, a real interest was observed by the company directors and the Eco-team as well.

As the work progressed, some barriers to development of the CP program occurred in the Bakery X, among them:

- The access to all the employees – due continuous production and large-scale production, some employees were overwhelmed, which made the awareness and training not possible; and
- The impossibility to collect data during the production processo on local – the direction did not allowed this step during peak production, which coincide with bigger amount of wastes generation, hence wastage.

3.1.2 Second step

The Bakery X produces several food products. The most significant ones in terms of quantity are bread, tarts, cakes, pastries, and snacks in general. The wastes production was observed to be generated mainly in the production process of bread and tarts (scraps, flour, crusts, etc.)

The establishment generates in average 16.05 Kg of wastes a production day, these wastes are mainly composed by organic materials, and therefore wastage of raw materials and food scraps occurs. These wastes are completely mixed with recyclable materials, and collected by the municipal system.

3.1.3 Third step

The main supplies used in the company are flours, baking soda, condensed milk, milk jam, and for cleaning purposes soap powder and detergents. The main ingredient, according to collected data by the responsible people, is wheat flour, which are used about 130 sacks of 15 kg per day.

The wastes that are generated on site come from the disposal of packages and scraps of raw materials that cannot be stored, production rejects, and wastes from eating area.

The wastes are generated on local, and posteriorly collected and stored together with inorganic wastes (of packages). The Bakery X does not have sorted containers inside and outside of the establishment, hence this mixture occurs.

The lack of waste separation in the origin of its generation causes a great damage to the wastes that could be recycled in the future. Thus, the main focus of action regarding the implementation of CL on local, following the levels of CP, the minimization of solid wastes generated and after that the adequate sorting on source, so the inadequate mixing that makes these materials unfeasible for recycling is avoided.

Having considered the collected data and analysis realized in the company, a proposal of CP options was generated, which are guidance actions towards the implementation of this practice on local. These options are described below.

3.1.3.1 Cleaner production options

- Sorting of recyclable and non-recyclable wastes for trading or adequate disposal: the implementation of this action bring economic, social and environmental benefits. Economically, it generates extra profit by trading recyclable wastes, mainly metals, glasses and papers. In environmental sector, it helps by reducing the volume of recyclable materials disposed in sanitary landfills. In the social point of view, it helps in the process of recycling of materials, in line with the support to recycling of wastes for the collectors side. This important action brought up the necessity to determine the gravimetric composition, in order to help the company to address an adequate destination to these wastes. This study will be presented in the next item of this work;
- Good practices in products manufacture (*Good Housekeeping*): From the awareness and the training of the staff, a reduction in raw material consumption was obtained in the manufacture, mainly, of breads, cakes and salty snacks, hence reduction of organic wastes generation, avoiding wastage and providing economic advantages. Moreover, these advantages can be found in the field of water and energy consumption;
- Purchase of raw materials for products manufacture with bigger packages: Usually the raw materials are purchased in smaller packages, which can be substituted by bigger packages obtaining, consequently, a significant reduction of the costs, and reduction packages wastes. For instance, in the case of flour it could be purchased in

bigger packages and in case of condiments, bulk purchase;

- Reduction of electric energy used in illumination of the local: In some windows, the curtains are closed making necessary to keep the lights on. A better utilization of sunlight, via installation of transparent roofing tiles and a bigger number of windows to bring more natural light can help to reduce the expenses with electricity. The awareness of the employees to use as maximum as it possible the natural light became extremely necessary, because daily attitudes are strongly important to the success of the practice;
- Adjustment of the loaf pans to use the total internal area of the oven: the pans that are used when placed in the oven do not occupy the total area available, wasting approximately 20% of the oven capacity. For example, if 100% of internal area of the oven is used, it is possible to bake 1000 unities instead of 800, at the same time, saving the energy used.

3.2 Physical characterization of solid wastes generated at Bakery X

During the days of visits and analysis, a big variety of wastes generated and non-sorted by classes was observed. In an initial observation, the wastes were identified as organic materials, paper, plastic, metals, and etc. Thus, in order to facilitate the process of solid wastes final disposal, an important part of Cleaner Production (CP), a characterization of them is necessary.

In the four days in which the generated solid wastes were analyzed, on September 08th, 2014, was the day with the biggest generation, presenting a total of 19.10 Kg of wastes (Table 1). This high generation probably occurred due the fact this day was a Monday after the Holidays of September 7th, Brazilian Independence day. Generally, after Holidays there is a bigger wastage of food that could not be sold. This was proven by the bigger amount of organic wastes observed in this day specially, 60.7%.

Regarding the specific wastes, the bigger percentage is organic with 58%. The bigger quantity of this waste was obtained in September 08th,2014. The other categories: paper, plastic, metals, and etc. were, respectively, 18%, 14%, 7%, and 3% of the total wastes generated (Figure 6).

It is observed that the most significant generation is the organic materials that have origin in the food scraps produced in the Bakery X, in addition to products that are not used in more elaborated processes, like, for instance, a tart, which can produce leftovers of cakes, fillings, and other items that are used.

As a way to value these organic wastes, the biological treatment process of wastes, for instance, composting, would be a suitable alternative considering that currently the organic wastes, mixed with recyclable, are transported to a municipal sanitary landfill.

3.3 Benefits of cleaner production

The implementation of a Cleaner Production (CP) Program allows the company to better realize its industrial process via continuous monitoring to maintenance and development of an Eco-efficient system of production with generation of environmental and process indicators. This monitoring enables the company to identify the necessities of: applied research, technological information, and training programs.

Moreover, the CP Program will be integrated to the Systems of Quality, Environmental Management, and Occupational Health and Safety, providing the complete understanding of the managing system of the company.

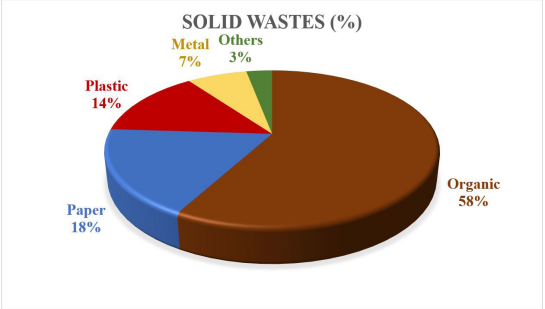

Figure 6. Percentage graph of the average of wastes generated.

Table 1. Wastes generated in the company.

	Wastes (Kg.day^{-1})					
Dates	**Organic**	**Paper**	**Plastic**	**Metal**	**Others**	**Total**
08/03/2014	8.50	2.50	2.00	0.50	0.50	14.00
09/08/2014	13.30	3.00	1.50	1.00	0.30	19.10
09/19/2014	7.50	5.00	3.00	0.40	0.10	16.00
09/24/2014	8.00	1.30	2.50	2.50	0.80	15.10
Average	9.33	2.95	2.25	1.10	0.43	16.05
Average (%)	58	18	14	7	3	100

The CP Program bring to the company environmental and economic benefits that yields a global efficiency of the production process, via:

- Eliminating wastage;
- Minimizing or eliminating raw-materials and other supplies that are impacting to the environment;
- Reducing wastes and emissions;
- Reducing the costs of managing the wastes;
- Minimizing environmental passive;
- Increasing health and labor security.

And also contributes to:

- Improving the company's image;
- Increasing the productivity;
- Environmental awareness of the employees;
- Reduction of expenses with fines and other penalties.

As in any kind of project, the decision in investing on CP depends on the relation cost-benefit that investment will have. Comparing with the changes that occur in the structure of a company costs in two possible situations, when there is not and when there is investment in Cleaner Production, it is verified that in the last case the costs decrease significantly along the time, as a result of the benefits generated from the increasing process efficiency, efficient use of raw-materials, water and energy, and the reduction of wastes and emissions generated.

4 Conclusions

The realization of this work allowed the authors generate options of Cleaner Production that can improve significantly the economic, social and environmental aspects of the establishment. The results obtained were good practices of CP in products manufacturing, the separation of recyclable and non-recyclable wastes for trading and environmentally-adequate destination, the purchase of raw-materials with bigger packages, and the adjustment of the loaf pans to maximize the energy efficiency.

The most significant generation is the organic material which has its origin in the food produced in Bakery X. In order to value the organic wastes, the biologic treatment process of the organics, composting per example, is explained as an excellent alternative, since currently the organic wastes are mixed with the recyclable and transported to the municipal sanitary landfill. This problem is frequent in Brazilian municipalities, generating a quicker closure of the landfill cells which can be fulfilled in half of the predicted lifetime.

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