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AN APPLICATION OF CLEANER PRODUCTION PRINCIPLES IN A PASTA MAKER

UMA APLICAÇÃO DE PRINCÍPIOS DE PRODUÇÃO MAIS LIMPA EM UMA EMPRESA DE MASSAS

Estela Maria Perez Diaz* E-mail: estela.maria@ifmg.edu.br
Edward Chang* E-mail: coordenacao.tma.gv@ifmg.edu.br
Wendy Peixoto Martins* E-mail: wendypxmartins@hotmail.com
Eduardo Romeiro Filho** E-mail: romeiro@dep.ufmg.br
*Instituto Federal de Minas Gerais (IFMG), Minas Gerais, MG, Brasil.
**Universidade Federal de Minas Gerais (UFMG), Minas Gerais, MG, Brasil.

Abstract: This study was carried out in a large food company located in the northeast from Minas Gerais, Brazil, where Cleaner Production was applied mainly aiming at reduction of waste generation at source (level 1) during mass production. The methodology used was the case study, starting with the environmental diagnosis, which identified a company's reactive posture in relation to the environmental aspect, aimed mainly at compliance with legislation (although elements of change to a proactive posture). A gap in the Company's environmental management was also identified with regarding the requirements of the ISO 14001 model, in the implementation and certification of the ISO series 14000. The Cleaner Production program also contributes to this issue, allows the company to use its resources more efficiently, reducing and/or eliminating waste and being more responsible to society and the environment.

Keywords: Cleaner production. Paste industry. Production systems.

Resumo: Este artigo apresenta um estudo realizado em uma empresa de alimentos de grande porte localizada no nordeste de Minas Gerais, Brasil, onde a Produção Mais Limpa foi aplicada visando principalmente a redução da geração de resíduos na fonte (nível 1) durante a produção em massa. A metodologia utilizada foi o estudo de caso, a partir do diagnóstico ambiental, que identificou a postura reativa de uma empresa em relação ao aspecto ambiental, visando principalmente o cumprimento da legislação (apesar de elementos de mudança para uma postura proativa). Também foi identificada uma lacuna na gestão ambiental da Companhia no que diz respeito aos requisitos do modelo ISO 14001, na implantação e certificação da ISO série 14000. O programa Produção Mais Limpa também contribui para esta questão, permite que a empresa utilize seus recursos de forma mais eficiente, reduzindo e/ou eliminando resíduos e sendo mais responsável com a sociedade e o meio ambiente.

Palavras-chave: Produção mais limpa. Indústria de Massas. Processos de Produção.

1 INTRODUÇÃO

The food industry is one of the most important in the world and, therein, the production of pasta represents great value as this is one of the most popular and consumed foods worldwide Fusi *et al.* (2016). Despite the potential environmental impacts generated, they are several opportunities for improvement, such as better use of water El-Salam and El-Naggar, (2010), improvements in land-use processes Recchia *et al.* (2019) or use of methods of lower environmental impact in production Pappalardo *et al.* (2017). These measures can be incorporated into the principles of the so-called Cleaner Production (C+P), concept developed by the United Nations Environment Program (UNEP) and United Nations Industrial Development Organization (UNIDO), as one of the environmental management models created to implement concepts and objectives for the sustainable development Oliveira *et al.* (2016). C+P measurements are not necessarily complex and can consistently contribute to the Enterprise to become more sustainable, in the sense that they can contribute to a better working environment, better interaction with the environment. As examples in food industry, we have the production of dairy products Santos *et al.* (2018), Nigri *et al.* (2014), granola Dahiya, (2018) and Bakery, Pimenta and Gouvinhas, (2012).

The concern with environmental preservation is amply justified by the large quantities of waste that have been produced around the world, Orth *et al.* (2014), in addition to growing scarcity of natural resources and risk to the environment Sachdeva and Zhao, (2021). In addition, public opinion has become sensitive to environmental issues, affecting companies both in the boycott of consumers and investors to polluting companies, Beck, (2019), as in the expansion of product markets that are perceived as less harmful to the environment Nguyen *et al.* (2018).

This situation ends up leading to a new approach, where the residue is no longer something inherent to the production process and becomes a clear indication of its inefficiency, an aspect that can be considered the principle of C+P, as well as from the perspective of a "cradle-to-cradle" life cycle McDonough and Braungart, (2002). The application of clean technologies now has as an objective not only the continuous improvement of the product and/or production process, but also the reduction in the consumption of raw materials, waste emission and environmental impact. It is therefore, the reduction of production costs of the company's products and/or services. Marinho and Kiperstok, (2001) mentions 3 corporate mechanisms, through which the company can become sustainable: (1) norms and controls that govern the company, linked to economic and legal instruments to which the company must subject if it does not comply with the regulations; (2) economic instruments reflected in incentives for sustainability through tax incentives; (3) self-regulation, when the company considers potential competitive advantages it will obtain, especially with consumers. Oliveira Neto *et al.* (2015a) draw attention to the growing importance of stakeholders as element pressure to improve environmental results in companies. So, from the perspective of sustainable development, industries must optimize the consumption of energy, water and materials; minimize the generation of effluents; and, favoring the reuse of waste by application of eco-efficient industrial systems, in addition to minimizing disturbances or imbalances to the ecosystem Montibeller - Filho, (2008). Thus, companies need to deal with the impasse of creating a structure for its growth and expansion, compromising in a minimal way the environment. It is essential to develop new production techniques, reorganization of the production process, administrative strategies that increase quality and at the same time, reduce negative impacts on the environment Alayón et al, (2017), Schlicmann et. al. (2020) describes the importance of manufacturing environment, notably the machines on the machines on the shop floor, for application of C+P. Thus, C+P is a management model in order to optimize production through changes in the production process, prioritizing the use of raw materials from renewable sources, with conscientious use, to generate a minimum of waste and emissions that cause damage to the environment Henz et al, (2018). In fact, the most widespread C+P principles in companies in Brazil are linked to production planning and control, environmental education and control of waste destination Oliveira Neto *et al.* (2015a). This concept of C+P was defined by UNEP in the early 1990s as the application continuation of a preventive environmental strategy integrated to processes, products and services to increase eco-efficiency and reduce risks to man and the environment, based on the assumption that clean production as such does not exist UNEP, (1999). Each process of production generates some form of contamination, but it is possible to continuously reduce the generation of contaminants at each stage of the life cycle, whether in industry, services, transport or agriculture.

For industrial production processes, the benefits of a C+P program include raw material and energy conservation; elimination of the use of toxic raw materials and reducing the quantity and toxicity of all emissions and waste prior to exiting the process. It represents wide possibilities for improvement, even for small businesses

Shi *et al.* (2008), with reduced impacts throughout the life cycle of the products, from the extraction of raw material, going through its use, until its final disposal. The C+P reduces risk for workers, the community, product consumers and future generations, in addition to reducing production costs, end-of-pipe treatment, health services and environmental cleanliness. While improving the efficiency of processes and product quality may present high investment costs, the period of recovery may be short UNEP, (1999) since, in production processes, it has the objective of guaranteeing the economy of raw materials and energy and the elimination of the use of harmful materials to health both in quantity (in the raw material) and in waste and emissions. The implementation of the C+P is divided into three levels, with the sequence to apply according to priorities, economic and technical feasibility of minimizing waste and emissions and/or reuse of waste and emissions. Figure 1 presents these three levels and the possible options to minimize or reuse waste and emissions.

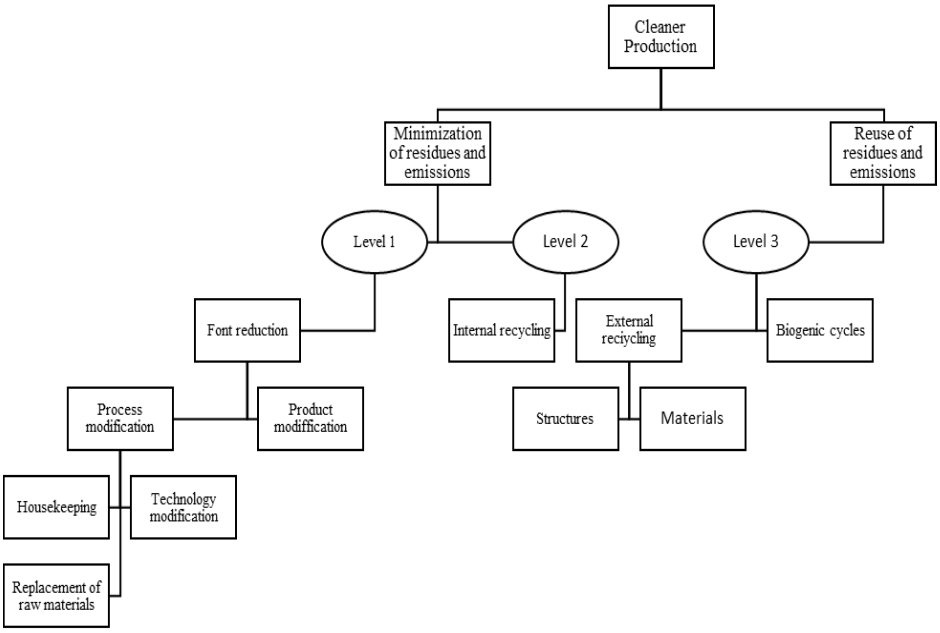

Figure 1 - Flowchart of generating Cleaner Production options and priority levels
Source: UNEP, (1999) and CNTL, (2003).

The approach proposed by the literature UNEP, (1999), CNTL, (2003), Werner, (2011) recommends sequential prioritization for C+P. The preferred solution is usually associated with level 1, which provides for the reduction of impacts at the source, through changes in the production process and in the product itself. It is reasonable to note that the introduction of product modifications typically require a more refined and holistic approach. They should not shift the focus away from process improvements, which can have short-term benefits. Product modifications can lead to an improved ecological situation in terms of production, use and disposal of the product, which may lead to the replacement of the product by a service, to increase the life of the product through the use of different materials or changes in product design, Alves et al, (2016). On the other hand, a consistent approach aimed for process improvements can help to greatly reduce waste, effluents, emissions and waste. Another approach of good practice is characterized as the careful use of raw materials and processes, including organizational changes. In most cases, these are the most economically interesting measures and easy to put into practice, usually one of the first C+P activities to practice. In its level 2, the C+P proposes solutions such as internal recycling systems, where waste that cannot be avoided should be reintegrated into the company's production process, as in recovery of used solvents, alternative use for raw materials or products used for a different purpose, use of varnish residues for painting parts not visible of products, recovery (even if partial) of water and its use in its process, etc. Level 3 basically consists of the external recycling of waste, effluents and emissions outside the company, after having been sold off the alternatives at level 1 and 2, since in these levels the measures taken will be more efficient, that is, the closer to the root of the problem the more efficient the measures will be. This can happen in the form of external recycling or a reintegration into the biogenic cycle (such as composting). The recovery of higher value materials and their reintegration into the economic cycle - such as paper, shavings, glass, composting materials - is a less recognized method of integrated environmental protection through waste minimization.

C+P must be integrated into the Integrated Management System, as presented in figure 2. In the case of Environmental Management, C+P helps to analyze the lag in relation to the requirements with ISO 140001. Thus, according to UNEP, (1999), CNTL, (2003), Hens, L. et. al. (2018) and other author’s state that among the main advantages of implementing the results of an integrated management system are: reduction of the duplication of internal resources and infrastructure, reduced number of documents and complexity in the organization.

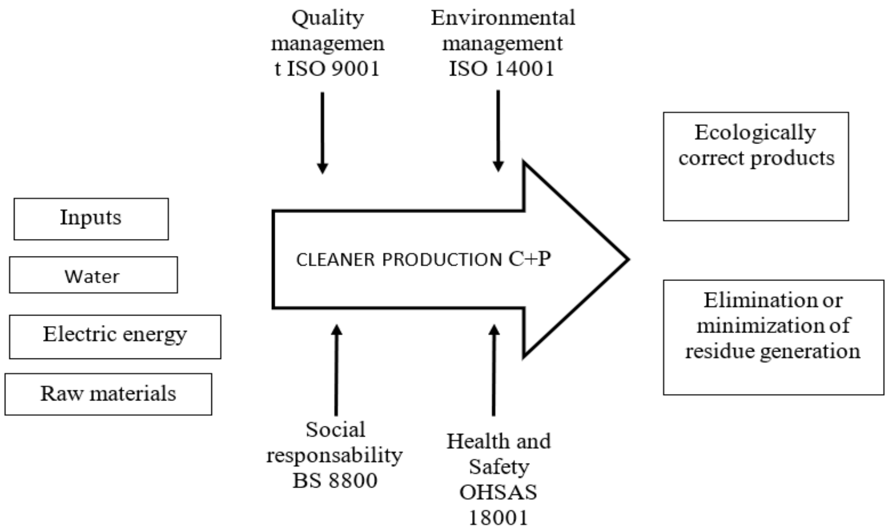

Figure 2 - Management Systems Integration Scheme
Source: Adapted from ENRIQUES and QUELHAS (2007).

2 MATERIAL AND METHODS

The research method was based on the case study Yin, (2013), Lakatos and Marconi, (2010), with a literature review, analysis of company documentation (not confidential), interviews and detailed data collection of the production process (inputs, transformation process and outputs). The survey started with a presentation on the theme aimed at the company, aiming at making the project viable. This initiative was particularly opportune, with a view to creating a “critical mass” on the subject and to make contacts with companies in the food sector, focus of the research. Among the existing possibilities, a pasta production company was selected, with a view to, (1) interest in research, (2) characteristics of the process, considered appropriate to the proposed theme (the company is medium-sized and the production process technology allows an in-depth analysis and with adequate cutout), (3) the possibility of providing data consistent on the production processes and (4) the possibility (expressed by the company) of application of the results. Once the company is defined, the data collection that was performed through:

- Application of closed questionnaire (appendix 1) to personnel (1) responsible for production, (2) environment and (3) administration, with the objective of carrying out the environmental diagnosis and knowing about the general form on the production lines.

- Conducting semi-structured (appendix 2) open interviews (in loco), aiming (1) to highlight and analyze the differences in the environmental management of the unit in relation to the ISO 14001 system (which was of interest to the company) and, consequently, of the possible need for improvement environmental management and, finally, knowing certain administrative aspects of consumption of resources.

- Examination and analysis of non-confidential documents related to the company and its system of production, especially those who provided guidance in relation to the environmental aspect.

- Field research, with detailed monitoring of production processes in different pasta production lines, with the objective of characterization and identification of opportunities for improvement and application of C+P tools.

- Detailed analysis of data related to generation, emissions and waste in the sectors operational and technological, as well as identification and quantification of waste. The consumption of water was estimated based on the company's global consumption, considering its limited use in the investigated process.

- Preparation of a technical report, for the company, with the survey results, analysis and interpretation of all project information, as well as final considerations.

3. RESULTS AND DISCUSSION

3.1. Diagnosis

3.1.1. Company characterization

The company is classified as an industry in the Manufacturing of food products non-specified or unclassified, the main products being pasta and biscuits. It has 528 own employees and 30 outsourced employees, being classified as a large company.

The company's work regime is 24 hours/day, 30 days/month and 12 months/year, with a stopover of shifts of different employees every 8 hours. The manufacture of products is in series and large volumes.

The production lines are pasta (which cover 99% of the total produced), biscuits, mixes for cakes, juice powdered and various seasonings. Currently the company's productive capacity is 1,680,000 kg of pasta per month (with an installed capacity of up to 2.550,00 kg per month), with an average frequency of new product launched every six months. The Company is considered the largest lasagna producer in Latin America, operating in the market with an own brand and third parties.

3.1.2. Production process

The pasta manufacturing process is not very complex, being formed through the steps of (1) raw material preparation, (2) mixing/hydration, (3) kneading, (4) molding or drawing, (5) drying, (6) packaging and (7) storage (prior to final shipment). These **steps are detailed below:** Raw material preparation: The wheat flour is received in 50 Kg or "big" raffia “bags" of 1.250 Kg accompanied by a supplier analysis report and checked by the company laboratory. After analysis and release, the flour is sent through a screw conveyor to a rotary sieve with magnet, in order to eliminate any materials unsuitable for the manufacturing process. Then the flour is sent to silos with 15 ton. Capacity. Additives and dehydrated eggs are dosed in portions determined according to the recipe of the type of dough, going through the same process as the flour.

Mixing/Hydration: From the silos, the flour-additive-egg mixture, or flour-additive (according to the mass that will be produced) is transported by worm to the feeder. Flour and water are dosed and deposited in the trough basin, where by mechanical means (shafts and pallets) they are mixed until obtaining a homogeneous mass in a vacuum system.

Kneading: In the continuous process, kneading is carried out in the extruder cannon, to where the dough is conveyed and kneaded by the action of an endless screw.

Molding or wire drawing: After kneading, the mass is distributed through the basin distributor to extruder screws consisting of cylinder and worm screw. The dough goes through a matrix (wire drawing), which will give the final character to the product. The wire drawing is coated with teflon, it has low coefficient of friction, which provides greater production of masses with more surfaces smooth. Due to the large amount of heat released in this step, the tube is cooled extruder to keep the dough temperature below 50°C. Due to the appropriate conditions of temperature, water activity and pH for microbial growth, periodic cleanings are carried out.

Drying: Through a chain conveyor, it is sent to the drying tunnel, which has the purpose to lower the moisture of the mass, thereby establishing a definitive shape for the product, as well as to ensure microbiological safety. Drying is done in two steps: inserting or pre-drying and the drying itself. In the first step, the mass featured with a moisture content in the range of 28 to 30%, through hot ventilation and controlled humidity, has it´s humidity reduced to 19%, within an interval of 50 to 60 minutes at a temperature of 90°C. Then, it goes on for definitive drying in a period of 14 hours slowly and gradually reducing this humidity to 12%. The average temperature is 70°C. After this process, the mass is automatically deposited on a conveyor belt, passing then by circular saws, at this point, suitable for consumption and with structure that does not offer conditions for microbiological growth.

Packaging: The product (already in the defined format) is automatically deposited in a bucket elevator that will supply the automatic packaging machines, thus avoiding manual contact (except lasagna, which is collected in appropriate boxes and taken to the bench of weighing to later be manually selected and placed in cribs of paper, which are weighed on electronic scales and sent to the automatic packaging machine flow pack type), which preserves the product from possible contamination. The product is weighted in polyethylene bales with a final net weight of 10 kg. In this step, the batches are dated and samples are taken for laboratory analysis. After drying, before of the packaging, dough cooking tests are carried out in order to verify characteristics like color, shine, strength and flavor.

Storage: In order to avoid possible cross-contamination, the entire process of Manufacturing is carried out in-line (silage, extrusion, packaging and storage, in that order).

The warehouse is in a dry and ventilated environment, and the products are placed on wood pallets, to avoid contact with the ground, and at a minimum distance of 50 cm from the walls to facilitate cleaning and sanitizing.

3.1.3. Noodle production equipment

The company's input electric power substation with maintenance keys, protective circuit fuses and 13,800 Volt circuit breakers; a step-down substation composed of three transformers, 2 of 300KVA and the third of 125 KVA. It also has a set of boilers, comprising a TGA hot water generator, a set of reserve pumps, a hot water generator with a production capacity of 1500 Mkal/h with a wood-burning furnace, the firewood being used for reforestation; reserve pumps, a system water hardness treatment compact with softening filters. Pressure vessels for the closed hot water circuit, in order to prevent water vaporization, and piping thermally insulated complete the equipment of this system. Being the total of 1,025,000 watts, it is estimated that the consumption of production equipment uses 80% of energy, which would represent 820,000 Watts.

A comparison of this consumption was made with industrial equipment currently available in the Brazilian market, by consulting the pasta production equipment manufacturers. With the change and updating of production line equipment, it is estimated that energy consumption could be reduced by up to 44% in the case of electrical energy and 36% in terms of thermal energy (according to a survey with equipment suppliers). However, it is noted that the company's investment capacity is limited, which makes it difficult to reduce energy consumption. Therefore, the study turned to aspects where improvement could be effectively implemented, such as the waste of raw materials.

The production equipment is an Italian technology, comprising two lines of manufacture of long pasta, with a capacity of 2,500 kg/h; a long pasta manufacturing line, with a capacity of 700 kg/hour; a line of cut dough with capacity for 1000 kg/hour; and a lasagna dough line with a capacity of 700 kg/hour. It is worth mentioning that packaging equipment, in addition to working with Italian technology, work with national technology. The following are the equipment’s used:

Vertical Kneader: kneading equipment, built in enameled iron, composed of 2 axes vertically and 5 palettes on each, one palette for scraping and 4 for mixing the ingredients and knead.

Mechanical dumper: equipment designed to tip the carts used in kneaders. It is composed of two lateral bases with an axis between them where there are two forks fixated to fit the cart. Allows to rotate 140o in relation to the ground depositing the dough in the desired container.

Kneader cart: built in plates, having 3 wheels, side guides and other accessories.

Feeder unit with two cylinders: Equipment designed to form a continuous feeding of pasta. Composed of two mounted grooved cylinders on the horizontal and with an opening adjustment at the top, a funnel where the dough is deposited is in the dough trolley.

Pre-roller: with the objective of forming a continuous horizontal blanket of dough to continue the lamination work.

Laminators: Equipment intended to overlap in the transverse direction to what was laminated, pasta or other type of pasta that requires a blanket with several layers in the same pasta.

Laminating cylinders: Equipment for rolling pasta, consisting of two robust axes mounted horizontally with adjustment to calibrate the thickness of the dough.

Folding sector: Equipment for laminating foodstuffs or other types of pasta that require a blanket with several layers in the same mass.

Intermediate Laminating Cylinders: Equipment designed to laminate foodstuffs. Composed of two robust axes mounted horizontally with adjustment to calibrate the thickness of the dough.

Stamping Machine: Equipment composed of cutting and engraving rollers, of great precision, enabling individual and synchronized adjustments for the perfect functioning of the entire set.

Gas Oven - 1st Stage: Equipment designed to bake biscuits. The process is characterized by burning gas directly in the cooking chamber, with burners installed in the top of the biscuit and bottom of the biscuit.

Gas Furnace - 2nd Stage: The process is characterized by the reuse of heated air, that circulates within a zone several times.

Cooling Conveyor: It is motorized and composed of a metallic profile structure, cub canvas liner and automatic stretcher.

Feed conveyor, linear vibrators and dynamic loaders: Responsible for transport, leaving the cookies lined up and prepared to be packed. It is observed that the pasta preparation process is similar for the different types of the company's products, with changes in ingredients according to the recipe and cut format. An important aspect to be considered is the difference in usage time between different equipment, and in the analyzed plant quite a lot of new equipment coexists with others that are already obsolete, generating chronic problems of waste (which result in ultimately, the increase in the environmental impact generated by the process).

3.1.4. Environmental Situation

The literature indicates that companies that work with sustainability must have defined their environmental policy that is known to all the employees who have been trained and, if possible, classes on environmental education Cuba, (2010); Seiffert, (2011); Barbieri, (2011); Silva Filho *et al.* (2007). An effective policy for formation of an environmental policy or the workers knowledge on the subject has not been seen. Some interviewees linked to the company's senior management declared the adoption of “good practices" aimed at reducing water and energy consumption, but with the primary objective of cost reduction rather than reducing environmental impacts. The Company performs the biannual monitoring of water treatment systems, with a view to meeting the existing legislation, in a posture considered reactive in terms of concern with C+P principles. It should also be noted that the Company does not provide resources for environmental management, whether in terms of human resources, financial, organizational infrastructure, qualifications and technology. It was observed that workers are unaware of environmental aspects related to its activities, not identifying risk and emergency situations, its role in the compliance with environmental policy, individual responsibility and consequences for the environment of non-compliance with procedures. Tasks that impact the environment were observed, apparently without the perception of this impact by workers. No training or structured dissemination of information on the matter in the company were reported. The communication of environmental aspects related to the production in the company's internal documentation analyzed during the research was not observed.

3.1.5. Operational Control and Environmental Education

The company segregates rainwater drainage from other industrial effluents, with the objective of not mixing with industrial effluent that undergoes treatment through systems of Septic Tank Treatment and Anaerobic Filter, which are monitored every six months, keeping within the limits of environmental legislation. This posture can be considered reactive, as it only aims to keep the company within the standards established by legislation Ometto *et al.* (2019) which are, ultimately, a minimum standard to be followed and not represent a necessarily positive aspect.

On the other hand, the interviews showed that senior management is aware of various C+P tools and application forms to reduce waste and consequent environmental preservation, as well as the relationship between C+P and the competitiveness of the company. Table 1 presents the results of the analysis of environmental self-monitoring and the monitoring of effluents according to the technical report of the company's analytical tests.

Table 1 - Analysis Results

Control item	Inspection Method	Verification Item
Physical conditions of the external parties	Visual	Absence of cracks or clefts
Supernatant layer of sludge	Visual	Absence of foreign material (plastic, metals, etc.)
Liquid output effluent conditions	Visual	Normal
Physicochemical analysis in system entry and exit cesspool/filter	Sampling	pH, BOD, COD, sedimentable solids, solids in suspension

Limit established by Normative Resolution COPAM 01/08
Source: Company Data.

According to the report, inspections carried out found that the exposed parts of the systems did not had cracks or clefts and that the discharge of the sanitary effluent occurs normally, no obstructions, as well as no foreign material found in the supernatant sludge. Effluent samples were collected for analysis at the entrance and exit of the system Pit/Filter, which presented the following results (Table 2):

Table 2 - Analysis Results

Parameter	Unit	Result		Limit
		Input	Output	
pH	-	6,24	6,2	6,0 – 9,0
BOD	mgO2/L	678,8	33,2	60
COD	mgO2/L	1662,5	85,8	180
Sedimentable solids	mgO2/L	0,4	<0,30	1
Suspended Solids	mg/L	116,1	41,9	100
Total Coliforms	(CFU/100ml)	1.0x108	7.6x107	---------
Fecal Coliforms	(CFU/100ml)	1.6x107	3.0x106	---------

Limit established by Normative Resolution COPAM 01/08.
Source: Company Data.

Pollution data show that it is within permissible standards with the use of personal protective equipment. According to the Environmental Performance Assessment Report (RADA) the maximum detected emission level (dB) is found in the 65dB to 93dB range inside the production hall. Regarding the outside of the factory, measurements were carried out on the company's land boundaries and no levels were recorded above the limits. In addition, no complaints from residents close to the production unit in terms of noise levels.

The measurement of the necessary index for environmental control are carried out every six months and, in terms of legal requirements, the company demonstrates that it complies with the legislation applicable to its environmental aspects, whether a city, state or federal. Table 3 presents data regarding the generation of solid waste.

Table 3 - Solid Waste Generation

Denomination	Generation/ Origin	Class	Average rate of Waste Generation (kg)	Disposition Final
Paper and Cardboard	Productive process	II	81,83	Donation/Recycling
Big Bags	Productive process	II	439,5	Recycling
Portion	Productive process	II	23871	Animal food
Plastics	Productive process	II	439107	Donation/ Recycling

Source: Company Data.

From Table 3 it can be seen that plastic, paper and cardboard are donated, as a form of final disposal that would be preventive (but not necessarily, as donations ensure the exit of the material from the company but do not guarantee an adequate destination). The residues generated during the production process are destined for the production of animal food, the which (according to the company) does not represent recovery of the loss generated with the loss of the material press, but avoids the formation of an environmental liability.

It is observed in table 4 that the exposed parts of the systems do not present cracks or clefts. It was also observed that the discharge of the sanitary effluent occurs normally, without obstructions according to follow-up, as well as no strange materials were found in the supernatant sludge. The results of sampling carried out by staff in charge of monitoring in the company are presented in table 5.

Table 4 - Results of the inspection of the Effluent Treatment Systems II/2013

Control Item	Inspection Method	Verification Item
Physical conditions of the external parties	Visual	Absence of cracks
Sludge supernatant layer	Visual	Absence of foreign material (plastic, metals, etc.)
Outflow conditions of the effluent liquid	Visual	Normal
Physicochemical analysis at input and cesspool/filter system output	Sampling	pH, BOD, COD, sedimentable solids and solids in suspension

Source: Authors, based on Company data.

Table 5- Analysis results of effluents from the Effluent Treatment Systems

Parameter	Unit	Result		Limit
		Input	Exit	
pH	-	6,63	7,40	6,0 – 9,0
BOD	mg/L	1.824,5	139,0	60,0
COD	mg/L	5.322,5	253,5	180,0
Settling solids	mg/L	4,00	<0,30	1,0
Suspension Solids	mg/L	2.730,0	8,00	100,00
Total Coliforms	(CFU/100ml)	4.2 x 105	4.2 x 105	---------
Fecal Coliforms	(CFU/100ml)	4.2 x 107	4.2 x 105	---------

Source: Laboratory Report.

According to the laboratory analyses results, it can be seen that all parameters analyzed are within the release standards established by the Deliberation Normative State Council for Environmental Policy (DN COPAM), and the parameters BOD and COD were framed by efficiency, having an efficiency of 92,4% for BOD and 95.2% for COD. The company maintains control of water consumption, but does not have any consumption rationalization program.

It is observed that the company does not have an environmental policy, although it has indirectly implemented C+P practices, such as careful control of raw materials and processes, adoption of operating practices aimed at reducing losses (such as minor improvements or repairs to older machines). They were also cleaning and maintenance intervals have been reorganized, minimizing water consumption and energy and improving results through good practices (such as the prior use of spatulas for removing to the mass from equipment and care related to the consumption of water, for example). Water consumption in the production process was considered low, considering that the water used in the process is only for the recipe itself and the necessary for the cooling of the machines. These activities, although they can be associated with the reduction of environmental impact by the company, are part of the first level of C+P, seeking solutions for housekeeping. The savings provided by good operational practices in some cases can enable new investments in the company, including new technologies more suitable for a C+P approach. Another important point is the improvement in recording and control of environmental aspects in the company and contribute to the development of mitigating measures to any problems encountered and aiming the implementation of an environmental management system.

After a first step, with the adoption of a series of good practices for cleaning and equipment maintenance, it was considered the action on the problem of high waste (Table 2) due to leakage from the machines during the production process (especially in the pressing stage): 23,871 kg/year (or almost two tons per month) quantity destined for animal food production. This option represents an alternative to simply discarding the material, but the economic return is not significant, according to production supervision. Yet according to the supervision, this degree of waste is very representative and its reduction (or elimination) is considered a high priority by the company. It is important to note that some company actions regarding errors in the production line can be characterized as principles of C+P, such as (1) the destination of the process leakage to the production of animal food and (2) procedures for reinserting material from leakage (but not contaminated) to the production process. Although they may seem trivial, these procedures can contribute for the reduction of waste and the environmental impact verified during the process of production, in addition to demonstrating the feasibility and subsidizing the initiative to implement other technical solutions that minimize the impacts of the process.

4. CONCLUSIONS

This study carried out in a Brazilian pasta manufacturing company aimed to help the application of a C+P program, aimed mainly at reducing waste generation in the source, level 1. The application of the method generated scientific and technological knowledge in order to contribute at a theoretical level and applied in solving some of the problems raised in the company, notably for the engineering areas. The results also allow the company become more competitive, using its resources more efficiently, which demonstrates that C+P goes beyond an environmental perspective, allowing an approach system of the production process in the company. From the diagnosis performed, it is concluded that the company had a reactive attitude towards the environment, focused solely on adequacy to the standards of legislation as shown in the charts. On the other hand, it can be considered that the results of the work can sensibilize the company's directors and managers through presentation of the C+P program, the exposure of well successful cases, highlighting its economic and environmental benefits.

It was also evidenced that there is a lag in the Company's environmental management in study in relation to the ISO 14001 model; such as the lack of an environmental policy, integration of the environmental management system with the company's strategies, risk management and mitigation measures and continuous improvement for the production unit. On the other hand, it is appropriate to indicate also that this study helped the company in enabling the implementation of systems of environmental management.

From the survey of information on the production process, it is concluded that the company had in its production process a lot of waste, mainly because of the poor performance of obsolete machines and beyond their useful life, a fact that the application of good practices in production was not able to compensate. However, it is concluded that the research had relevant results, whether in the effective reduction of waste in the process, or in raising awareness of high administration on the benefits (including economic) of the C+P principles application.

These results indicate possibilities for research developments, as well as the adoption of actions by the company in order to improve production processes aiming at good results in terms of C+P. Indeed, demonstrating the relationship between the technology adopted (and obsolete equipment), the economic losses and the environmental impact generated represents a vital element of motivation for implementing improvements in the company. In this case, the company was recommended to carry out future research in order to quantify the losses in financial terms, in order to assess the period necessary for the return on investments in new equipment (which generate less losses). This assessment will also be useful to indicate possible production “bottlenecks” that prove to be a priority in economic and environmental terms, guiding senior management in the preparation of a technology modernization and C+P strategy. Finally, it will be opportune to carry out this research in other companies, aiming to assess the situation of the pasta production market in Brazil and how the evaluated company compares to others in the same sector.

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APPENDIX 1 - Questionnaire structure

General data: Company name; Contact person; Address; Number of employees (Administration, Production, Outsourced)

Production:

What is the area of the company? ( ) Administration; ( ) Factory floor; ( ) Effluent treatment

What are the company's product families/lines and what is their respective percentage?

Is there seasonal variation? ( ) No ( ) Yes How does it vary?

What is the percentage of each product line within the company's total revenue?

What is the nominal productive capacity of the company?

What is the current production capacity of the company?

Does the company intend to increase the factory's nominal capacity? In what timeframe? In the same location? For how much?

What is the workday?

The company manufactures by: ( ) Order: ( ) Series – large volumes ( ) Series – small volumes:
Which suppliers does the company work with?
What is the period for launching new products? ( ) one year ( ) six months ( ) others:

Environmental issue

Environmental Policy: Does the unit have an Environmental Policy? Does the unit mention the nature, scale and environmental impacts of its activities, products and services?

Environmental aspects: Does the company have data on water and energy consumption?
Legal and other requirements: Does the company have continuous access to municipal, state and federal legislation applicable to its environmental aspects? Does the unit have legal processes on environmental issues?

Resources, Roles, Responsibilities, and Authorities: Are responsibilities properly communicated to the personnel involved? Does the administration provide resources for environmental management, including human, financial, organizational infrastructure, specific skills and technology?

Competence Training and Awareness: Does the company systematically identify its environment-related training needs? Are employees and service providers aware of the environmental aspects of their activities, risk and emergency situations, their role in complying with the Policy, Individual Responsibility and consequences for the environment of non-compliance with procedures? Are personnel performing tasks impacting the environment received education, training and experience at appropriate levels?

Communication: Are environmental aspects communicated internally between the various levels? As? Are all communications received from interested parties reviewed and responded to?

Documents control: Is that system rigorously complied with in practice? Are documents legible, dated (with revision dates), easily identifiable, maintained in an organized manner, and retained for a specified period of time?

Operational control:

Liquid effluents: Are there devices and/or equipment and/or systems for the treatment of industrial or sanitary effluents? Is storm drainage segregated from other effluents?

Waste, Vibration and odor: Are the levels of residues, if they reach the community, measured and maintained within the limits of environmental legislation? Are Vibration levels, if they reach the community, measured and maintained within permissible standards? Are odor levels, if they bother the community, minimized in any way?

Water and energy consumption? Does the company keep track of water consumption? Is there a program to rationalize water consumption? Does the company keep track of energy consumption? Is there a program to rationalize energy consumption?

Emergency Preparedness and Response: Has the company planned emergency and mitigating actions for possible accidents? (Emergency Response Plan); Are roles, responsibilities and authorities defined, including for communication with public bodies? In the planned emergency actions, is the final destination of the waste generated defined?

Monitoring and Measurement: Are there procedures and a monitoring plan related to significant environmental aspects (atmospheric emissions, effluent output, receiving bodies)? If certain measurements of significant aspects do not meet legal standards, are there procedures in place to correct the problem? Are records kept?

Non-compliance, Corrective Action and Preventive Action: Are non conformity systematically treated and recorded, as well as analyzed for their scope and root causes? Are the corrective actions proportional to the magnitude of the impacts and do they aim to eliminate the causes? Is the effectiveness of the action plans verified?

Registry Controls: Does the company have a procedure for identifying, storing, protecting, recovering, and disposing of environmental records?

APPENDIX 2 - Semi-structured open interviews structure

Surveys carried out:

Solid waste: Type of waste; Quantity (ton/month); Source process; Disposition/Control

Liquid Effluents: Type of effluent; Amount; Origin process; Disposition/Control

Atmospheric Emissions: Type of pollutant; Origin; Issuance fee; Control Equipment

What are the inputs used (fuel, water, electricity, etc.) in terms of average monthly consumption?

What equipment does the company use? Equipment; Manufacturer / Model; No. of equipment; Process used; Workday; Nominal capacity

What equipment is used in the company? Process equipment (beneficiation): Equipment; Manufacturer / Model; No. of equipment; Product type; Process used; Workday; Nominal capacity.

Are there procedures per process (recipes)? If so, can you provide it to us? Which?

What are the auxiliary equipment used in the company? Equipment; Product type; Inputs; Nominal capacity; Water consumption; Workday; Description; Manufacturer/Model; Number; Function

Estela Maria Perez Diaz
Graduada em Engenharia de Produção pela Universidade Maior de San Simon (1991), mestrado em Engenharia de Produção pela Universidade Federal de Minas Gerais (1998) e doutorado em Saneamento, Meio Ambiente, Recursos Hídricos pela Universidade Federal de Minas Gerais (2007). Atualmente é professora EBTT do Instituto Federal de Minas Gerais - IFMG.

Edward Chang
Graduado no curso técnico em meio ambiente no Instituto Federal de Minas Gerais - Governador Valadares (2014) e em medicina pela Universidade Federal de Juiz de Fora, Campus Governador Valadares (2022). Atualmente exercendo profissão como

médico generalista na UBS Parque São Bernardo, localizado no município de São Bernardo do Campo, SP.

Wendy Peixoto Martins
Graduada em Engenharia de Produção pelo Instituto Federal de Educação, Ciência e Tecnologia de Minas Gerais, campus Governador Valadares (2017). Especializada em Gestão de Projetos pela Faculdade de Venda Nova do Imigrante (2019). Atuação como Supervisora do Setor de Projetos do ramo de telecomunicações da empresa Konnet Telecom de 2016 a 2018 e como Coordenadora de Projetos do ramo de Infoprodutos desde 2018.

Eduardo Romeiro Filho
Graduado em Desenho Industrial pela Universidade do Estado do Rio de Janeiro (1987), Mestre (1993) e Doutor (1997) em Engenharia de Produção pela Coppe/UFRJ. Professor Titular da Escola de Engenharia da Universidade Federal de Minas Gerais, no Departamento de Engenharia de Produção.

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