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ZERO PROCESS WASTE DESTINED FOR LANDFILL

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ABSTRACT

Veracel was the first pulp mill in Brazil, in 2005, to start manufacturing operations with a unit that produces agricultural products ready to receive solid waste from the pulp manufacturing process and convert it into fertilizers and soil acidity correctives. However, in 2011, the recycling rate for process solid waste was around 70% and their generation was 55 kg of waste per ton of pulp (kg/Adt), on dry basis. Consequently, the only cell in the industrial landfill had its useful volume for receiving residues almost exhausted. This was a very challenging scenario that motivated the company in 2012 to design a very robust action plan to increase recycling and pursue an extremely challenging long-term goal of reducing to zero the amount of process waste sent to the landfill by 2025. This was the milestone that changed the company's waste management vision and motivated everyone to look for alternatives for recycling and reusing waste. In 2017, Veracel reached a 98% process waste recycling rate. That year, waste generation dropped to about 30 kg/Adt. In addition, the same landfill cell was used until July 2020. This means that the action plan increased the landfill's useful life by twofold. In 2019, we reached a 99% process waste recycling rate, which means that only about 1% of the waste generated is sent to the industrial landfill. In general, this generation is the result of sporadic events, related to some disturbance in the process. August 2020 was the first time that the recycling rate reached 100%. Currently, the annual generation of limestone waste at the Veracel plant is in balance with the need to use soil acidity corrective in 1/7 of the company's eucalyptus plantations. In other words, 100% of the soil correction used in the forest area is supplied by the agricultural products unit at the Veracel mill. The soil acidity corrective and fertilizers are also sold to agricultural producers in the region at very competitive prices. All agricultural products are duly registered with the Ministry of Agriculture in the name of Vida Desenvolvimento Ecológico Company, at the service of Veracel.

Keywords: Process waste, agricultural products, recycling and pulp mill.

INTRODUCTION

The objective of this article is to present the evolution of solid waste management at the Veracel Celulose S.A. plant, with emphasis on the challenges and solutions encountered since start-up of the pulp production plant to date.

Veracel Celulose S.A. is located in southern Bahia and is a joint venture between Storaenso and Suzano, two of the largest pulp and paper producers in the world. Its operations range from the production and planting of eucalyptus, through the manufacturing of pulp, to the ocean transport of pulp.

The plant is located in the municipalities of Eunápolis and Belmonte, and industrial operations began in May 2005. The annual production rate is about 1.1 million tons of bleached eucalyptus pulp.

The pulp mill was designed to contain an Industrial Waste Treatment Center (IWTC). The operation of the IWTC occurred simultaneously with the plant start-up. This was the first time this happened at a pulp mill in Brazil. This fact demonstrates that waste management has maintained recycling a key element since the project phase. The purpose of IWTC is to transform process waste into agricultural products. Since start-up, it has been operated by the Vida Desenvolvimento Ecológico LTDA, which company specializes in manufacturing agricultural waste products from the pulp production process. All agricultural products are duly registered with the Ministry of Agriculture in the name of Vida Company.

The Kraft process of pulp manufacturing basically generates two types of solid waste: organic waste and mineral waste. The organic waste includes eucalyptus bark from the wood preparation stage, bark waste from the log cleaning yard, biological sludge from the Effluent Treatment Plant (ETP), primary sludge, which is the lost cellulose fiber from the bleaching and drying stages recovered in the ETP, and the brown stock pulp waste from the fiber line. The main mineral residues are dregs and grits, lime mud, burnt lime and lime kiln precipitator purge (both from causticizing and the lime kiln), sand from the washing of wood logs, sand from the biomass boiler, fly ash from the biomass boiler precipitator,

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waste from the Water Treatment Plant (WTP) and sand from brown stock pulp purification.

In general, the pulp industry generates residues with very valuable agronomic characteristics. The strategy adopted by Veracel for the treatment of this waste was to transform organic waste, such as biological sludge from the ETP, into organic fertilizer and eucalyptus bark into a substrate for plant; also, to convert mineral waste such as dregs, grits, lime mud and fly ash into soil acidity correctives. In addition, the temporary storage of primary sludge from the ETP had been planned in a warehouse for later commercialization with recycled paper factories. The other process waste was initially planned to be destined for industrial landfill.

The agricultural products from industrial waste are registered by Vida with the Ministry of Agriculture and began being marketed to rural producers in the region and also used in Veracel's eucalyptus plantations.

However, when the plant started up in May 2005, the mass balance of the Industrial Waste Treatment Center (IWTC) for limestone waste was positive. That is, there was more waste arriving at the IWTC than correctives of soil acidity leaving this Center and the reasons were:

1. The demand of the local market for soil acidity corrective was low compared to the generation of limestone waste from the plant. The main reasons were because it was a new agricultural product and most agricultural producers did not trust the quality of products from solid waste and did not buy.
2. The demand for soil acidity corrective through the Veracel forest area was also low, as limestone was still bought from the market for use in the eucalyptus plantations because the balance of nutrients (calcium and magnesium) in this corrective, at the time, did not meet the agricultural needs of the forest area
3. The generation of dregs and grits from the Causticizing Plant was far beyond what was foreseen in the project because the lime kiln limited the production of the Causticizing Plant. To offset this, the amount of lime (CaO) purchased had to be increased in the processing of green liquor and consequently this generated a larger quantity of disposal lime mud ($CaCO_3$) from the dregs filter.
4. Mechanical problems in the bark shredders became increasingly frequent and the generation of bark waste to the composting process increased significantly, dramatically overloading the bark yard in the IWTC.
5. Difficulties in selling primary sludge due to the distance between the Veracel plant and the consumer market, caused an overload in the storage of primary sludge in the IWTC warehouse.
6. There were no targets to reduce the generation of process waste.

Then, there began to be an accumulation of waste in the yard of the Treatment Center and part of the generation of this waste became destined for the industrial landfill. In 2009, 2010 and 2011, due to the crisis in the pulp and paper market that began in 2008, the main customer of soil acidity correctives, which was Veracel's own forest area, halted the reform of eucalyptus plantations and this drastically reduced the use of the soil acidity corrective. As a consequence, in 2012, the life expectancy of the only industrial landfill cell was only 8 months. Up until that time, the mill waste recycling rate was about 70%.

METHODS

It was during the crisis period in process waste management that, in April 2012, Veracel's environmental, industrial, forestry and engineering areas joined forces to come up with solutions to analyze the alternatives available for the reduction, reusing in the pulp process, and recycling of solid waste. From that very robust action, a plan was prepared and a significant change in waste management began unfold.

Veracel decided that the solid waste is all materials from the process sent to the recycling area or industrial landfill. Materials that are reused in the process itself as raw material or energetic resource are considered byproducts. This concept of what is solid waste has encouraged, over time, the reuse of different residues in the pulp manufacturing process.

Firstly, generation targets were defined for each process waste and the disclosure of the quantities of each waste generated and foreseen for that month began to be disclosed weekly at production meetings.

An environmental management tool called "Daily Environmental Indicator" (DEI), which aims to evaluate the daily environmental performance of each area of the pulp manufacturing process was internally created. It is an "online" tool in which the main process parameters that directly impact waste generation, effluent quality, atmospheric emissions, and water use are included. For each selected process parameter, an operation range is defined, based on process stability periods. The system evaluates, daily, whether variations in parameters from the previous day are within or outside their operating ranges. If a parameter has varied outside the operating range, that means there has been a deviation. Depending on the number of parameters with deviations within the same day, the performance of the area is automatically classified as "great", "good", "regular" or "poor". It is worthy to note that some parameters are classified as critical, and it is enough for a single critical parameter with deviation for the performances of the area and management to be classified as "poor". The parameters of deviations are discussed daily in operational and management meetings of production, and process improvement actions are adopted for the performances of the areas not exceed 3 consecutive days of the classification "poor". Above is a DEI screen print.

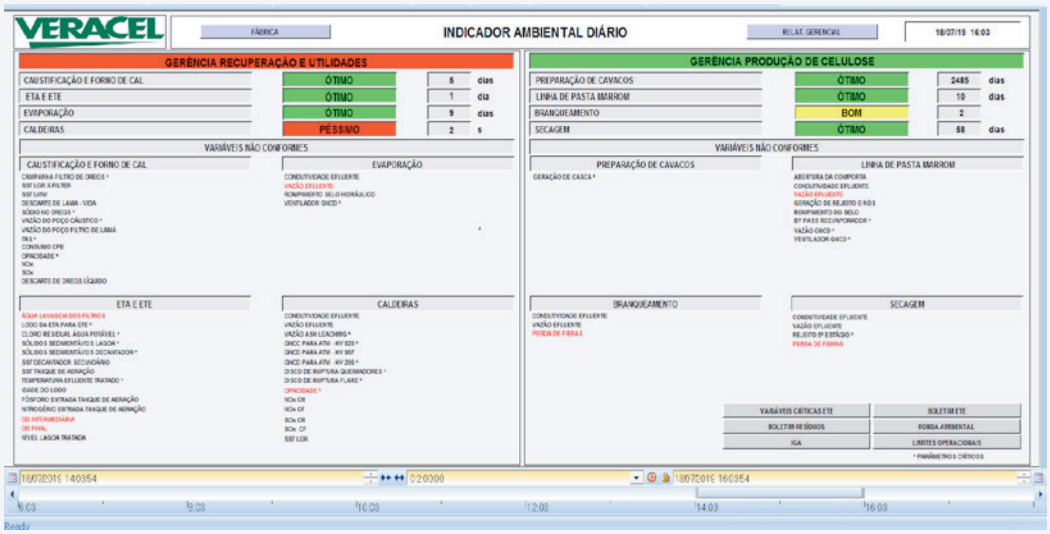

Figure 1 – Daily Environmental Indicator (DEI)

The interval of the dregs filter cycle and the disposal time of lime mud have a direct impact on the generation of plant waste. For this reason, these parameters were inserted in the DEI. This daily monitoring contributed greatly to reducing the production of the waste of dregs and lime mud, which at the time were the process residues with the largest generations.

The generation of dregs and grits increased significantly because the production of the lime kiln limited the causticizing production. In order not to impact the production rate of the factory, increased purchased lime (CaO) applications were performed and consequently it became necessary to extract a large amount of lime mud through the dregs filter, reducing the interval of exchange of the filter layers. This situation was only resolved in March 2014 with the replacement of the Lime Mud Dryer (LMD) with Andritz's Lime Flash. The purpose of this equipment was to accelerate the drying of lime mud, reducing the need to increase the size of the lime kiln. However, the LMD format favored the formation of stones, especially when working at higher temperatures. This obstructed the kiln and for this reason it was necessary to reduce production. With the installation of lime flash equipment, it was possible to work with high temperatures in the kiln without forming stones. Since then, this change has significantly increased lime kiln production by about 100 tons of lime per day.

Whereas in 2008, 2009, 2011 and 2012, due to lack of storage space in the IWTC yard, much of the plant's generation of dregs and grits had been destined for industrial landfill. In April 2012, the landfill life expectancy forecast was only 8 months, so the following decisions were made:

- Formulation of soil acidity correctives according to the calcium and magnesium needs of forest soils, guaranteeing exclusive use of correctives, manufactured by Vida, in 100% of the eucalyptus plantation reform areas, including the forestry fostering program.
- Create workshops for agricultural producers in the region to present the characteristics of soil acidity correctives and agronomic results obtained in different agricultural crops and eucalyptus plantations.
- Sale of the acidity corrective of bagged soil to serve cocoa crops, located in regions with more rugged terrain.
- Presentation of agricultural products at agricultural fairs in the southern region of Bahia.
- Intensification of visits to agricultural producers by the technical and commercial area of Vida Company for product dissemination.

In 2014, after two long stops of the kiln for maintenance and consequently the acquisition of a large volume of lime, it was decided to stop buying lime from the market and set a goal of returning 100% of the lime mud waste from the stocked lime. This stock of lime mud lasted until mid-2017 and during this period there was no purchase of lime for use in causticizing. Since then, the good practice of returning 100% of the lime mud of the IWTC yard to the kiln has been adopted, zeroing the generation of this residue in the company.

In 2012, due to breakdowns of the bark shredders in the chip preparation area, bark was being generated much more than expected in the project and it was the waste with the third largest generation in the plant. All generation of this was sent to the IWTC yard for the formation of the composting trees and the manufacture of substrate for the plant. However, due to the high volume of bark generated at the time resulted in the overload of the IWTC bark yard, the increase in the size of the bark piles and some occurrences of fires.

To immediately solve this problem, it was decided to restrict sending this kind of bark to the IWTC. Since then, a procedure has been adopted to store the bark next to the chip preparation tables and return almost 100% of this bark to the process, along with the wood logs, right after the bark shredders are operational. Thus, all bark returned for burning in the biomass boiler for electricity generation was no longer counted as a waste and became an energetic resource.

To maintain the production of substrate for plants, the bark from the cleaning of the wood yard was destined for recycling. It is worth mentioning that until that time this kind of bark was sent to the industrial landfill.

Another residue that until mid-2012 was destined for the industrial landfill and started to be used in the pulp manufacturing process was the pulp screening waste from the Brown Stock Area. Since then, a procedure has been adopted to allocate this waste to the chip pile to return to the cooking process. Only when contaminants are suspected, such as plastic, rubber, metal or other types of dirt, is this waste destined for industrial landfill.

The primary sludge from the effluents of the pulp bleaching and drying processes and recovered in the primary decanter of the ETP was sold until 2015 to recycled paper mills.

However, the primary sludge waste began to accumulate in the IWTC storage yard because of the following:

- Distance between Veracel's plant and recycling paper factories.
- Price variations in the paper recycling market.
- Quality variations of primary sludge.
- And mainly, the loss of return freight due to the interruption of the purchase of lime.

In 2016, some tests of primary sludge burning in the biomass boiler were carried out and had positive results, helping control the temperature of the boiler bed. In 2017, an auger hopper was installed to feed the primary sludge directly into the conveyor belt and the primary sludge for burning in the biomass boiler was started. However, in 2018, problems with the efficiency of the sludge dewatering system began to impair the burning in the biomass boiler and the burning of primary sludge was stopped. In 2019, a procedure for drying the primary sludge in a greenhouse was adopted and sludge with a dry content of at least 30% was guaranteed for burning in the boiler. In parallel, the failure analysis was carried out to evaluate the occurrences of efficiency loss of the primary sludge dewatering system of the ETP and this analysis became a green belt project using the Lean Six Sigma methodology. Another application adopted in parallel for primary sludge was composting for the manufacture of organic fertilizer. However, this alternative was not prioritized because the stake composting process takes about 5 years.

The sand waste from the biomass boiler and the sand from the eucalyptus log washing process were destined until 2013 for the industrial landfill. Due to being inert waste, since 2014, both have been destined to fill the natural clay deposit next to the factory which was excavated and used for the construction of the new industrial landfill cell. Thus, these residues began being considered recyclable.

The burnt lime generated during the crusher breaks was another waste destined for the industrial landfill until 2017. Since then, a procedure for breaking lime stones using the front loader has been established and then this type of burnt lime (CaO) is returned to causticizing, eliminating the generation of this residue.

The burnt lime generated during the re-startup of the lime kiln and the cleaning of the kiln during the general shut down maintenance of the pulp mill was sent to the industrial landfill by 2019. Since then, a procedure has been adopted to carry out the safe slaking of lime in a yard covered with dregs and grits on top of a depleted landfill area. Subsequently, the slaked lime (CaOH) is then sent to the IWTC for the manufacture of soil acidity corrective.

The clay residue from the water treatment plant (WTP) was buried in the landfill until 2015. Since then, this residue has been used to waterproof the part of the depleted cell of the landfill. Thus, this action replaced the need for the use of clay from the natural deposit for waterproofing the landfill and the clay residue became a recyclable waste.

And finally, the sand residues from the brown stock process, which are impregnated with black liquor, were buried in the landfill until July 2020. As of August 2020, they have been used to cover the organic residue of the restaurant within the new industrial landfill cell. Thus, this action replaced the need to use sand from natural deposits to cover this organic residue and the sand residue became a recyclable waste.

RESULTS AND DISCUSSION

For the calculation of industrial waste recycling indicators and specific generation of industrial waste, the following premises were adopted:

1. Only waste generated in the pulp manufacturing process.
2. Waste is all that is sent for recycling or to the industrial landfill.
3. The amounts of waste reused in the pulp manufacturing process as raw material or as an energy resource are not included in the calculation as waste.
4. Consider waste figures on dry basis and by weight.
5. Temporary stocks of lime mud reused later in the lime kiln are excluded from the calculation of waste.
6. The monthly amount of primary sludge burnt in the biomass boiler are excluded from the monthly generation of primary sludge waste.

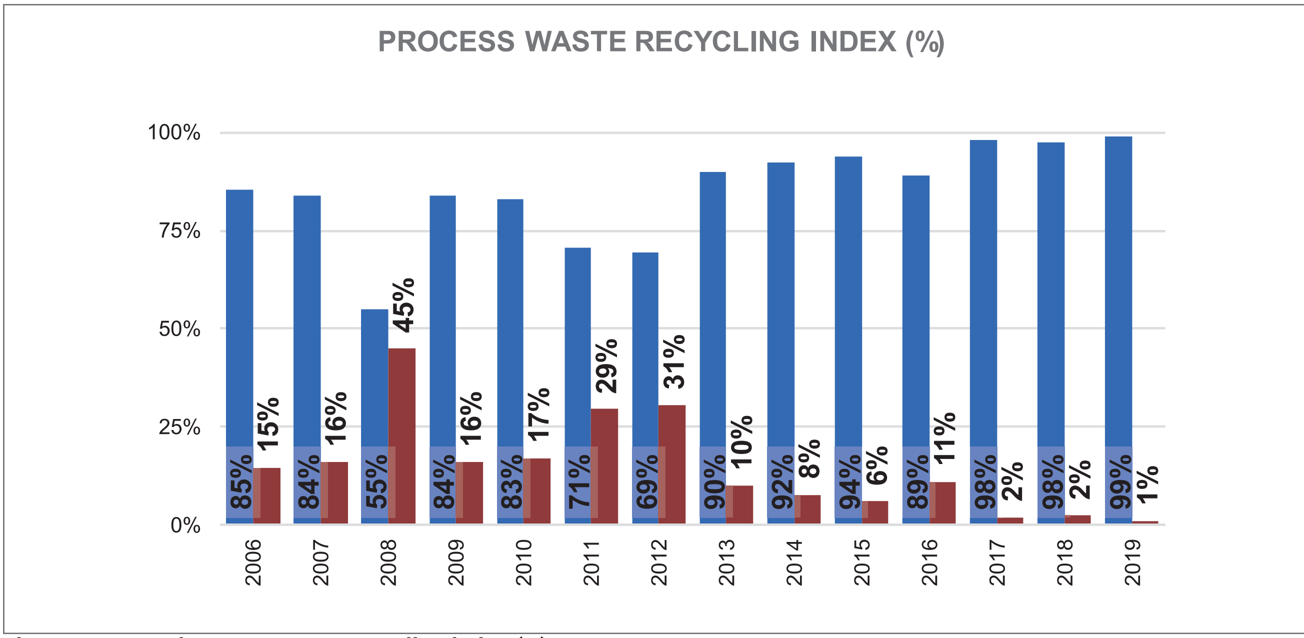

Figure 2 - Annual process waste recycling index (%)

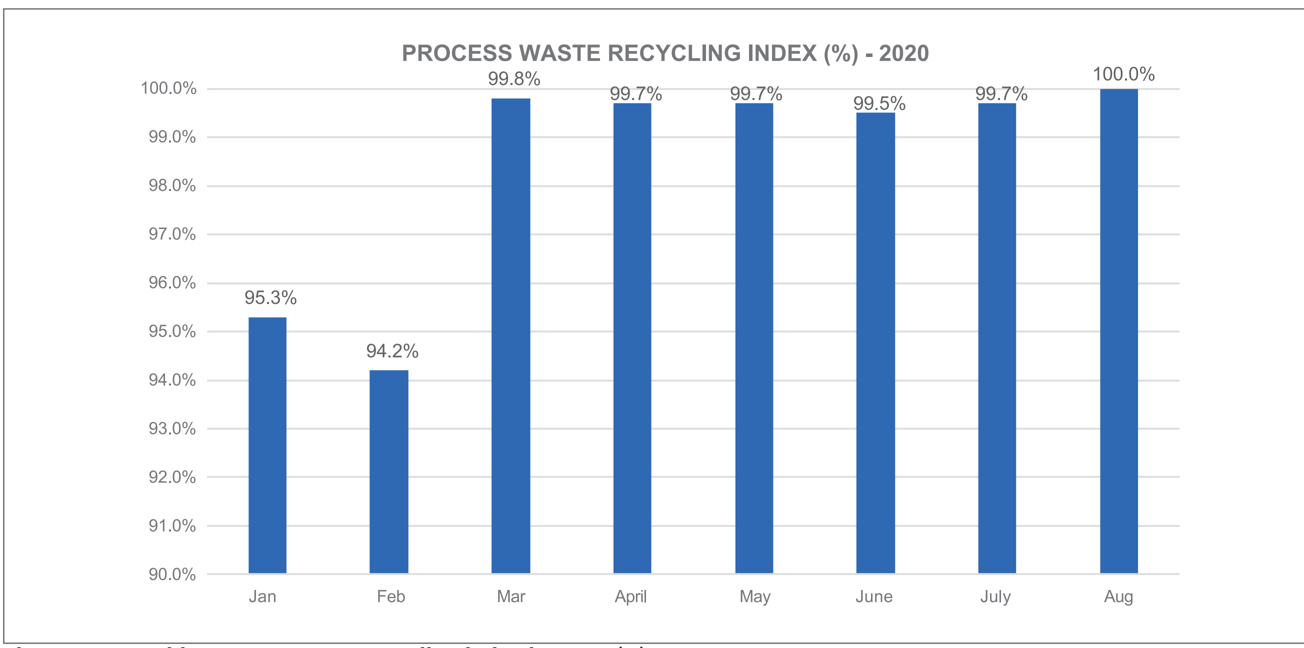

Figure 3 - Monthly process waste recycling index in 2020 (%)

Figures 1 and 2 show the history of the industrial waste recycling indicator.

It is observed that the changes made in the management of solid waste implemented since 2012 provided the increase in recycling rates from about 70% in 2012 to 99% in 2019. It is important to note that since March 2020 the recycling rate became 99.7% and in August 2020 the recycling rate reached 100%, as shown in Figures 2 and 3.

The process waste generation index shows that from 2015 the company reached a new level in the specific annual generation of waste, that is, since then this generation has been significantly reduced, as shown in figure 4.

The soil acidity corrective was manufactured from the addition and mixture of the waste: dregs and grits, fly ash from the biomass boiler and lime mud. Since 2015 all lime mud generated and in stock in the waste plant yard began to be returned to the lime kiln, with the aim of replacing 100% of lime purchased from the market. Since then, the manufacture of soil acidity corrective has been done without the addition of lime mud.

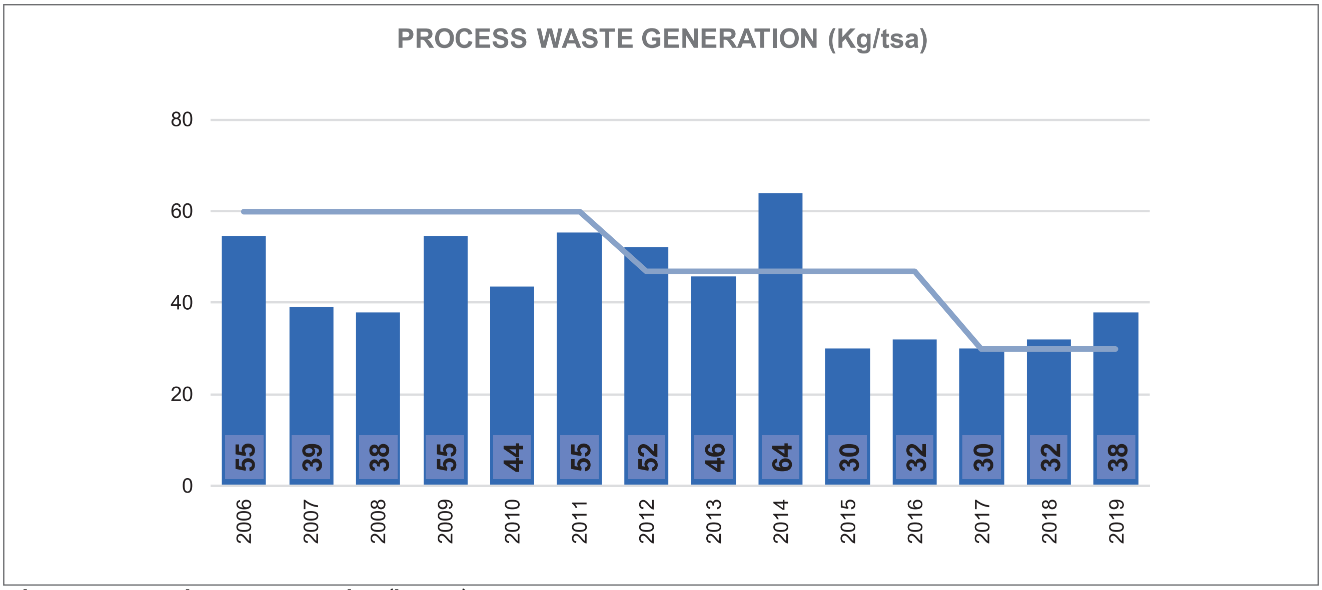

Figure 4 - Annual waste generation (kg/tsa)

Table 1 - Mass balance of limestone waste in IWTC

ANNUAL GENERATION OF LIMESTONE WASTE (T) X ANNUAL PRODUCTION OF SOIL ACIDITY CORRECTIVE (T)																
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
ENTRY	TOTAL ANNUAL GENERATION OF DREG AND GRITS	5917	11752	15712	17684	17657	14879	17928	29640	20926	21312	19467	16992	16743	16039	17613
	TOTAL ANNUAL GENERATION OF FLY ASH		2144	1831	793	1372	4553,448	2978,3184	3017,558328	2627,366616	3456,278568	2842,27	2850	3052	3458	2491
	TOTAL ANNUAL GENERATION OF LIME MUD	416	16126	3500	4336	15555	3972	12140	9422	17170	22802	0	0	0	0	0
OUTPUT	ANNUAL SELLS OF SOIL ACIDITY CORRECTIVE	283	2516	3241	6354	5327	2422	4019	3865	7427	9902	12141	13155	13554	8526	10382
	USE OF SOIL ACIDITY CORRECTIVE BY FOREST AREA	0	108	2666	5651	11199	9781	3636	22307	27500	22888	22845	27300	18900	14045	24920
	RESULT	6050	27398	15136	10808	18058	11201,448	25391,3184	15907,55833	5796,366616	14780,27857	-12676,73	-20613	-12659	-3074	-15198

Table 1 shows the mass balance with the entry of limestone waste into the IWTC and the output of this soil acidity corrective. It is observed that only from 2015 the corrective output became greater than the entry of waste in the IWTC. Since then, stocks of limestone waste in the IWTC have begun to drop significantly.

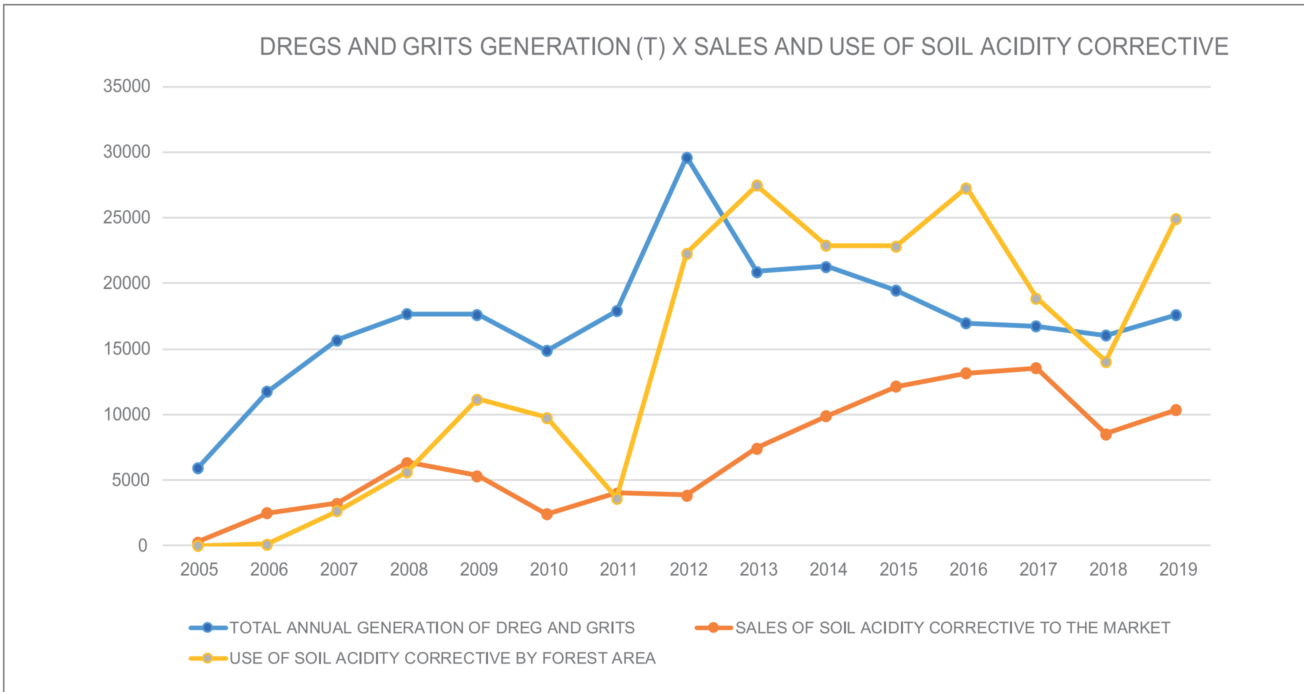

Figure 5 – Comparison among dregs and grits generation, sales and use of soil acidity corrective

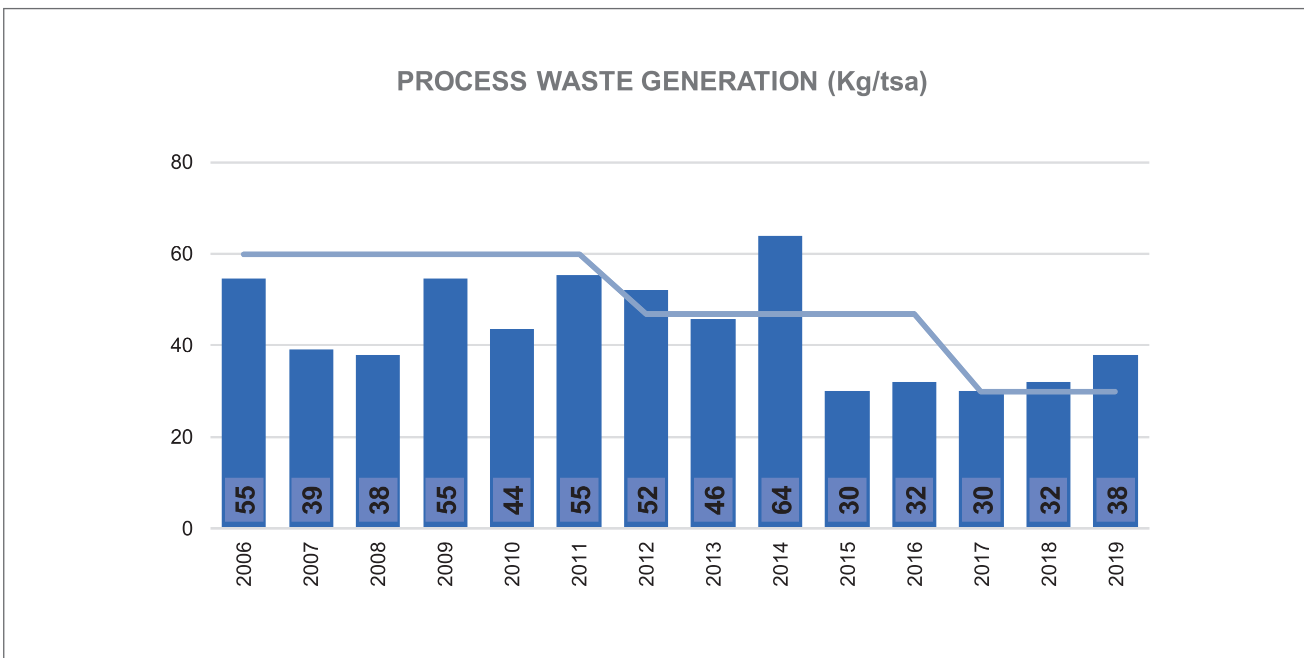

Figure 6 – Comparison between total generation of dregs and grits and amount of dregs and grits sent to the landfill

Figure 5 compares the annual generation of dregs and grits versus the sale of soil acidity corrective to the market and with the use of Vida's corrective by the forest area. This data highlights that, until 2012, only the generation of dregs and grits was greater than the sum of sales and the use of soil acidity corrective.

Figure 6 compares the total generation of dregs and grits versus the quantity of dregs and grits destined for the industrial landfill. It is observed that in 2008, 2009, 2011 and 2012 significant amounts of dregs and grits were allocated to the industrial landfill.

Figure 7 shows the projection of the useful life of the industrial landfill carried out in 2012, indicating that if the destination of dregs and grits continued being sent to the industrial landfill, by October 2012 the landfill would be exhausted. On the other hand, if this destination were to be discontinued in March

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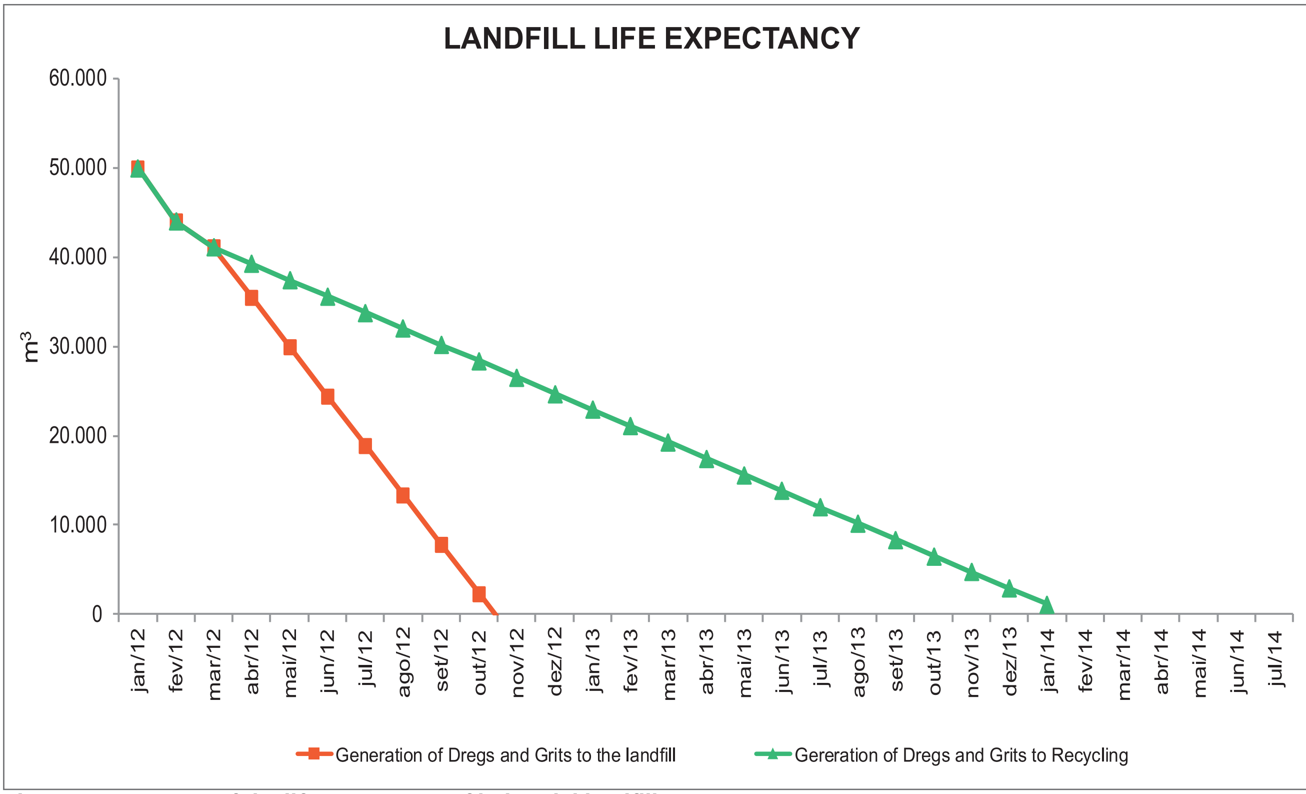

Figure 7 – Forecast of the life expectancy of industrial landfill

2012 the life expectancy of the landfill would be postponed to January 2014 and this change would give the time needed to build a new industrial landfill cell.

CONCLUSIONS

The results achieved by the changes implemented in Veracel's solid waste management in 2012 prevented the life of the industrial landfill cell being exhausted in October 2012.

These results were so extraordinary that the new industrial landfill cell only started to be used in August 2020. That is, the life expectancy of the previous landfill cell increased twofold.

It is worthy to note that the only industrial residue destined for industrial landfill in July 2020 was the sand residues of brown stock pulp purification. As of August 2020, this sand residue began to be used in the coverage of organic waste from the restaurant, eliminating the need to use sand from a natural deposit for this purpose. That was the first time that the recycling rate reached 100%.

However, eventually, some waste can be destined to the landfill as a result of sporadic events, related to some disturbance in the process, such as: dregs and grits containing more than 5% of sodium, pulp screening waste containing contaminants such as plastic, rubber, metal or other types of dirt and waste from the cleaning of pulp mill tanks.

Currently, the annual generation of limestone waste at Veracel's plant is in balance with the need to use soil acidity corrective in 1/7 of the company's eucalyptus plantations. In other words, 100% of the soil correction used in the forest area is supplied by the agricultural products unit at the Veracel mill.

And that's how Veracel reached the milestone of "zero process waste destined for landfill". Good waste management will continue to be important to maintain waste recycling index at this level. ■

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