

## ST09 - Solid Waste Masterplan: A New Approach for the Circular Economy in Alunorte Alumina Refinery

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### Abstract

The alumina industry has a great challenge: the waste generated in the Bayer process and support areas. Several efforts have been made to find a more sustainable destination for the bauxite residue and the same approach is necessary for other types of waste. The method proposed here includes a more holistic view of waste management in order to advance the circular economy and the state of the art for waste destination related to process and support areas. At Hydro's alumina refinery Alunorte in Barcarena (Brazil), a multidisciplinary analysis involving a team composed of environmental, technical, and operational specialists identified process improvements to avoid waste generation and new potential routes for reinsertion in order to reduce the incineration and disposition of waste in landfills. New key performance indicators (KPIs) were also established and reported to support the corporate goals and strategy. The main results were new potential alternative destinations for other operational residues currently landfilled (beside bauxite residue), reduction of wasted lime, reinsertion of all hydrate out of specification, and development of markets for buying residue as a by-product.

**Keywords:** Circular Economy, Waste, Masterplan, Sustainability.

### 1. Introduction

Pursuing an environmental agenda is relevant in various contexts, particularly in the industrial sector. The industrial sector is constantly concerned with ensuring best practices. This paper discusses the case of Hydro's alumina refinery of Alunorte, in Barcarena (Brazil).

The development of a Solid Waste Master Plan aims to map the generation of waste in the refinery and based on that, to outline strategies to enable more sustainable alternatives for the disposal of waste sent to the Solid Waste Deposits (DRS) in the short, medium, and long term, so that the lifespan of the deposits can be extended.

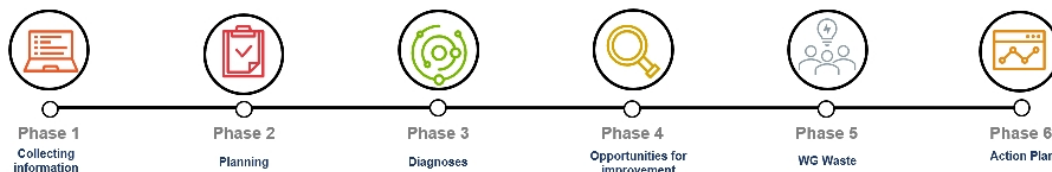
The Master Plan tool should seek to reorganize the space in question or create a new expansion front without causing drastic changes in the existing context. In this regard, it is necessary to identify improvement opportunities and prioritize them, in order to define a set of activities that will ensure sustainable waste management.

Furthermore, it is worth noting that the proposed actions must be aligned with the objectives of the Brazilian National Solid Waste Policy (PNRS), Law No. 12,305/2010 [1], which as its main purpose aims to give waste the most appropriate final destination, according to its characteristics.

Usually, the standards for waste management are defined by the environmental team, while reduction targets are set in the operational area. The present article proposes a new approach for an integrated management and an optimum synergy across areas for a more sustainable solid waste masterplan.

## 2. New Methodology

The Solid Waste Master Plan (SWMP) has 6 phases (Figure 1). It begins with gathering information. The team responsible for conducting the activities collect and analyses all the available information regarding waste, for example: inventories, classification reports, Environmental aspect and impacts spreadsheet, procedures, and technical documents.



**Figure 1. SWMP deployment phases.**

Phase 1 consists also in a literature review tracking the best practices and mapping alternative destinations for each residue that are potentially more sustainable. The concept is to bring the academical knowledge closer to the operational team.

Phase 2 is the planning. A preliminary list of waste is made and will be the guide for the following phases and the fieldwork. The leadership of each operational area is engaged in the work and indicates the specialist to participate together with the technical and environmental teams. The chronogram and agenda are scheduled with a view to covering the whole refinery.

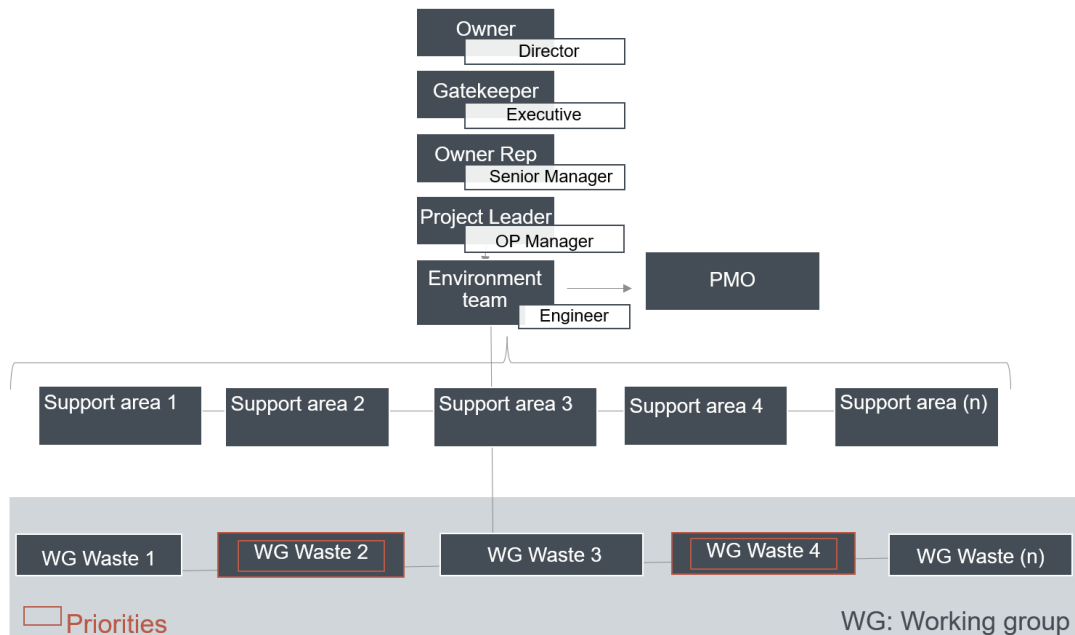
Phase 3 is the diagnoses. The meetings will take approximately 5 days per area. The operational area starts to present its process, with the focus to highlight any potential waste generation. The team describes each category of waste from cradle to grave. The Project Management Office (PMO) will highlight the synergies across the operation.

After the technical discussion, there is the fieldwork. Each type of waste should be checked in locus to confirm what has been discussed in the meetings and analysed from all perspectives, for example: the environmental aspects, how to avoid waste generation, any potential technical improvement, and the feasibility of the previously mapped potential of new destinations. After fieldwork, a wrap-up meeting is scheduled to consolidate and validate all the information and analyses made.

Phase 4 is the critical analysis of what has been identified in terms of potential improvements in waste management in the operational areas. This will form the base to gather all the expertise

necessary to address the issues. For example, it can be decided which employees from the operational areas should be involved, or whether there is a need for an external consultant to join the working group.

Phase 5 is the establishment of a working group for each type of waste to highlight the main priorities for the company. The SWMP will be structured to support the Factory to achieve the waste strategic goals and report to the head through the management team. An organizational chart is proposed in Figure 2.



**Figure 2. Example of organizational chart for reporting the achievements.**

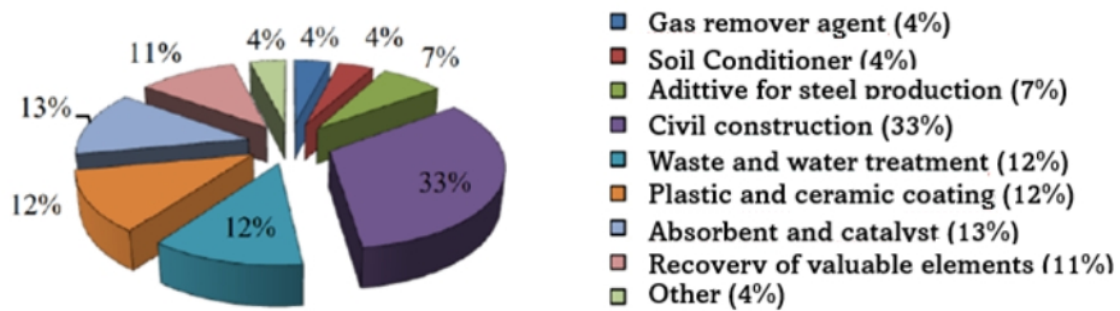
In Phase 6, the working groups will detail the issues and consolidate an action plan for each type of waste. The improvements are guided by the 3R (Reduce-Reuse-Recycle). The top priority is Reduce, which is to reduce waste generation, then reuse, and then Recycle, to give waste material a second chance before disposing them to the landfill.

The action plan will comprise a short-, medium- and long-term perspective. The head and the management validate the action plans and follow-up meetings are held once a month.

### 3. Results and Discussion

#### 3.1 Literature Review

In the literature, various applications of bauxite residue (red mud) reuse/recycling can be found, such as the recovery of valuable metals, preparation of construction materials, and its use as an alternative catalyst for various processes, including hydrochlorination, hydrogenation, and hydrocarbon oxidation. In addition to these options, the possibility of using this type of residue in wastewater treatment, soil remediation, and flue gas purification is highlighted. The distribution of patents granted between 1964 and 2008 [2] related to bauxite residue applications is shown in Figure 3, where it can be observed that the civil and building construction sector was leading the list, with 33 % of the total developed techniques. This was followed by the use of bauxite residue as an adsorbent or catalyst, accounting for 13 %.



**Figure 3. Patents granted worldwide between 1964 and 2008 related to red mud applications. Source: Shinomiya (2015).**

Khairul et al. [3] stated that the use of bauxite residue for the production of construction materials, including cement and bricks, is an area with considerable potential for the elimination or minimization of problems associated with the massive disposal of this type of waste. Thus, the following alternatives for such applications, as well as applications for soil remediation, are presented.

Besides the bauxite residue, there are a lot of articles about the use of ashes, in general, in the production of Portland cement, which began around 1970 in some European countries. In Brazil, the first industrial application occurred in 1969 at S.A. Ind. Reunidas Matarazzo [4].

According to Montini [4], all the content of fly/light ashes produced at the alumina refinery in São Luís, Maranhão (Brazil) is sold to a cement factory due to its high carbon content, approximately 50 %. Meanwhile, the heavy ashes are deposited in landfills. Considerable efforts have been made in research aiming to develop technologies for the reuse of fly ashes, also known as coal fly ash (CFA), resulting from coal combustion, such as in the production of cement, concrete, zeolites, vitreous ceramics, adsorbents for flue gas cleaning, lightweight aggregates, road sub-bases, and clay bricks [5,6,7,8]

Another promising application for bulk ground ashes is their use in agriculture as a nitrogen source for plant cultivation [9]. Bottom ashes, whether in their raw or treated state, can also be used for snow and ice control in road construction [10]. They can also be applied as granules for roofs or as grit for sandblasting. Finer bottom ashes, with particle sizes similar to silt and clay, can be added to porcelain and ceramics to create textures and colors [11].

Horckmans et al. [12] indicated that spent refractories have been widely used in recycling applications, such as roadbed aggregates [13] and slag conditioners in the steel industry [14,15].

Basic bricks, such as dolomite and magnesia, are commonly used as slag formers or conditioners in metallurgical processes [13]. Traditionally, metallurgical lime and dolomite are added to increase the MgO saturation of slag in Electric Arc Furnaces (EAF) to reduce refractory attack. The substitution of dolomitic lime with spent MgO-C refractory has been shown to increase MgO in the slag and extend refractory life [15,16], provided that the appropriate dosage is carefully determined. The recycling practice of spent MgO-C refractories in EAF has been tested and implemented industrially and is now considered a recommended metallurgical practice [15,16].

The literature review identified many articles related to bauxite residue, fly ash and refractory. Most of the literature reviewed analysed and evaluated potential new destinations based on reusing. Otherwise, the priority should be the reduction of waste generation.

### 3.2 Working Groups

Due to heavy rain and high humidity at Alunorte's location, lime and limestone may get a gravelled granulometry, which compromises its use in operations. The working groups developed a crushing process to make these material useful again. The lime group also identified the opportunity to set a better position for the lime slaking pump. These two improvements were responsible for net zero limestone waste generation and a reduction of 58.6 % in wasted lime.

Two other residues were identified as recoverable in-house. The Bayer process may recover these residues and reprocess them. The material previously landfilled is now reinserted in the digestion process. More than 14.000 m<sup>3</sup> has been already reprocessed.

Two other types of landfilled waste were identified as salable. The region has already a market for them to be used as raw materials in other industries. The commercial team is involved in boosting the negotiations in order to guarantee the sale of the total amount.

The Bayer process also has an intense use of filter fabric. It would be very important to have a working group for this area. The operational area follows up on the performance and timely replacement of filter fabric. Increasing performance in this area has a great potential to reduce filter fabric waste. It is very important to engage the suppliers, in assessing the possibility to improve the lifespan of these materials and/or to reverse the logistics.

### 3.3 Hydrate Reinsertion (Practical Example)

One of the main recoverable types of wastes in the Bayer process is hydrate. It may be generated in the cleaning of conveyor belts and tanks. This material has a high aluminium content and can be recovered in the digestion process.

A working group has been established to recover all the hydrate waste generated at Alunorte. The hydrate collected in the operational area is transported to the deposits and stocked in piles. It may come in different granulometry, and one of the main problems is that it often occurs as big blocks (Figure 4).



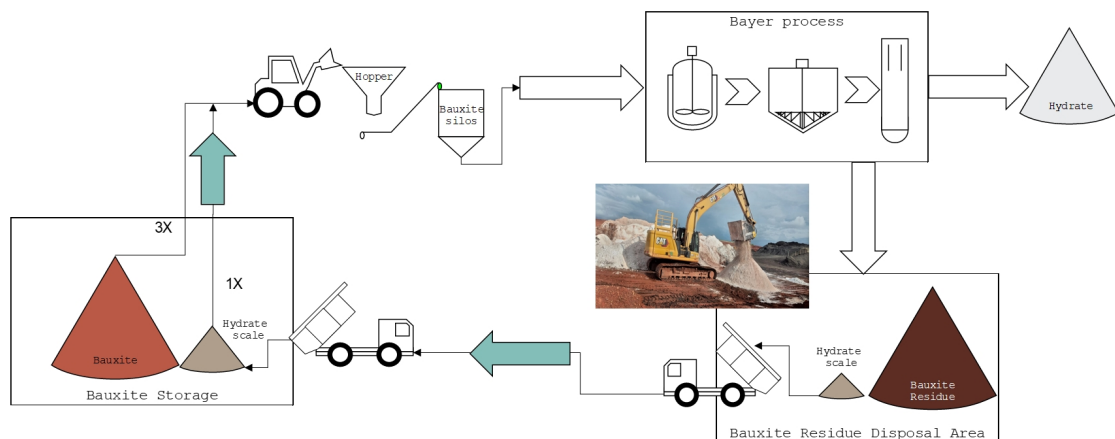
**Figure 4. Big block of hydrate in a storage pile.**

These big blocks are not only a problem for the process itself, but also a safety issue. They may clog the pipes and stop lines, or obstruct conveyor belts. They could also easily fall, causing high risks of incidents. The team identified the need for a crusher that can be attached to a bulldozer in order to eliminate these risks (Figure 5).



**Figure 5. Crushing all the hydrate to homogenize the granulometry.**

The crushing process eliminated the risks both from the operational and the Health, Safety and Environment perspective. The place for reinserting the hydrate was the hopper already in operation for bauxite. It allowed for the reinsertion of all hydrate waste generated and improved the process efficiency. The flow chart for the hydrate reinsertion is shown in Figure 6.



**Figure 6. Flow chart for the hydrate reinsertion.**

### 3.4 New KPI

It is always important to set a parameter to evaluate the progress of improvements and action plans. The Solid Waste Master Plan proposes a new KPI (Key Process Indicators) based on the total amount of landfilled waste per production as shown in Equation (1)

$$KPI = \frac{\Delta Q_{\text{landfilled waste}} (kg)}{\Delta Q_{\text{production}} (\text{tonnes})} \quad (1)$$

Where:

$\Delta Q$  landfilled waste: Total amount of landfilled waste.

$\Delta Q$  production: Total hydrate production

The new KPI helps to track which areas are performing better and which ones may need special attention to overcome challenges.

## 4. Conclusion

Alumina refineries all over the world have been engaging in activities that make alumina production landfill-free in the future, and it all starts with processes that we are already implementing today. The Solid Waste Master Plan has the potential to gather completely different departments across the company, from the more operational to the board, around the same goal. It is a fundamental tool for consolidating a robust roadmap for efficient waste management.

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