# BR01 - Evaluation of Bauxite Residue Rehabilitation Strategy: One Year Monitoring Assessment

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**Abstract**

The Bauxite Residue Disposal Area (BRDA) of Hydro Alunorte refinery has received residue since beginning of its operation in 1995 and current total area is approximately 270ha. Annually, the refinery produces over than one million cubic meters of bauxite residue. Following global best practices, Hydro Alunorte has invested in press filtration of the residue since 2016, a novel technology ensuring safer disposal. Furthermore, the company started in 2018 the rehabilitation of BRDA in order to reduce dust generation, wastewater and other environmental risks usually associated with bauxite residue. BRDA Closure project was developed for Hydro Alunorte to be implemented in annual strips of rehabilitation within 15 years, including construction of experimental sites in order to evaluate suitable alternatives of cover layers and capping over the residue. The present work was undertaken to evaluate the success of rehabilitation conducted on eight sites of 1500 m² within Bauxite Residue Disposal Area at Alunorte – Alumínio Norte do Brasil S/A refinery. This was achieved by monitoring natural regeneration, plant mortality, wastewater quality of runoff and underdrainage by lysimeters. All sites were revegetated in April 2019 which received different covers and capping alternatives. Wastewater quality was bimonthly assessed for main metals present in bauxite residue besides pH. Plant mortality and natural regeneration was assessed semiannually by in situ plant identification. Soil samples were collected form 20 cm composite sampling and analyzed for main metals. Plant mortality were lower in treatments that received permeable caps (1A and 1B) followed by in situ remediation (3A) with gypsum and soil without capping. Natural introduction of new species was also higher in treatments with permeable caps and in situ remediation (areas 1A, 1B and 3A). More tests applying is situ remediation strategy is recommended to evaluate long term efficiency.

**Keywords**: Bauxite rehabilitation, Hydro Alunorte.

## 1. Introduction

Hydro Alunorte is one of the biggest refineries in the world and is estimated that more than 50 million meters cubic is deposited at its Bauxite Residue Disposal Area – BRDA. Since 1995 Hydro Alunorte BRDA has storage residues at BRDA and current total area is approximately 270 ha. Management and remediation of bauxite residue is considered the major challenge for the alumina industry in terms of environmental and social as aspects. Following global best practices, Hydro Alunorte has invested in press filtration of the residue since 2016, a novel technology ensuring safer disposal. Furthermore, the company started in 2018 the rehabilitation of BRDA in order to reduce dust generation, wastewater and other environmental risks usually associated with bauxite residue. BRDA Closure project was developed for Hydro Alunorte to be implemented in annual strips of rehabilitation within 15 years, including construction of experimental sites in order to evaluate suitable alternatives of cover layers and capping over the residue. The closure of BRDA has historically received installation of a cap or cover system below the soil layers for plant growth in order to isolate the underlying bauxite residue from further rainfall generating contaminated leachate. Cover system is made by high density polyethylene, which prevents rainwater infiltration to bauxite residue layers. This impermeabilization consequently avoid water moving upwards with high pH and high alkalinity reaching the roots zone [1]. Capping of bauxite residue ensures that the soil is not contaminated maintaining soil quality thereby plant growth. Some authors have affirmed that cap and cover system do not provide "walk-away" solution for bauxite residue closures, as the geochemical and physical properties remains unchanged [1]. Several work applying in situ remediation in bauxite residue has carried the last decades [2,3,4], however there is not a consensus regarding the methodology. Therefore, despite disagreement in its use, capping system is still considered the safest and fastest method for vegetation cover and environmental impacts mitigation.

To date, two main approaches are employed for tailing management: "cap and store" or "in situ remediation" At in situ remediation, amendments (organic or inorganic) are added to bauxite residue expecting changes in its key physical and chemical properties towards to natural conditions providing a substrate able to sustain vegetation growth. Currently, application of gypsum combined with organic amendments are the most usual remediation approach [5], also microbial application as bioremediation strategy was studied [2]. In both cases results has been successful decreasing pH, salinity and sodicity, decreasing bulk density and increasing aggregation. Application of *in situ* remediation in BRDA closure is only possible when amendments are highly available, low cost and easily accessible, otherwise the closure project might become more expensive than when capping system is applied [6]. In contrast, cap and storage methodology isolate the residue by high density polyethylene liners or impervious layers at the top (eg. compacted clay) followed by soil layers with drainage system at the base to collect and transport the leached. Liners avoid rainfall to reach bauxite residue minimizing the possibilities of contaminated leached (high pH, high salinity and high dissolved metals concentrations) impact surrounding areas. The result of total insulation of the residue is that the leached has contact only with soil layers generating leached within the limits of environmental legislation. Also, installation cost of rehabilitation methodology is an important factor that must be considered. Generally, capping the residue increase the cost of rehabilitation compared to in situ remediation due to costs of liners and following layers and drainage system. However, if amendments are costly due to transport or difficulties to be obtained in situ remediation may become as expensive as capping and store method.

Reduce environmental risk of bauxite residue by addressing high alkalinity and salinity of dust and leached are the major challenges of tailings closure projects. Permeable caps have been demonstrated positive effects on vegetation establishment in bauxite residue [6]. However, few works have demonstrate the effects of total and partial insulation of bauxite residue in leached and vegetation growth to date. Effects on vegetation and leached will depend on capping insulation capacity and compaction of over layers. For example, high density polyethylene liners isolate completely the bauxite residue whereas geotextile isolate partially permitting infiltration of rainfall.

The present work was undertaken to evaluate the success of rehabilitation conducted on eight sites of 1500m² within Bauxite Residue Disposal Area at Alunorte – Alumínio Norte do Brasil S/A refinery. This was achieved by monitoring natural regeneration, plant mortality, wastewater quality of runoff and underdrainage by lysimeters. All sites were revegetated in April 2019 which received different capping alternatives and amendments. Wastewater quality was bimonthly assessed for main trace elements present in bauxite residue besides pH and Electrical Conductivity. Plant mortality and natural regeneration was assessed semiannually by in situ plant identification. Geotechnical data from piezometers were investigated bimonthly in order to assess

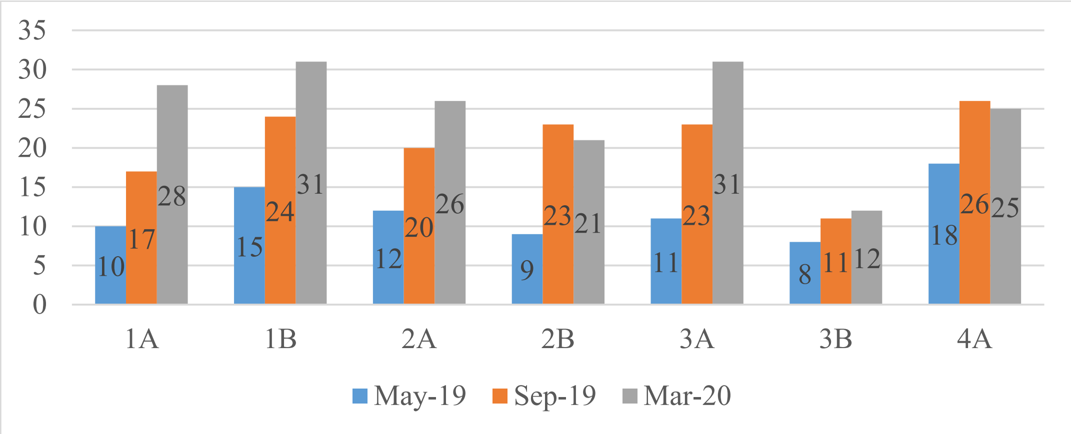


**Figure 8. Number of new species introduced naturally in 8 treatments within DRS1 disposal area. Area 4B did not have any introduction of new species.**

## 4. Conclusions

The current work was undertaken in 8 treatments with 1500 m², during 12 months of monitoring. It is important to note that this work does not provide results with statistical analysis, therefore there are no replication that support conclusions and recommendations. Nonetheless, the results seen on the field give us important inputs for the future rehabilitation which are listed below:

- Impermeable cap affected negatively plant development compared to permeable cap;
- Area 3A (in situ remediation) had better plant development compared to 2A and 2B (impermeable cap);
- Concentration of Sodium (Na), Aluminum (Al) and Iron (Fe) seems to affect plant development and natural regeneration in areas 3B and 4A;
- Layers permeability may have affected metal concentration in underdrainage effluent

In order to confirm these results, plant development at the first rehabilitation strip, where 7ha was rehabilitated applying impermeable cap (same as area 2B), will be followed up. If the low plant development is confirmed permeable cap may be applied in following strips of rehabilitation. In addition, one more test field of 1500 m² will be added to investigate in situ remediation with different amendments materials available in northern of Brazil.

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