A Water Resources Management System using the hydrologic potential of the tailings dam on iron ore mining

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Abstract This paper presents the water resources management system developed for an iron ore mining project using the potential of water regularization from the tailings dam simultaneously with its function to recycle the tailings water. The study considered the assessment of the present and future water demands of the project and all the potential watercourses that could be used for water abstractions. After the study, the optimal alternative could be verified using the hydrologic potential of the tailings dam to get less water abstractions from other sources and take some economic advantages in terms of implementation and operational costs.

Key Words Tailings dam, water resources management system, iron ore mine, water supply

Introduction

The Amapá mining project from Anglo American has expected production of 6.5Mt of iron ore in the amazonic region of Brazil. Currently it is under ramp-up phase with production growing gradually. The water resources management in the amazonic region has important aspects to be assessed due to its hydrologic regime, the abundance of water and the absence of other concurrent water users in some areas. So, for the present study, the potential of use of the reservoir of the tailings dam could be assessed with the objective to verify the possibility to optimize the water resources use and reduce costs of implementation and pumping.

While a mine is operational the act of mining itself can have a significant impact on the natural environment. This is because mining activities inevitably disrupt preexisting hydrological pathways (Younger and Wolkersdorfer 2004). In the specific case of the use of water from the tailings dam, it is important to evaluate the quality of its Waters, to verify the possibility of use. In some mining projects, as in Ávila et al (2008), mine wastes that contain sulphide concentrations are notorious for their potential of acid mine drainage and leaching of contaminants during and after mining, often resulting in pollution of waters, stream sediments and soils. This is not the case of iron ore mining projects, what could allow the use of the water from the tailings dam. Mudd (2008) also highlights that a major strategic issue for all sectors of the global mining industry is the use and management of water resources.

Methods

The development of the water management system for the Amapá Project followed some methodological steps, aiming the main aim of guaranteeing its water supply, evaluating the hydrologic potential of the tailings dam. In this sense, the study consisted on these steps:

1. Diagnostic and the characterization of the Project water resources uses and the region technical characteristics;
2. Assessment of the growth projection of the Project water demands;
3. Assessment of the potential use of the tailings dam reservoir;
4. Characterization of the water availabilities of the main watercourses in the region and evaluation of the alternative sources for the supply of the project;
5. Development of the indicators for the choice of the best sources for the supply;
6. Development of the management system.

Considering that all the studies were done for a mining project still during ramp up phase, some information was already available due to the monitoring facilities. Anyway, some of the nec-

essary information still needed diagnostic studies and the water resources characterization from the basin. Among the presented steps, it is important to highlight the assessment of the potential use for the tailings dam reservoir. This aspect corresponds to the main innovation of the present study once usually these reservoirs are only used with the aim of recycling the water contained on the tailings. In the present study, the hydrologic potential of the reservoir was also studied. After the study in terms of quantity aspects, its quality till now was also evaluated, also to define its potential to use.

Results

This chapter presents a synthesis of the obtained results, considering the methodological steps of the study. During the first phase of the study, all the water uses of the project were evaluated, taking into account the beneficiation plant process requirements, mine and road watering (dust allaying), the irrigation of the seedling nursery, the drilling operations and water services. The water services consider the human consumption of the offices, refectory and labs.

The use for road watering (dust allaying) is executed using a run-of-river abstraction from a small surface watercourse named "igarapé Jornal", with the maximum daily water demand of about 100 m^3. The "igarapé Mario Cruz" is used for mine watering and the maximum daily volume used corresponds to 300m^3. It is noteworthy that the uses for mine and road watering demand greater water volumes during the dry season, that occurs between august and december. Thus, the maximum daily volume of used water equals 400m^3 which indicates the average flow abstraction of 17m^3/h.

The beneficiation plant process water requirement was estimated based on its water balance, flowchart and also the balance of the reservoir, considering the water volume contained on the tailings and the total recycled water. With this information, the average daily necessity was estimated on 400m^3/h, which is equal to a daily volume of 9,600m^3. The total water demands for the other water uses equals 100m^3 per day, which means an average abstraction of 4m^3/h.

After obtaining all the water demands for each use, it could be possible to define the total demands for the supply of the project, which consists on the daily value of 10.100m^3 or an average flow of 420m^3/h from various sources. The beneficiation plant process water requirements correspond to 95% of this value. The figure 1 presents the project location and its main facilities.

After the calculation of all the water demands at the first phase, the study continued with the estimation of growth projection of the Project, considering the expansion of the mining production. The actual beneficiation plant process requires a consumption index of about 1m^3 of water per tone of produced iron ore. In this sense, considering that the expected production is of about 6.5 Mt of iron ore, the estimated water demands for the beneficiation plant is of about 6.5Mm^3,

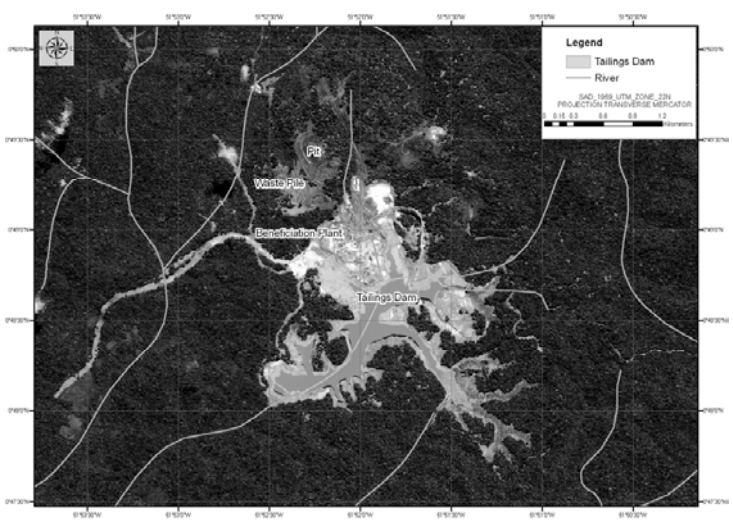

Figure 1 *Project location and its main structures*

which means an average flow necessity of 800m³/h, in function of the operation hours of the project per year. Maintaining the number of 95% of the total water used for the process, it is possible to estimate the total demand for make-up water of 840m³/h at the moment when the mine will achieve its project production of 6.5Mt per year.

At the next step, the studies consisted on the potential use of the reservoir of the tailings dam. Therefore, initially the quality of the abstracted water from the reservoir was assessed. Considering the iron-ore process, this evaluation was based mainly on the parameters due to iron ore process: pH, concentration of dissolved iron and manganese and also suspended solids. The presented results of this evaluation were that the water from the reservoir is within the standards and may be used in all process activities. Then, the hydrological potential of regularization provided by the reservoir formed in the "igarapé Mario Cruz" was studied. The table 1 presents the summary of the results of the regularization curve of the reservoir, with the possible inflow of abstractions, based on its accumulated volume. The available volume of water in the reservoir corresponds to 1.3 Mm³, which means the possible abstraction of about 500m³/h.

Considering that the possible abstraction flow from the reservoir of the tailings dam equals to 500m³/h and the future water demand of the project is 840m³/h, it was necessary to define other sources for the water supply. In this sense, all the watercourses closer to the project and surrounding the pit were evaluated. The figure 2 presents the main assessed watercourses.

Based on the feasible alternatives for the water supply of the project, the next step consisted on the proposal of indicators that could be used for the choice of the best one to be implemented and to be used integrated to the reservoir of the tailings dam. The main proposed indicators and used in this analysis were: water availability of each abstraction point; cost of implementation of the alternative and extension of the pipeline, which considers the pumping costs. The table 2 presents the summary of the results of the indicators, which took to the final choice of the alternatives.

Table 1 *Hydrologic potential of the tailings dam reservoir*

Possible abstraction (m³/h)	% of the average long-term flows	Available volume (10^3 m³)
187	20	188.858
280	30	391.519
373	40	660.345
467	50	970.484
560	60	2.111.325
653	70	3.253.837

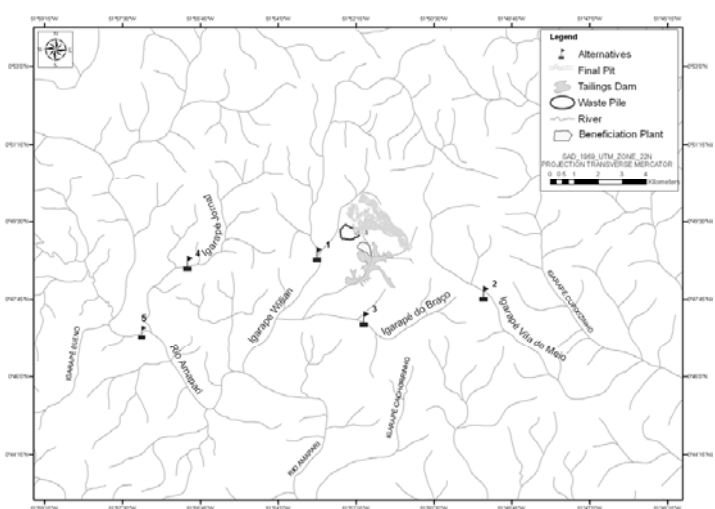

Figure 2 *Main assessed watercourses and the alternative sections*

Table 2 *Alternatives for water supply and the main indicators used on the choice*

Streamflow	Drainage Area (km^2)	Available inflow (m^3/h)*	Distance of the beneficiation plant	Distance of the reservoir of the tailings dam	Cost of implementation (ordinal)**
Igarapé Vila do Meio	**13.8**	**400**	**4 km**	**2 km**	**2**
Igarapé Willian	42.0	800	2 km	4 km	1
Igarapé do Braço	11.4	350	3 km	2 km	3
Igarapé Jornal	17.1	500	8 km	9 km	4
Amapari river	10,570	200.000	14 km	15 km	5

*Available inflow considers the legal environmental flows defined by state organisms for sustainability of aquatic life in this basin.

** Average costs of implementation were estimated as US$ 1.1 million per km of pipeline.

Despite the studied abstraction of the igarapé Willian have lower costs of deployment and pumping, and also great water availability, the quality of its waters was not adequate for the beneficiation plant and so its use was discarded. Besides, the necessary demands correspond only to the incremental flow of 340m^3/h, after the hydrological potential of the reservoir of the tailings dam. So, it could be attended by any of the assessed alternatives. Thus, the results of the study and application of indicators considered that the abstraction of the "igarapé Vila do Meio"could be the best one to be implemented. It is interesting to highlight that the initial idea of the company was to implement the abstraction structures and pipeline from the Amapari river, due to its huge flows, even if it would demand the implementation of a pipeline with the extension of 14 km. The technical studies identified the water availability from closer sources and with less costs of deployment and pumping, as the hydrologic potential of the tailings dam could be used.

Finally, based on the results of the previous steps, it could be developed the management system. This system evaluates, each month, the volume of the reservoir and, based on the recession curves of the watercourses, estimates the affluent flows at the next months. It is possible, then, to assess, for each month and for the dry season, the available flows. In this sense, the total abstracted volume from the alternative source in the "igarapé Vila do Meio" stream is minimized. Then, the results of the system can indicate the optimization of pumping costs and thus, the costs related to water resources.

Conclusions

The water resources management for the Amapá iron ore mining project had the initial aim of its water supply. However, with the analysis of the hydrologic potential of the reservoir of the tailings dam and the main streams surrounding the area, it was verified the possibility of optimization of the water supply, also with the development of a water management system. Thus, it was developed the system using the potential of the tailings dam, in order to reduce the volume abstracted from other farther sources. In this sense, it is important to highlight the innovative aspect of this study once this potential usually is not used. So, in other projects, maybe the costs of implementation and pumping for the water supply of the beneficiation plant could be optimized due to the potential of the tailings dam.

So, the main conclusion of this study is that the use of the hydrologic potential of the reservoir of the tailings dam could take to the reduction of costs for implementation of abstracting structures and pumping. Also, another conclusion is verified from the fact that the development of a water resources management system can ensure optimal supply to the demands for water from the mining venture throughout its lifetime. It is also important to highlight, finally, that the water management system could be studied for any other mining project and the use of the tailings dam can also be assessed in order to guarantee the optimal water supply of the project.

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