SUBJECT: Evaluation of the efficiency of Biocelerator at the Ribeirão Vermelho wastewater treatment plant

I – INTRODUCTION

The Ribeirão Vermelho wastewater treatment plant, which was designed by Holos Engenharia, began operating in February of 2010. It consists of a preliminary treatment sector (bar screens for the removal of solids, mechanical desander and Parshall flume), four UASB reactors, four anaerobic upflow filters, two maturation lagoons, twelve drying beds, a UV disinfection system and a waste gas burner (which is not operational). Due to the average influent rate of the plant, one of the reactors and the No. 4 filter are not operational.

Maturation lagoon No. 2, shown in Figure 1, had undergone extensive aggradation, and, in light of the difficulty of removing this sludge, COPASA and VEEGA Comércio Importação e Exportação Ltd signed a technical partnership with the aim of evaluating the performance of Biocelerator , a product which, according to its manufacturer, would improve the performance of the wastewater treatment plant with respect to BOD, COD, settleable solids (organic material) and scum formation, and eliminate the sludge/organic matter that had accumulated in the maturation lagoon.

Figure 1: View of maturation lagoon No. 2, depicting the degree of aggradation prior to the application of Biocelerator

Biocelerator began to be applied on 29/11/2016 at a rate of 10 litres/day, divided over two different times (morning and afternoon): 3 litres were applied at the preliminary treatment sector and 1 litre at the inlet of each lagoon. After 83 days of Biocelerator application, significant performance improvements were noted at the treatment plant, as described herein.

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II - PURPOSE

To evaluate the benefits of applying Biocelerator at the Ribeirão Vermelho wastewater treatment plant by demonstrating the performance improvements at the plant, not only with respect to mitigating the aggradation of maturation lagoon 2, but also in reducing the formation of scum at the reactors and curtailing the emanation of offensive odours.

III - DISCUSSION

Since it became operational in February 2010, the Ribeirão Vermelho wastewater treatment plant has been operated in accordance with the COPAM/CERH (Environmental Policy Council/State Water Resources Board) Joint Normative Resolution with respect to effluent quality standards. However, the following operational challenges emerged during this time period:

- The formation of scum in the reactors;
- The (probable) blockage of the filters;
- The aggradation of maturation lagoon No. 2;
- The release of characteristic offensive odours;
- The constant need to remove and discard the sludge from the reactors and filters; this sludge, once dewatered, is then removed from the drying beds.

With the aim of more precisely characterizing the aggradation of maturation lagoon No. 2 at the Ribeirão Vermelho plant, a bathymetry of the lagoon was completed on 07/11/2016 along two longitudinal sections and 10 transverse sections, as shown in Figures 2 and 3.

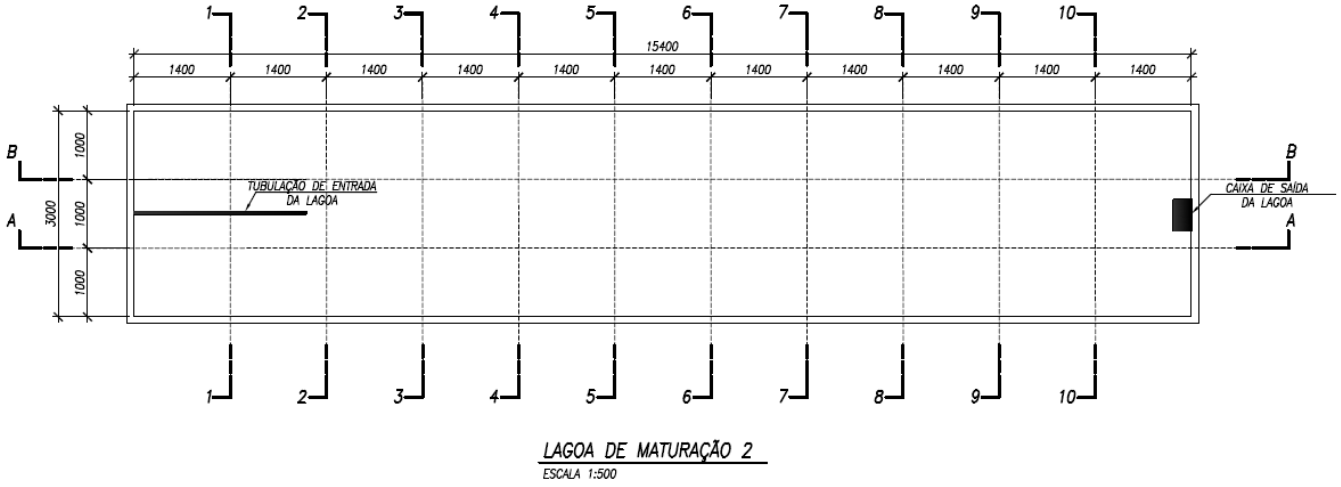

Figure 2: Maturation Lagoon 2 Bathymetry Sections and Measurements

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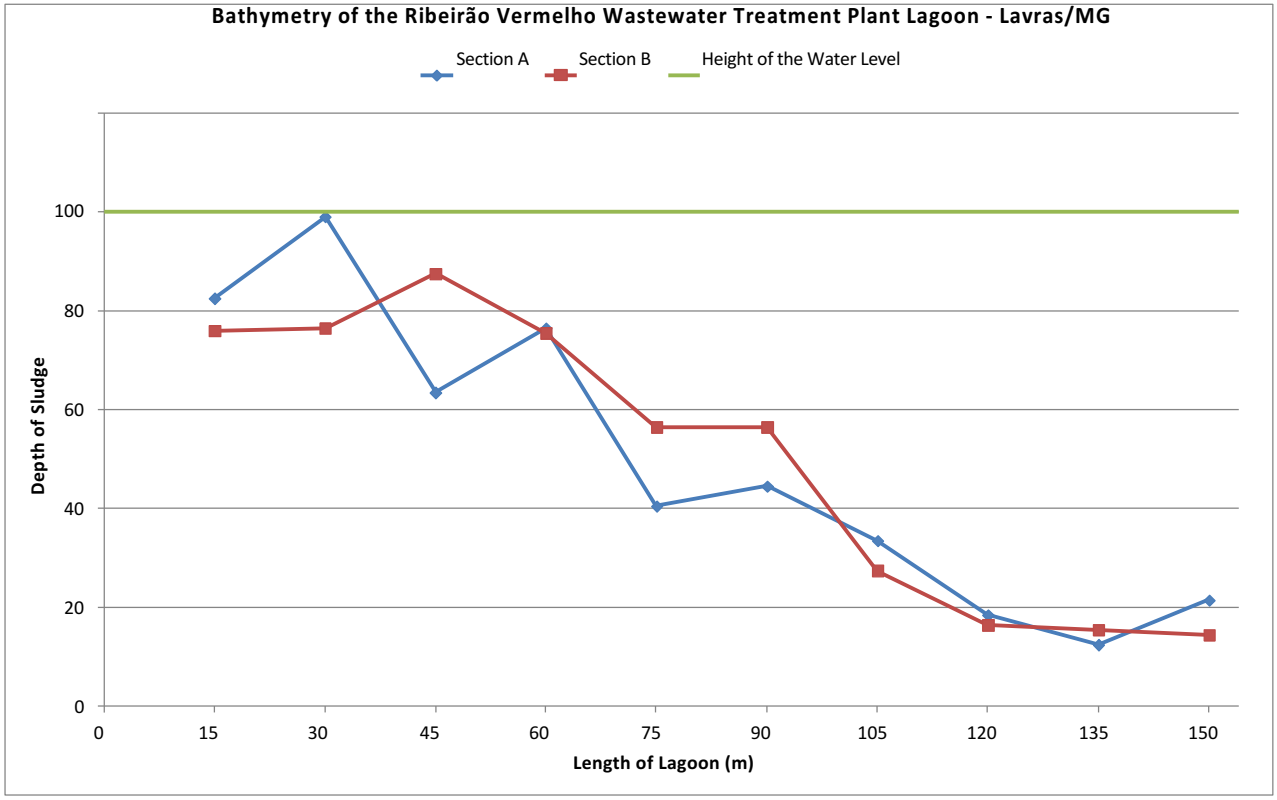

Figure 3: Cross-sections of the bathymetric measurements at maturation lagoon 2

The aggradation profile shows that approximately 58.8% of the useful volume of the lagoon had undergone aggradation, as shown below:

- Taking longitudinal cross-section B as a point of reference, and adding a trendline on this section while adopting a third-order polynomial regression, the equation that describes the formation of the sludge is shown in Figure 4:

$$y = f(x) = 1x10^{-6}x^3 - 0.0003x^2 + 0.02x + 0.5067$$

$$where\ R^2 = 0.9693$$

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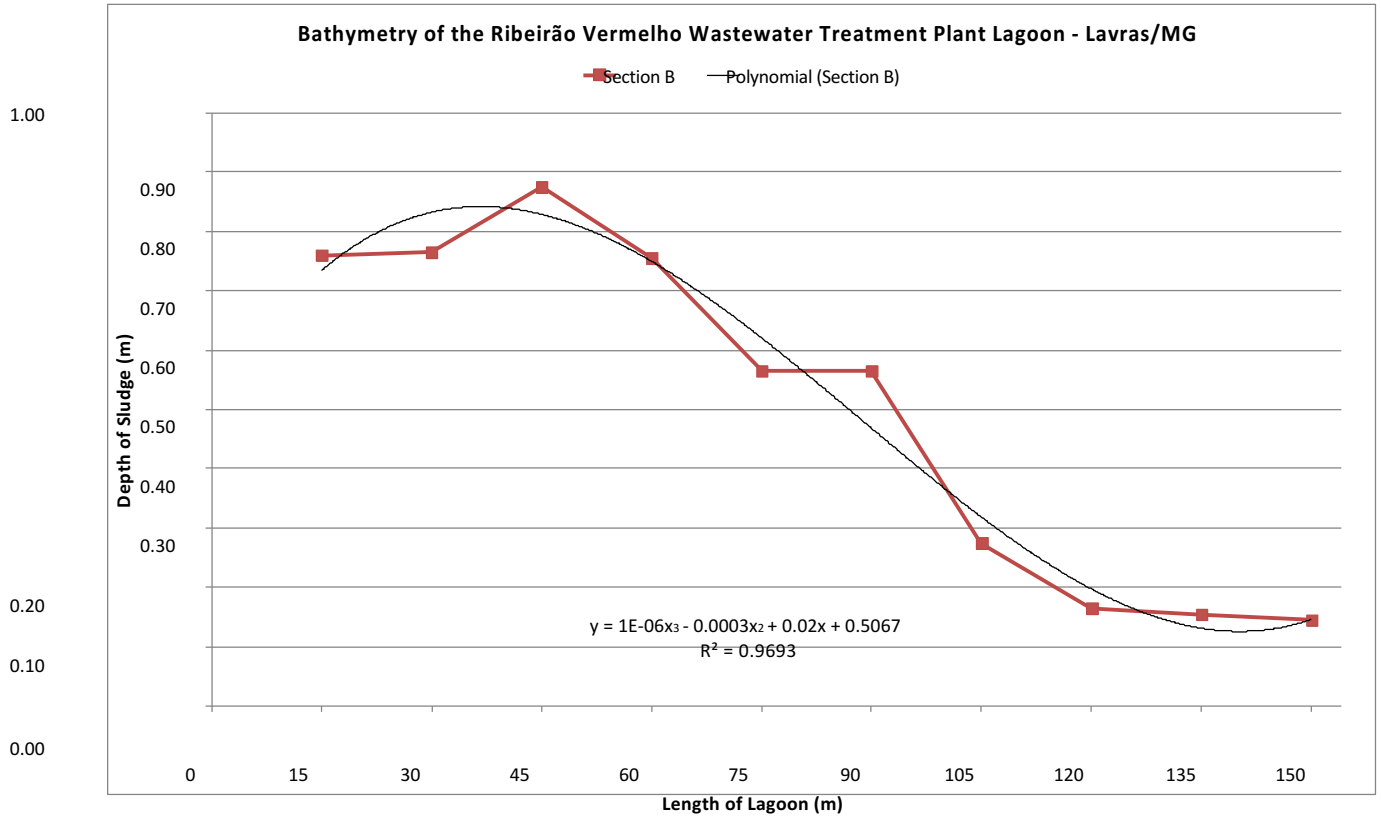

Figure 4: Regression of the bathymetric profile of maturation lagoon 2

- Taking the integral of the function above, the area beneath the curve can be calculated, thus obtaining the approximate volume of sludge which, according to the calculations below, equals 2,717 m³;

$$\int f(x) = 1x10^{-6}\frac{x^4}{4} - 0.0003\frac{x^3}{3} + 0.02\frac{x^2}{2} + 0.5067x + C$$

$$\int_0^{154} 1x10^{-6}\frac{x^4}{4} - 0.0003\frac{x^3}{3} + 0.02\frac{x^2}{2} + 0.5067x + C = 90.58m/m$$

As such:
Volume of sludge = 90,58x30 ≅ 2,717m³

- Considering that the lagoon has a volume of 4,620m³ (154x30x1.00), the approximate volume of sludge is equal to 58.8% of the total volume of the maturation lagoon.

In parallel, on 29/11/2016, COPASA's Southern Regional Laboratory completed a characterization of this sludge in which it was determined that, on average, 57.8% of the sludge consisted of total volatile solids (organic matter). Based on the operational challenges that were listed previously, COPASA and VEEGA Comércio Importação e Exportação Ltd signed a technical partnership in order to apply and

experiment with Biocelerator. Considering an average effluent flow rate from the wastewater treatment plant of 100 L/s, or 8,640,000 L/d, the application of 10 litres of Biocelerator per day was recommended by the manufacturer, who also stated that it was not necessary to apply the product continuously. In light of the above, it was determined that the Biocelerator be applied at 08:00 a.m. and 02:00 p.m. At these times, 3 litres would be applied at the preliminary treatment sector and 1 litre would be applied at the inlet of each lagoon. Because Biocelerator is not a threat to the health or well-being of the plant's operations personnel, they were able to disperse the product using only the PPEs that they already normally use.

After only 22 days of Biocelerator application, the following preliminary results were recorded:

- Maturation lagoon No. 1 no longer had a greenish appearance;
- Formation of scum/sludge clusters in the maturation lagoons;
- Release of gases in both lagoons, in the "dead zones" as well, where small bubbles formed;
- Flow of sewage in "dead zones" where previously there was no flow in maturation lagoon No. 2;
- Although it had not been eliminated completely, the appearance of the scum in the reactors had changed;
- Reduction of offensive odours at the plant.

After 83 days of Biocelerator application, upon completion of the partnership with VEEGA (Biocelerator dosage period), the results that were obtained at the plant were the following, as seen in Figures 5 through 13:

- The effluent from the maturation lagoons had become substantially clearer, devoid of solids and offensive odours;
- Sewage had begun to flow in the "dead zones" in maturation lagoon No. 2;
- The island of scum in maturation lagoon No. 2 had been significantly reduced, and, over a period of a few days, there was continuous, preferential flow along the entire length of the lagoon, including an absence of "dead zones";
- Over the final days of testing, it was noted that the sludge at the bottom of the lagoon was loosening, since once again sludge, albeit of lesser density, was being generated at the lagoons, remaining at the surface;
- Reduction of scum/sludge at the outlets of the maturation lagoons;
- The scum from the reactors had been completely consumed; only a large quantity of inorganic material remained (small pieces of plastic and fabric, among other objects);
- Operators and other plant staff noticed a significant reduction in offensive odours, as did members of the community as they walked or drove past the plant on the adjacent road;
- Marked improvement in the efficiency of the plant regarding reductions in BOD and COD, attaining efficiency levels that had been recorded two years previously;
- Reduction of the solids in the rectors, and, as a result, there was no need to dispose of sludge from the reactors since the quantity of settleable solids was negligible, varying from 0 to 5 mg/L (maximum value), even during periods of maximum flow. The following were the last dates on which material was discarded from the reactors:

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Reactor 1 – 07/12/2016, 14/09/2016, 22/06/2016, 16/03/2016, 14/01/2016;
Reactor 2 – 09/12/2016, 11/08/2016, 16/06/2016, 05/04/2016, 08/02/2016;
Reactor 3 – 26/09/2016, 22/07/2016, 15/06/2016, 09/02/2016.

Figure 5: Comparison of the conditions - inlet of maturation lagoon No. 1 - before & after

Figure 6: Comparison of the conditions - outlet of maturation lagoon No. 1 - before & after

Figure 7: Comparison of the conditions - inlet of maturation lagoon No. 2 - before & after

Figure 8: Comparison of the conditions at the outlet of maturation lagoon No. 2 - before and after

Figure 9: Comparison of the scum at the reactors - before and after

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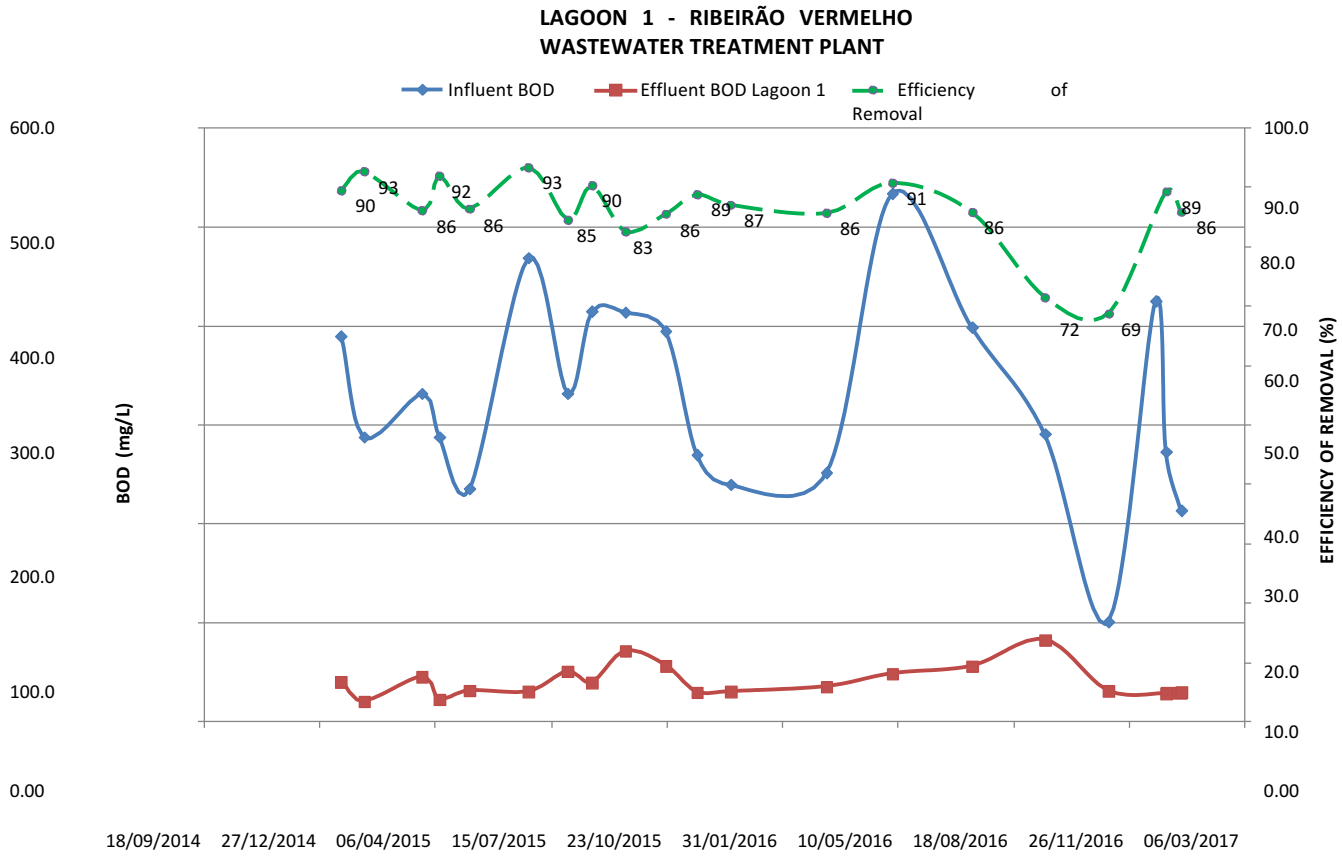

Figure 10: Performance comparison of the plant for BOD at Lagoon No. 1

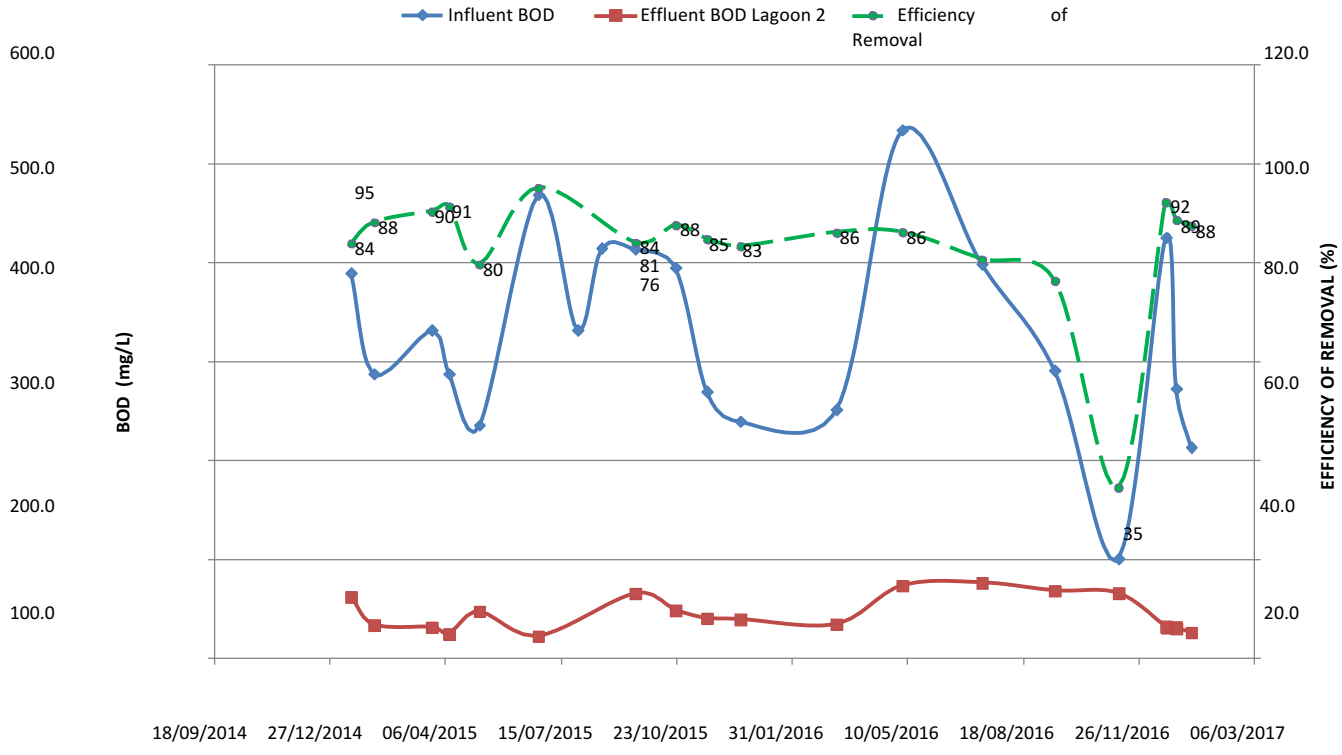

Figure 11: Performance comparison of the plant for BOD at Lagoon No. 2

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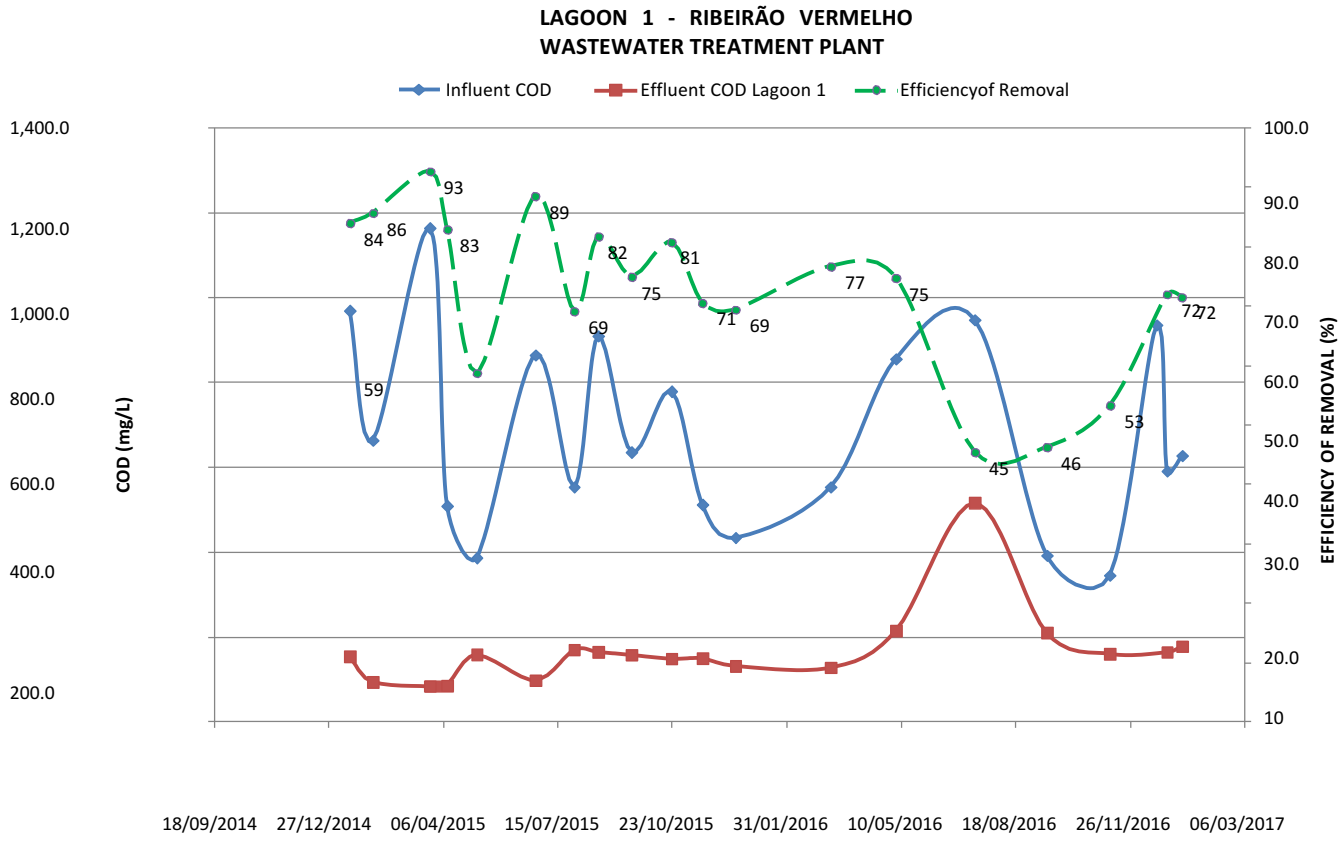

Figure 12: Performance comparison of the plant for COD at Lagoon No. 1

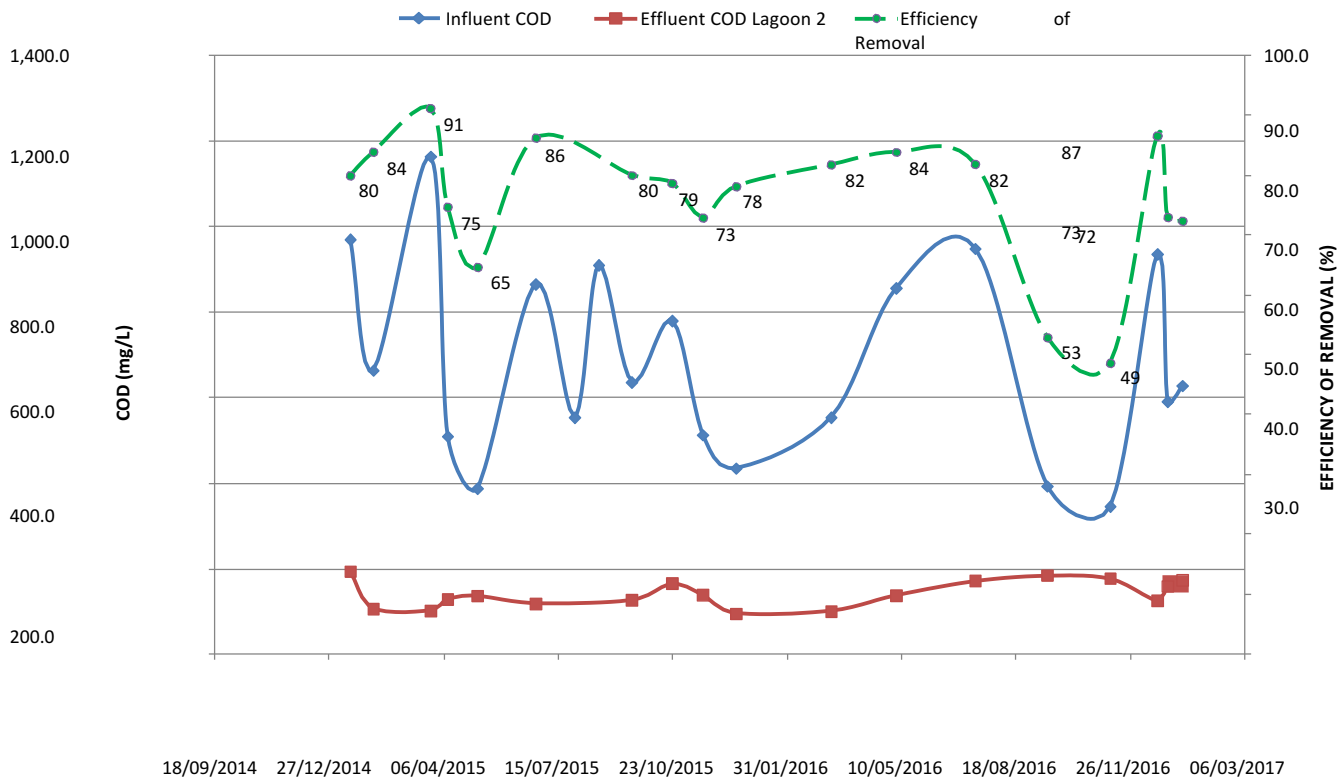

Figure 13: Performance comparison of the plant for COD at Lagoon No. 2

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In addition to the improvements that are listed above, the application of Biocelerator brought about financial gains for COPASA, mainly with respect to the reduction in manpower required for the periodic cleaning of the drying beds and the transport and disposal of the sludge in a landfill, which was outsourced.

Considering that:

- Each time a reactor is emptied, two drying beds are required;
- The equivalent of three dumpsters of material is generated by each drying bed;
- The time required for removal of the sludge is two weeks per drying bed, taking into account two plant assistants working continuously;
- The cost of transporting each dumpster is R$ 80.00;
- The salary of each plant assistant is approximately R$ 1,706.61 per month;
- The payroll taxes for each plant assistant is approximately R$ 1,809.01/month;
- The cost of meal vouchers per assistant is approximately R$ 1,133.39/month.

The total savings that arise simply from eliminating the need to dispose of the sludge from the three reactors equals:

$$Cost\ 1 = (1706.61 + 1809.01 + 1133.39)\ x2x3 + 3x2x80 = R\$28,374.06 / month$$

The approximate cost that was estimated for dredging maturation lagoon No. 2, which was estimated in 2015, was greater than R$$2,000,000.00. As such, considering that the volume of sludge contained in maturation lagoon No. 2 was approximately 58.8% of the total volume of the lagoon, and, furthermore, that 57.8% of that volume consisted of volatile solids, the total cost reduction with respect to the optional dredging of the lagoon would be equal to:

$$Cost\ 2 = 2,000,000 \times 0.588 \times 0.578 = R\$679,728.00$$

Considering that the plant has been operating for six years and that it would be necessary to dredge the lagoon for it to operate in conformity with current environmental legislation, the average cost of maintaining the operation would equal:

$$Cost\ 3 = \frac{679,728}{6x12} = R\$\ 9,440.67 / month$$

Adding costs 1 and 3, the monthly savings for COPASA, just for maturation lagoon No. 2 and the drying beds, would equal:

$$Total = 28,374.06 + 9,440.67 = R\ \$\ 37,814.73 / month$$

IV – CONCLUSION

Despite the relatively short period during which Biocelerator was tested at the Ribeirão Vermelho Plant (3 months), it quickly became clear that the product is highly efficient in delivering what it promises. We would like to continue using it at this wastewater treatment plant, and we would also like to, as soon as possible, begin applying it in other plants in the Lavras Regional District in light of the fact that similar challenges are also being dealt with in those facilities. These challenges include the difficulty and/or impossibility of removing scum from inside the reactors at the São

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Tiago, Água Limpa and Conceição da Barra de Minas wastewater treatment plants; issues regarding offensive odours at the Santana da Viagem plant; the low efficiency of the Colônia do Marçal plant and the lack of drying beds and space for disposing of sludge at the Prados, Santana da Vargem and Conceição da Barra de Minas plants.

Lastly, considering that the application of the product reduces the need for hiring personnel to operate wastewater treatment plants, existing plant assistants can be allocated to complete other work required by COPASA, thus reducing the company's need to hire extra manpower to maintain its operations.

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