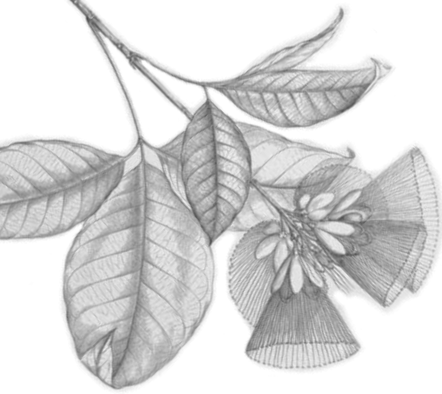

Operational Performance of an Anaerobic-Anoxic-Aerobic Treatment System

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ABSTRACT:

An anaerobic (UASB) – hybrid aerobic (suspended and attached growth activated sludge) wastewater treatment system was evaluated on the removal of organic matter, solids and nitrogen following its pre-operational phase. Analysis were made weekly based on composite samples, prepared by grab samples taken every four hours, during 24-hour cycle, weighted by flow rate, on each monitoring point (raw sewage, UASB, anoxic chamber, aerobic reactors, return sludge from secondary decanters and final effluent). The plant presented an average flow rate of 908 m^3/h with peaks from 10 to 14 h. BOD was removed by 86% (310 to 41 mg/L) being the highest parcel accounted by UASB reactors (70%) and removal of total suspended solids reached 63% (190 to 94 mg/L). Mean removals of TKN (71%) and Ammonium (77%) were above the value predicted by design and, probably the nitrification-denitrification process was not the dominant route.

Keywords: Pollution Control; Organic Matter Removal; UASB Reactor; Wastewater Treatment.

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While infrastructure of human settlements, the environmental sanitation is a subject highlighted in social, economic, political, and environmental areas. Such attention occurs from the fact that coverage ratios per collective systems of water and sewage, as well as the quality of service are important indicators of life quality. This infrastructure comprises four systems: water supply, sewerage, drainage and management of rainwater, and solid waste.

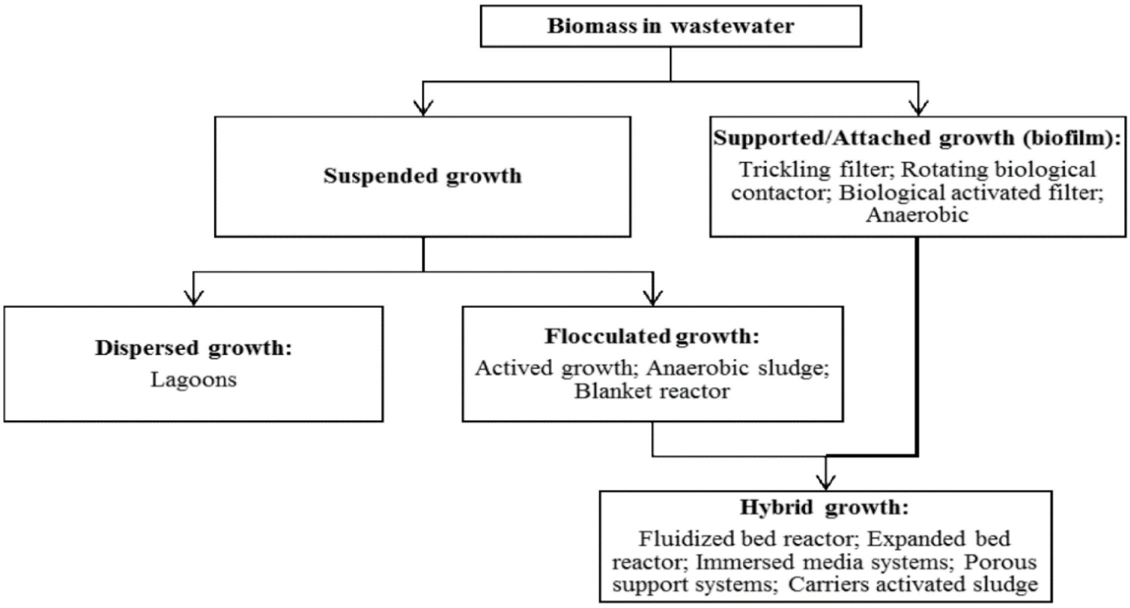
In Brazil, the Law 14445/07, The National Sanitation Policy, and the increments of environmental laws has stimulated advances in the sector. In this regard, it is highlighted the protection scope of water resources on effluents discharge in water bodies. The country has CONAMA resolutions 357/2005 and 430/2011, where in the first, the classification criteria and surface water bodies framework are established, while in the second, discharge standards are established. For environmental protection, sewage treatment is the most effective measure in pollution preventing and disruption of disease dissemination cycles. This helps to explain the recent scenario, in which, over the past decade, occurred an increase in number of wastewater treatment plant (WTP) in the country, including projects, implementing and operation.

As for technological profile used in design of many of these equipments, it emphasizes the integration of anaerobic and aerobic reactors. The sum of different treatment techniques means, potentially, to achieve treatment stations configurations including greater balance between efficiency and cost, as much operating as capital. This aspect is significant against fast growing of urban centers. The increasing availability of intellectual capital to maintain and operate such stations (i.e., engineers, technologists and technicians), is another motivator to more complex treatment systems development.

As for WTP conception, until the beginning of this century, it was common understanding to evaluate distinctly the anaerobic and aerobic digestion technology, often treating them as separate alternatives. Low utilization of power supply and easy operation in tropical climates are the main characteristics of anaerobic systems, since high temperatures favor the organic matter digestion process (Foresti 2001, Mara 2004, Lettinga 2011). As for aerobic systems, it is highlighted mainly for its high power of organic matter reduction, however, with high sludge generation (von Sperling 2005, Jordão and Pessoa 2009). There is also, at less extent, the use of reactors operating under anoxic conditions.

In a mature and more recent understanding, the biological treatment system configurations have become hybrid. This occurs not only on the combination of biochemical mechanisms prevalent in pollutants degradation, but also in biomass sustaining, and on its action in the treatment itself. Figure 1 presents a general structure on biomass in reactors of biological treatment system of wastewater, and helps showing the complex of potential arrangements.

Figure 1. Systematic representation of biomass biological treatment systems.



Source: adapted from Jianlong et al. (2000).

It is also highlighted that, other technologies may be added to biological reactors settings, those not involving microbial biomass, such as coagulation-flocculation, sedimentation, flotation, ozonization, and ultrasound, as Gogate and Pandit review (2004a; 2004b). Thus, it is assumed a more innovative character for wastewater treatment.

The fact is that WTP are intricate systems of unit operations and processes operating on physical, chemical, and biological base. Therefore, at first, it is difficult to describe and evaluate, in detail, all processes involved (Potier and Pons 2006).

The advantages of the anaerobic treatment, like the up-flow anaerobic sludge blanket reactor, UASB, are well known (Lettinga et al. 1992, van Haandel and Lettinga 1994, Conceição et al. 2013, Singh et al. 20013, Hernandes and Rodrigues 2013). The association of UASB with activated sludge systems has been extensively researched for the treatment of domestic and industrial wastewaters (von Sperling et al. 2001, Huang et al. 2005, Huang et al. 2007, Tawfik et al. 2008, Saliba and von Sperling 2017). Combining these two reactors can be energy cost effective with lower sludge production and high effluent quality. In Natal, capital of the state of Rio Grande do Norte, a major program of expansion of the sanitary sewage collection network is under development and WTP design is based on the association of UASB-activated sludge reactors. The Central WTP (675 L/s), object of this paper, is under operation and two new WTP (1000 L/s and 1250 L/s) are under construction.

In addition, while a dynamic system, the wastewater treatment plant requires operational optimization. This study is based on this premise and tries to better understand the operation of a biological treatment system, in order to contribute to a better technical culture. The research purpose was The Central WTP, which was not evaluated with duly minuteness as for performance. The study presents the results of monitoring and initial assessment of this treatment system.

MATERIALS AND METHOD

THE STUDY TREATMENT STATION

The Central Wastewater Treatment Plant (Central WTP) is located in Natal (5 º47 '23.7 " south – 35 º 12 ' 42.7 " west, 31 m above sea level) in Rio Grande do Norte State, northeast of Brazil. The WTP was designed to receive an average flow of 675 L/s, at the final plan (in 2024) and is subdivided into three modules (lines) with a capacity of 225 L/s, each.

The modules have a common mechanical pretreatment system, consisting of grids (coarse [*e* = 20 mm]; fine [*e* = 3 mm]) and sandpit. After preliminary treatment stage, each module comprises a biological treatment line in itself. Two module (lines) have already been implemented, and are the focus of this work. Figure 2 shows a schematic representation of the WTP and a flow chart, while Table 1 shows the volumes and hydraulic retention time of processing phases.

Table 1. Physical and operational characteristics of the reactors.
* Based on the mean flow rate (908 m3/hour)

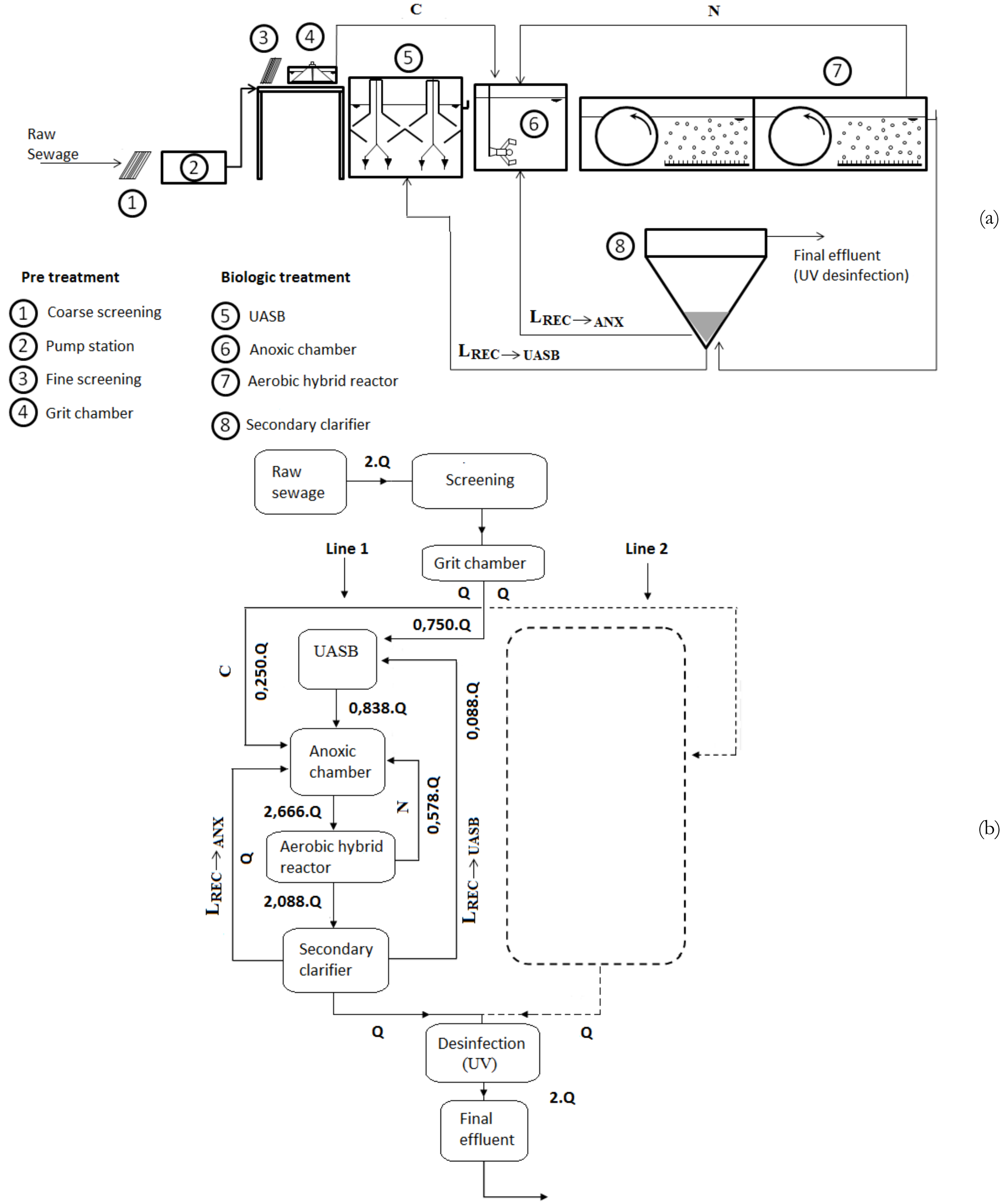
REACTOR	VOLUME UNIT (M3)	QUANTITY	VOLUME TOTAL (M3)	HRT* (H)
UASB	1420	8	11424	15.0
CANX	1298	2	2596	2.9
RAEH	1482	2	2964	3.2

Source: The Authors.

The total effluent flow (2Q) from preliminary treatment stage (Figure 2b) is divided into equal portions (Q). Each one goes to a biological treatment line (Line 1 and Line 2 – Figure 2b) consisting of a set of four UASB reactors (Anaerobic Reactor of Sludge Blanket) arranged in parallel, followed by an anoxic chamber (C_{ANX}), an hybrid aerobic reactor (R_{AEH}), and a secondary clarifier (D_S).

At the end of treatment, effluents form Line 1 and Line 2 are collected and sent to the same disinfection unit by ultraviolet radiation, for further disposal on the environment. The WTP has all equipment for the solid phase treatment, which was not the purpose of this study.

Figure 2. Schematic representation of Central WTP (a) and flow chart of liquid phase (b).



Source: The Authors

Considering each line, on liquid phase, the UASB reactors received around 75% of total line flow (Q), and a sludge recirculation flow of the secondary clarifier (L_{REC}). The remaining 25% is sent directly to the anoxic chamber (C_{ANX}) as the supplementary source of carbon (C) to assist in denitrification. A distribution box containing different weirs located at the end of the preliminary unit was used for flow division. Besides, the anoxic chamber is fed with the effluent flow of UASB, and receives a recirculation flow of the secondary clarifier (L_{REC}) and an internal recirculation flow of the hybrid aerobic reactor (R_{AEH}), as a source of nitrate. C_{ANX} was equipped as two submersible mixers for homogenization and to avoid dead spots and short circuit.

The C_{ANX} effluent goes to the hybrid aerobic reactor composed of aerated tank with biodiscs (surface area of 10,400 m^2, for biofilm formation), using corrugated conduit as support media. Blowers composed the aeration system, to introduce fine and coarse bubbles for aeration and biodiscs movement, respectively.

The plant was commissioned in June 2011 and no inoculum was used to during the startup period.

SAMPLING AND ANALYTICAL PROCEDURES

The study lasted five months (from June to October 2012), based on weekly collection of composite samples, considering the inflow, every four hours, during 24-hour cycle. Ten samples were collected per week, comprising the effluent of the primary treatment unit, after sandpit (RS); UASB reactor effluent set, through collected and homogenized samples (UASB1 and UASB2); effluent from anoxic chamber (CANX-1 and CANX-2); effluent from aerobic hybrid reactors (RAEH-1 and RAEH-2); return sludge from secondary decanters (LREC-1 and LREC-2) and; final treaty effluent (FE), before disinfection unit.

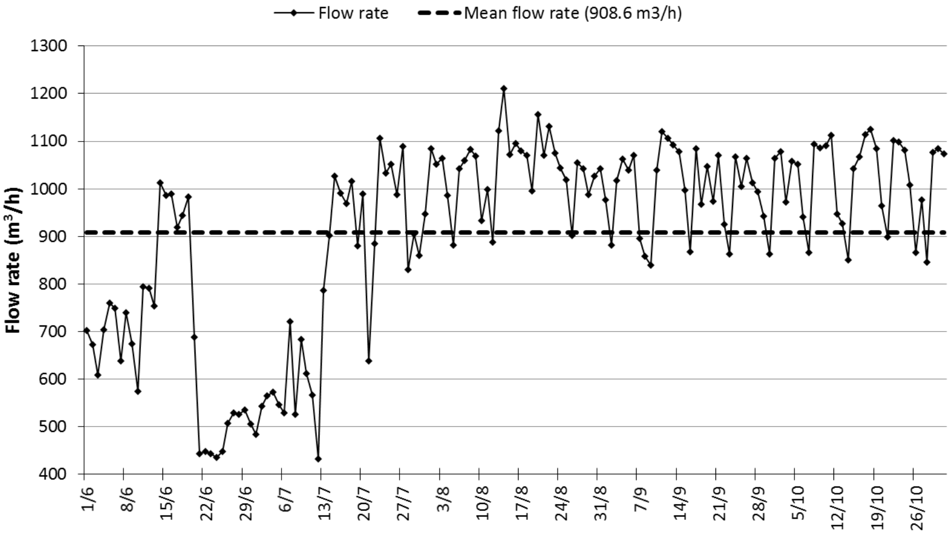
In the field, temperature parameters, pH and dissolved oxygen (DO) were determined at collections time, where DO was measured only in hybrid aerobic reactors and treated effluent samples, before disinfection. The following parameters were determined in laboratory: biochemical oxygen demand (BOD), total suspended solids (TSS), and volatile suspended solids (VSS), total alkalinity, ammonia nitrogen, organic nitrogen, and nitrate. Analytical procedures followed methods described in APHA et al. (2005). Flow measurement was performed through electromagnetic flowmeter installed in pumping pipeline of raw sewage lifting station.

RESULTS AND DISCUSSION

FLOW RATE AND PHYSICAL-CHEMICAL CHARACTERISTICS OF RAW SEWAGE

Inflows in the first two months, in general, were lower than those recorded in subsequent months, since the station was still in testing phase, therefore, not receiving the entire sewage flow generated in sewage basins, which composes the system. Considering the entire period, the average affluent flow was 908 m^3/h (Figure 3), around 56% of design total capacity (1620 m^3/h), considering both built modules. It is highlighted that, around June 20, the Collector General 1 was interconnected (CG1) to WTP. With inflow increasing, there was a cleaning system crash in one of the sandpit, fact that forced the drastic decrease in inflow for about three weeks (Figure 3).

Figure 3. Inflow variation of average hourly.

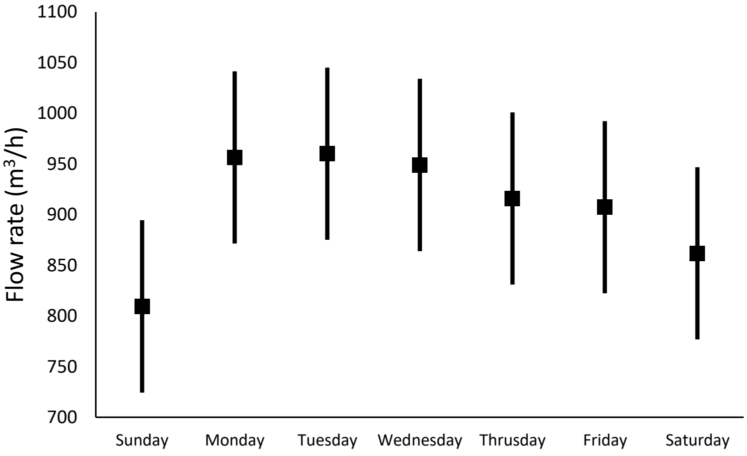


Source: The Authors

Figure 4 summarizes the hourly average flow rates over the weekdays. The higher flow was verified between Mondays and Fridays, and the smallers, over the weekend. However, variance analysis of 0.05 confidence level showed no significant differences between average hourly over weekdays ($p = 0.10741$).

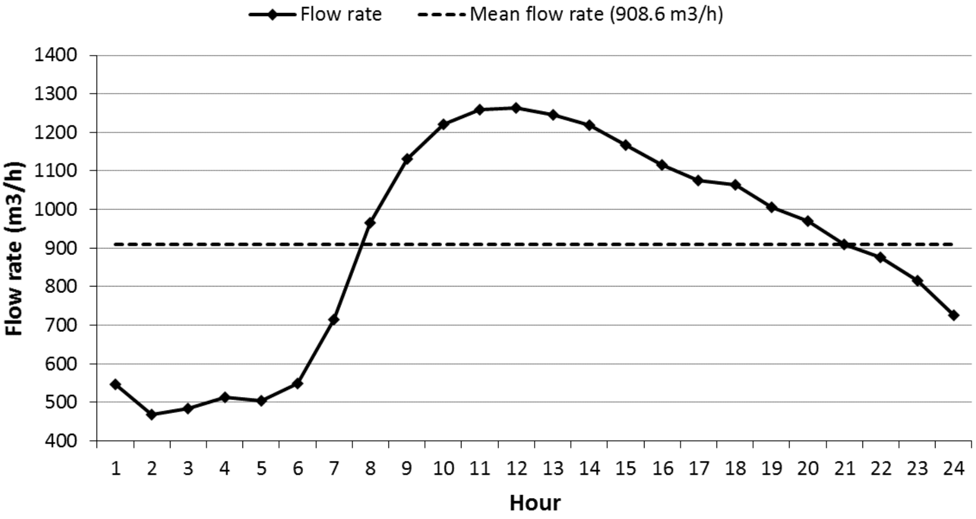
Hourly flow variation over 24 hours, every day of the week, was normal as mentioned in literature, with the lowest values occurring in the early hours (from 0 to 4 h), increasing rapidly throughout the morning, up to the maximum peak around 10 to 12 h, to then decrease gradually until midnight (Figure 5).

Figure 4. Comparison between average hourly of flows over weekdays.



Source: The Authors

Figure 5. Variations in average hourly flows over the day.



Source: The Authors

The physical-chemical characteristics of raw sewage are depicted on Table 2.

Table 2. Physical-chemical characterization of raw sewage.

PARAMETERS	N	MEAN	STANDARD DEVIATION	MINIMUM	MAXIMUM
Temperature (oC)	20	28.3	0.7	27,0	30,0
pH	20	7.14	0.22	6.87	7.73
BOD (mg/L)	20	310	29	270	360
TSS (mg/L)	20	190	65	66	318
VSS (mg/L)	20	138	76	10	300
Organic N (mg/L)	20	3.6	3.3	0.6	14.1
NH3 (mg/L)	20	29.8	5.3	20.3	37.1
NO3 (mg/L)	20	0.7	0.8	0.0	2.7
Alcalinity (mg/L)	20	181	14	163	200

Source: The Authors

TEMPERATURE, PH AND DO

Reactors effluents show generally, average temperatures between 28 oC and 30 oC, following external environment changes.

Raw sewage average pH was close to neutral (7.10) and decreased slightly in anaerobic reactors effluent for 6.80 (UASB1) and 6.90 (UASB2), remaining constant in anoxic chambers, and decreasing slightly again in aerated tanks, where values of 6.70 were observed in both lines. The final effluent from WTP showed average pH of 7.00.

In the first months of monitoring, hydrated lime was added in UASB reactors effluents, due to low pH values in the sludge blanket.

Aerated tanks had dissolved oxygen (DO) variations between 1.4 and 2.5 mg/L, 3.2 and 3.4 mg/L, respectively for RAEH-1 and RAEH-2, in two checkpoints. Problems in line 1 aeration system (RAEH-1) caused different concentrations ranges between aerated tanks. Thereafter, during an operational procedure and routine maintenance, it was figured out that some diffuser lines were clogged. Treated sewage showed an averaged of 5.9 mg/L. This high concentration average can be explained by the high turbulence caused in effluent fall, through secondary decanters channels, and in disinfection system entry.

ORGANIC AND SOLID MATTER

The affluent BOD ranged between 270 and 360 mg/L, with an average of 310 mg/L. After the entire treatment process, the final effluent showed an average of 41 mg/L ranging between 17 to 70 mg/L. It is important to highlight that the WTP was designed based on an effluent BOD of 250 mg/L, fact that may cause organic overload in reactors when the plant start receiving all designed flow. BOD removal of total efficiency ranged between 78% and 95%, with a general average of 86%, a value slightly lower than those estimated in the project (90%). A decreasing trend in BOD removal efficiency was observed throughout monitoring period, probably related to inflow increase tendency.

The total suspended solids concentrations varied in ranges from 66 to 318 mg/L and 24 to 288 mg/L, respectively, in raw sewage and final effluent. The average in both points were respectively, 190 mg/L and 94 mg/L, representing an average removal efficiency of 63%. As for BOD, the smaller solids removal efficiencies were observed at the end of monitoring period and are associated to floating sludge release in secondary decanters, probably due to denitrification.

Salles (2001) evaluated existing data on Miranda WTP operation, in Mato Grosso do Sul State, West-Central of Brazil, with design similar to Central WTP project, using biodiscs system in its aerated reactor, and found out removal efficiencies of 95% of BOD, and 99% of total suspended solids. BOD concentrations in final effluent are within the range observed by Oliveira and von Sperling (2005), in treatment stations located in Minas Gerais and São Paulo states, southeast of Brazil, as well as within the range (13 to 63 mg/L) mentioned for WTP composed of UASB reactors with post-treatment. However, in the same study, the authors observed total suspended solids concentrations ranging from 17 and 85 mg/L, while in this study the variation range was much higher (24 to 288 mg/L). It is worth to point that through the experimental period the sludge was continuously recirculated and besides no sludge excess was removed from UASB. This may have caused a solids overload in secondary decanters and a higher variation on solids concentrations. In combined UASB-activated sludge system Tawfik et al. (2008) found overall removal of BOD above 95%, and a similar removal (94%) was observed by Saliba and von Sperling (2017) on Betim Central WTP (514 L/s) in southeast of Brazil.

Assessing the behavior of each treatment line, UASB reactors presented a similar performance in BOD removal. $UASB_1$ and $UASB_2$ effluent showed and average of 101 mg/L and 97 mg/L, respectively, with no statistical difference at the significance level of 5% ($p > 0.05$). BOD removals average was close to 70%, as predicted in project. The worst results were observed in October/2012, probably due sludge recirculation rate of secondary decanters for UASB reactors to control solids release in decanters due denitrification process. This increased the upflow speed, probably causing a greater release of solid. During the study period average, the UASB reactors operated with a volumetric organic load (VOL) of 2.2 $kgDBO/m^3.day$, a volumetric hydraulic load of 1.6 $m^3/m^3.day$, an upflow speed of 0.42 m/hour and a HRT of 15 hours.

Rizvi et al. (2015) studied the influence of temperature (17 ºC to 38 ºC) and sludge ages (60 to 180 days) on UASB performances. They found DBO removals values from 61% to 85% and related the higher performances with higher temperatures and sludge ages. Tawfik et al. (2008) operated UASB reactors at 20 ºC to treat a combined domestic and dairy wastewater with HRT of 24 h and organic loadings from 1.9 to 4.4 $kgCOD/m^3.day$ and they found performances of BOD removal from 69% to 79%.

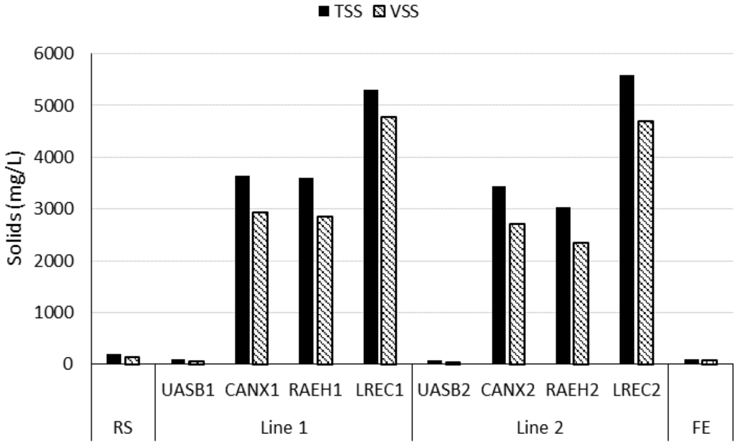
TSS concentrations in anaerobic reactors effluent showed a wide range of variation (20 to 204 mg/L), with mean average of 89 mg/L ($UASB_1$) and 81 mg/L ($UASB_2$), not differing statistically ($p > 0.05$), corresponding to an average removal around 58%. TSS values were not different from the research performed by Silva et al. (2012), who analyzing TSS concentrations in UASB reactor, reached an average of 88 mg/L. Florencio et al. (2001) monitored UASB reactors of Mangueira WTP, located in the metropolitan region of Recife-PE, and observed an average concentration of 80 mg/L. Oliveira and von Sperling (2005), assessing 166 WTP data, found that UASB reactors showed concentration variation range between 49 and 137 mg/L. In this same study, the UASB reactors showed BOD concentrations between 67 and 129 mg/L. Rizvi et al. (2015) observed, in UASB reactors, TSS removals from 41% to 73% while Tawfik et al. (2008) reported efficiency of around 70%.

As samples were composed proportionally of inflows, it was noticeable at collection time, that the largest TSS contributions occurred during periods of high flow, as well as Carvalho et al. (2008) showed in his study, by applying cyclical sinusoidal variations of flow, observing greater dragging of solids in periods of upflow speed increase. However, the sewage upflow speed in reactors was very low, an average of 0.4 m/h, because the average inflow is still far from those designed in the project. Thus, the variation may be related with sludge recirculation routines from secondary decanters to UASB reactors, as well as the disposal for sludge treatment line. Solid treatment line (sludge) was not operating yet, and there was impasses in its sludge destination, i.e., excess sludge discard was not performed, causing a high concentration of solids in UASB reactors.

Anoxic chambers showed TSS concentrations ranging from 2130 to 5000 mg/L (C_{ANX-1}), and from 1780 to 5125 mg/L (C_{ANX-2}), with average of 3633 mg/L and 3441 mg/L, respectively, while VSS concentrations presented averages of 2932 mgL (C_{ANX-1}) and 2712 mg/L (C_{ANX-1}). TSS concentrations in R_{AEH-1} (3605 mg/L) and R_{AEH-2} (3032 mg/L) were lower than the project (4000 mg/L), and the averages of volatile fractions were 2843 mg/L and 2348 mg/L, respectively. The increase of suspended solids in these compartments is due to microbial growth, being inherent to the technology type in question, and it is required to promote an efficient degradation of organic matter in the effluent. Figure 6 highlights the average concentrations of solids obtained in units composing the WTP, and variance analysis at 5% level, showed that both treatment lines showed similar behavior in relation to concentrations of TSS and VSS ($p > 0.05$).

The average of VSS/TSS relations indicated the predominance of volatile solids (biomass) compared to fix (inert), at all treatment stages. $UASB_1$ and $UASB_2$ show relations of 0.63 and 0.59 respectively, showing a large stabilization of sludge if compared with other stages. In this case, it is important to point that UASB reactors also work as sludge digester from secondary decanters. Anoxic chambers and aerated tanks showed similar results, with relations ranging from 0.76 and 0.81, and the highest percentage was found in sludge recirculation lines (0.84 and 0.90).

Figure 6. TSS and VSS average at monitoring points.



Source: The Authors

NITROGEN

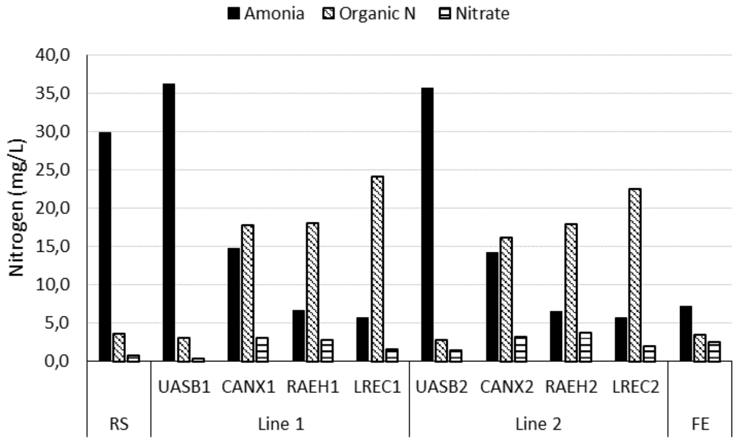
Figure 7 shows nitrogen behavior during the treatment process. As verified for solids, the variance analysis at a 5 % level, indicated that both treatment lines showed similar behavior in relation to nitrogen concentrations ($p > 0.05$).

Average concentrations of ammonia nitrogen increased between raw sewage (29.8 mg/L) and anaerobic reactors (36.0 mg/L) due to ammonification process of organic nitrogen present in raw sewage, and in sludge recirculation lines of secondary decanters for anaerobic reactors. In anoxic chambers, ammonia nitrogen concentrations were reduced to 14.8 mg/L (C_{ANX-1}) and 14.2 mg/L (C_{ANX-2}) and, later, to 6.7 mg/L and 6.5 mg/L, respectively, in aerated reactors R_{AEH-1} and R_{AEH-2}, which may be associated with assimilation and nitrification processes.

Organic nitrogen concentrations increased around 3.0 mg/L, in effluent of anaerobic reactors, for values ranging from 16.2 mg/L to 18.1 mg/L in C_{ANX} and R_{AEH}, probably due to high concentration of biomass in these reactors. After secondary decantation, treated sewage showed a low concentration of organic nitrogen (3.5 mg/L), being practically similar to those observed in raw sewage and effluents of anaerobic reactors. On the other hand, in sludge recirculation lines, higher concentrations were observed reaching averages of 21.4 mg/L and 22.5 mg/L in L_{REC-1} and L_{REC-2}, respectively, attesting the large amount of nitrogen assimilated by biomass. At the end of the treatment process, average removals of 71 % of NTK and 77 % of $N\text{-}NH_4$ were found far above 50 % of predicted removal by ETE project.

Nitrate levels were quite similar in C_{ANX} and R_{AEH} (Figure 7), and the final effluent showed a concentration of 2.5 mg/L.

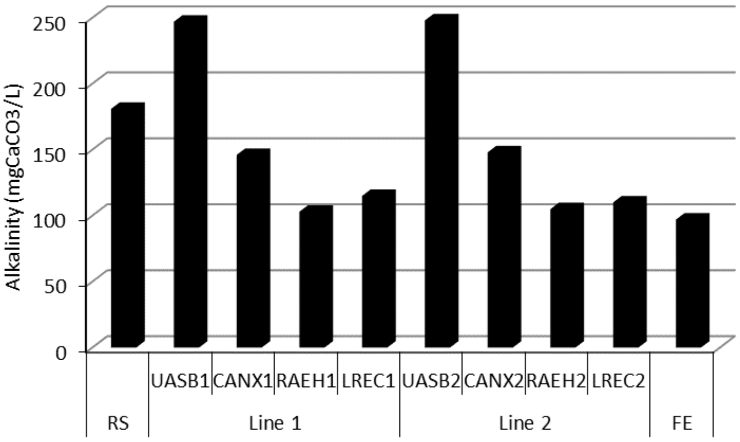
Figure 7. Average of nitrogen at monitoring points.



Source: The Authors

The alkalinity in reactors is directly related to nitrification and denitrification processes. Figure 8 shows alkalinity increases of raw sewage (175 mg/L) for UASB effluents (247 mg/L), probably due to addition of hydrated lime. Subsequently, continuous alkalinity decreases were observed in effluent of C_{ANX} (147 mg/L) and R_{AEH} (104 mg/L), reaching in the final treated effluent, a concentration of 97 mg/L. It is possible to observe lower alkalinity in R_{AEH} regarding C_{ANX}, probably due to its consumption during the nitrification process.

Figure 8. Alkalinity average at monitoring points.



Source: The Authors

FINAL CONSIDERATIONS

The mean influent BOD was 310 mg/L while the plant was designed by using 250 mg/L. Therefore, it is extremely important, if possible, to make surveys to assess the real characteristics of raw sewage, in the WTP planning and projects design phase. In addition, regarding new WTP projects, it was observed that for pre-denitrification systems, operational flexibility is important due to required recirculation rates.

Nitrogen biological removal, in systems with pre-denitrification, is affected by diverse operating factors, especially internal recirculation ratios of nitrified sewage, sludge recirculation of decanters for anoxic chambers, and the availability of carbon source in anoxic zone. Von Sperling (1997) shows that for pre-denitrification systems, the internal recirculation ratio varies between 100 % and 400 %. Therefore, it is very important that WTP be similarly configured to the present study, in order to achieve satisfactory removal of nitrogen, and present great operational flexibility.

During monitoring period, the aerated hybrid reactor operated with a constant internal recirculation ratio to the anoxic chamber of 936 m3/h. Between June and July, when occurred the smaller inflows; internal recirculation flow was about 128 % above the inflow. In subsequent months, the inflow increased by interconnections of collectors of sewerage system, so that, the internal recirculation ratio decreased for values close to 90 %. Observing the end of WTP plan, this may present a maximum internal recirculation ratio of 100 %.

Globally, the WTP showed an average efficiency of BOD removal, which is below of those estimated in the project, even operating with flow below that designed for final plan. High removal of ammonia nitrogen was achieved, as well as pH ranges and appropriate temperature, meeting the Brazilian Discharge Guidelines. However, it is important to observe that, during monitoring time, the plant average inflow was still 56 % lower of the value presented for final plan.

UASB reactors showed average removal efficiencies of BOD slightly lower than the 70 % expected in the project, which were mainly affected by TSS concentrations in effluents, even operating with high hydraulic retention times, and low ascension speeds. There is a tendency that these results are related to recycling procedures and disposal of excess sludge of secondary decanters, for digestion in UASB reactors, mainly by the fact that, during monitoring, the disposal operation and sludge dehydration had not started, yet. Thus, sludge disposal in excess was impaired forcing then, excessive recirculation, for both anoxic chambers and UASB reactors.

Regarding nitrogen removal, the results showed good efficiencies, however, with a downward trend during monitoring, probably due to increased flow and consequently decrease of internal recirculation ratio of aeration tanks for anoxic chambers. In addition, the removal did not occur through nitrification and denitrification processes probably, since too low concentrations of nitrate in effluent of aeration tanks were found. Nitrogen removal should be studied further, in order to determine the best setting of recirculation flow and sludge disposal, as well as bypass ratio for anoxic zone.

It is recommended to evaluate and improve the sludge disposal routine, digested in UASB reactors, as well as excess of sludge receiving from secondary decanters, in order to obtain improvements in solids removal efficiency.

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Avaliação Operacional de uma Estação de Tratamento de Esgotos Anaeróbia-Anóxica-Aeróbia

RESUMO:

Um sistema anaeróbio (UASB) - híbrido aeróbio (lodo ativado com biomassa suspensa e aderidaligado) foi avaliado na remoção de matéria orgânica, sólidos e nitrogênio após sua fase pré-operacional. As análises foram feitas semanalmente com base em amostras compostas, preparadas por amostras individuais coletadas a cada quatro horas, durante o ciclo de 24 horas, ponderadas pela vazão, em cada ponto de monitoramento (esgoto bruto, UASB, câmara anóxica, reatores aeróbios, linha de recirculação de lodo decantadores secundários e efluente final). A ETE apresentou uma vazão média de 908 m^3/h com picos entre 10 e 14 h. A DBO foi removida em 86% (310 para 41 mg/L), sendo a maior parcela nos reatores UASB (70%) e a remoção de sólidos suspensos totais atingiu 63% (190 a 94 mg/L). A remoção média de TKN (71%) e Amônia (77%) foi superior ao valor predito pelo projeto e, provavelmente, o processo de nitrificação-desnitrificação não foi a rota dominante.

Palavras-Chave: Controle de Poluição; Reatores UASB; Remoção de Matéria Orgânica; Tratamento de Águas Residuais.

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